DOE/EIS-0470

# Environmental Impact Statement for the Proposed Cape Wind Energy Project

Nantucket Sound, Offshore of Massachusetts

# Final Environmental Impact Statement

U.S. Department of the Interior, MMS EIS-EA, OCS Publication No. 2008-040,
OCS EIS/EA MMS 2010-11 and OCS EIS/EA BOEMRE 2011-024
Adopted as DOE/EIS-0470

## U.S. Department of Energy

## December 2012

**Lead Federal Agency:** U.S. Department of Energy

**Title:** *Final Environmental Impact Statement for the Proposed Cape Wind Energy Project, Nantucket Sound, Massachusetts (Adopted), DOE/EIS-0470*

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**Proposed Action:** The U.S. Department of Energy (DOE) is proposing to issue a loan guarantee to Cape Wind Associates, LLC (CWA) for the construction and start-up of the Cape Wind Energy Project (the Project), an off-shore wind energy facility. The Project would be located on the Outer Continental Shelf (OCS) on Horseshoe Shoal in Nantucket Sound, offshore of Massachusetts. The Project would entail the construction, operation and maintenance, and eventual decommissioning of up to 130 3.6-megawatt wind turbine generators, each with a maximum blade height of 440 feet. The Project would encompass approximately 25 square miles and the projected maximum electric power output would be approximately 468 megawatts averaging around 183 megawatts. Submarine cables from each wind turbine generator would interconnect within the array and terminate on an electrical service platform serving as a common interconnection point. A 12.5-mile submarine cable would deliver electricity from the interconnection point to a landfall location in Yarmouth, Massachusetts. A 5.9-mile land-based transmission system would deliver electricity from the landfall location to the Barnstable Switching Yard, which is part of the New England Power Pool.

**National Environmental Policy Act (NEPA) Process:** In 2005, prior to DOE Loan Programs Office (LPO) consideration of a loan guarantee for the Project, CWA submitted a lease application for the wind power facility to the U.S. Department of the Interior (DOI) Minerals Management Service[1] (MMS). In compliance with NEPA, the MMS issued the Cape Wind Draft EIS on January 18, 2008 (73 FR 3482), which was followed by the Final EIS on January 21, 2009 (74 FR 3635). On May 4, 2010, MMS issued an Environmental Assessment (EA) and Finding of No New Significant Impact (FONNSI) (75 FR 23798), and the Record of Decision (ROD) for the Project was issued on June 16, 2010 (75 FR 34152). The 2010 ROD approved the issuance of a lease to CWA on the OCS and identified the Proposed Action as the preferred alternative. The lease did not authorize CWA to construct or operate the Project, but granted CWA the right to submit a Construction and Operation Plan (COP), the approval of which would

[1] In June 2010, the DOI renamed the Minerals Management Service (MMS) as the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), and in October 2011, BOEMRE was reorganized and the Bureau of Ocean Energy Management (BOEM) was established. BOEM is responsible for managing development of the nation's offshore resources.

authorize the actual construction and operation of the Project. CWA submitted a COP for the project on October 29, 2010, and submitted a modified COP on February 4, 2011.

On April 22, 2011, after review of the COP, the DOI's Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) issued an EA and FONNSI and ROD for the Project (76 FR 22719). The ROD approved the COP with modifications, and authorized CWA to construct and operate the Project. Based on its independent evaluation of the 2009 MMS Final EIS and the EAs issued in 2010 and 2011, DOE has determined that the documentation satisfies DOE NEPA procedures. DOE's proposed action is to support the construction and start up of the same proposed project analyzed in the MMS Final EIS and the EAs. Accordingly, DOE is adopting the 2009 MMS Final EIS, in combination with the 2010 MMS EA and 2011 BOEMRE EA (per 40 CFR 1506.4), as a DOE Final EIS (DOE/EIS-0470).

**Public Involvement:** DOE did not participate as a cooperating agency in the preparation of the EIS; therefore, in accordance with NEPA regulations, DOE is re-circulating the EIS and EAs as a Final DOE EIS (DOE/EIS-0470) for a period of 30 days, and filing the DOE Final EIS with the U.S. Environmental Protection Agency (EPA). DOE's Final EIS is available at the following locations:

- DOE LPO website: https://lpo.energy.gov/?page_id=1506
- DOE NEPA Web site: http://energy.gov/nepa
- Public libraries located in: Edgartown, Boston Central, Hyannis, Falmouth, Eldredge, and Nantucket Atheneum, Massachusetts, and North Kingstown, Rhode Island

DOE may issue a Record of Decision regarding the proposed loan guarantee no sooner than 30 days after EPA publishes a Notice of Availability of this Final EIS in the *Federal Register*.

**Adoption:** DOE conducted an independent review of the EIS, EAs, FONNSIs, and supporting documentation for the purpose of determining whether DOE could adopt the EIS and EAs to satisfy all applicable environmental review requirements. As part of its review, DOE:

(1) Compared the action as proposed in the loan guarantee applications and the proposed action analyzed in MMS's Final EIS;
(2) Assessed the need for a floodplain review pursuant to 10 CFR Part 1022; and
(3) Reviewed the Project's environmental review and consultation requirements pursuant to 40 CFR 1502.25

**(1) Review of the Proposed Action -** DOE reviewed the action encompassed in the Cape Wind loan guarantee application to ensure it is substantially the same as the proposed action analyzed in the MMS Final EIS. This review also included a review of the information presented in the 2010 and 2011 EAs and FONNSIs. DOE concurs with the findings pursuant to the EAs that no new information was found that would necessitate a re-analysis of the range of the alternatives or the kinds, levels, or locations of the impacts of the Proposed Action on biologic, physical, cultural, or socioeconomic resources. The analyses, potential impacts, and conclusions detailed in the Final EIS remain applicable and valid. From its review, DOE concluded that the action encompassed by the Cape Wind loan guarantee application is substantially the same as the proposed action analyzed in the MMS Final EIS, MMS EA, and BOEMRE EA.

**(2) Floodplain Review –** The adopted Final EIS (DOE/EIS-0470) provides the relevant information for a floodplain assessment pursuant to 10 CFR Part 1022. A portion of the Proposed Action, two electrical transition vaults (each approximately 8 feet wide, 35 feet long, and 8 feet high) would be constructed within the 100-year floodplain where the submarine transmission cable makes landfall in Yarmouth, Massachusetts. The transition vaults would be below grade structures and would not require any fill or elevation changes, and would not result in any redirection of coastal zone flooding or alteration in patterns of sediment transport. DOE will incorporate a floodplain statement of findings in its ROD, which will be published in the *Federal Register*.

**(3) Environmental Review and Consultation Requirements –** DOE reviewed the MMS Final EIS, subsequent EAs, and supporting documentation to determine that the related surveys, studies, and consultations were completed or integrated with the environmental impact analyses. Through its review, DOE determined that DOI had completed the necessary consultations pursuant to Section 106 of the National Historic Preservation Act (NHPA), Section 7 of the Endangered Species Act (ESA), and essential fish habitat consultations pursuant to the Magnuson-Stevens Fishery Management and Conservation Act (Magnuson-Stevens Act). In accordance with Section 106 of the NHPA, DOI terminated its Section 106 process after determining that its differences with the consulting parties were irreconcilable. ACHP issued formal comments and DOI considered and responded to the comments prior to issuing its ROD. DOE is in agreement with DOI's determination (in its role as the lead Federal agency for the Section 106 process) and would incorporate the mitigation measures from DOI's lease into DOE's ROD. In accordance with Section 7 of the ESA, DOI consulted with both the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries). The USFWS issued a Biological Opinion on November 21, 2008, and NOAA Fisheries issued two Biological Opinions, the first on November 13, 2008, and the second on December 30, 2010. In accordance with the Magnuson-Stevens Act, MMS consulted with and submitted an Essential Fish Habitat Assessment to NOAA Fisheries with the MMS Final EIS. Additional information regarding other regulatory requirements and permits is available in Section 1.4, Regulatory Status, of the BOEM approved COP, available at: http://www.boem.gov/Renewable-Energy-Program/Studies/Cape-Wind.aspx.

MMS EIS-EA
OCS Publication No. 2008-040

# CAPE WIND ENERGY PROJECT

## Final Environmental Impact Statement

January 2009
Volume 1 of 3

U.S. Department of the Interior
Minerals Management Service

**CAPE WIND ENERGY PROJECT**
**ENVIRONMENTAL IMPACT STATEMENT**

**Draft ( )** **Final (X)**

**Type of Action:** **Administrative (X)** **Legislative ( )**

**Areas of Potential Impact:** Offshore marine environment and the coastal counties of Barnstable County, Nantucket County, and Dukes County in Massachusetts, and Washington County, Rhode Island.

**Responsible Agency:** U.S. Department of the Interior
Minerals Management Service
381 Elden Street
Herndon, VA 20170-4817

**Abstract:**

This environmental impact statement presents the characteristics of the environment in the project area and analyzes the effects of the construction, operation and maintenance, and decommissioning of the Cape Wind Energy Project, consistent with the requirements of the Outer Continental Shelf (OCS) Lands Act, (67 Stat. 462, as amended, 43 U.S.C.§1331 et seq.) and in accordance with the National Environmental Policy Act of 1969. The proposed action is a wind energy facility with a maximum electric output of 468 megawatts (MW) in Nantucket Sound off the coast of Massachusetts that can interconnect with and deliver electricity to the New England Power Pool. In addition to the proposed action, six alternatives were evaluated in detail, including the no action alternative.

In analyzing potential impacts of the project, consideration was given to a broad range of impact producing factors that could occur either under normal conditions or during unplanned or accidental conditions during the three phases of the project: construction, O&M, and decommissioning. Environmental resource characteristics from both the marine environment and the on land portions of the proposed action were then compared to these factors in order to assess and present the potential direct, indirect, and cumulative impacts of the proposed action and the six alternatives evaluated in detail.

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**MMS EIS-EA**
**OCS Publication No. 2008-040**

# CAPE WIND ENERGY PROJECT

## Final Environmental Impact Statement

***MMS*** U.S. Department of the Interior
Minerals Management Service

**January 2009**
**Volume 1 of 3**

# EXECUTIVE SUMMARY

## Purpose of the Document

The Cape Wind Energy Project developer, Cape Wind Associates, LLC (the applicant), proposes to build, operate, and eventually decommission an electric generation facility with a maximum electric output of 454 megawatts and an average output of 182.6 megawatts, in Nantucket Sound off the coast of Massachusetts (proposed action). The proposed action would generate electricity from wind energy resources on the Outer Continental Shelf. The applicant seeks to commence construction in 2009 and begin operation in 2010.

The applicant requests a lease, easement, right-of-way, and any other related approvals from the Department of the Interior, Minerals Management Service necessary to authorize construction, operation and eventual decommissioning of the proposed action. The Minerals Management Service's authority to approve, deny, or modify the Cape Wind Energy Project derives from the Energy Policy Act of 2005 (EPAct – http://www.mms.gov/offshore/PDFs/hr6_textconfrept.pdf). Section 388 (43 USC 1337(p) of the Act amended the Outer Continental Shelf Lands Act by adding subsection 8(p), which authorizes the Department of the Interior to grant leases, easements or right-of-ways on Outer Continental Shelf lands for activities that produce or support production, transportation, or transmission of energy from sources other than oil and gas, such as wind power.

The proposed action requires environmental review for Federal approval under Subsection 8(p) of the Outer Continental Shelf Lands Act. The National Environmental Policy Act provides the framework under which Federal agencies perform environmental review of projects for which they would be authorizing, funding, or undertaking on their own behalf. In this instance, the proposed federal actions resulting in the need for environmental review under the National Environmental Policy Act are the issuance of a lease, easement or right-of-way and related approvals by the Minerals Management Service for authorizing the construction, operation and eventual decommissioning of the Cape Wind Energy Project (the proposed action).

This Final Environmental Impact Statement provides a detailed description of the proposed action, including the construction, operation and maintenance, and decommissioning phases. An explanation of the alternative screening analysis, the locations and descriptions of the considered alternatives, as well as a comparison of impacts between the alternatives and the proposed action is also provided. The existing conditions of the affected environment are described and broken down in to the physical, biological and socioeconomic resources. A detailed analysis of the impacts on each of these resources according to construction, operation and maintenance, and decommissioning, is presented. Cumulative impacts and commitment of resources are discussed. The concept of an Environmental Management System is introduced that contains many of the mitigation measures and other commitments and requirements under which the proposed action would be constructed, operated, and decommissioned. Other important information contained in this Final Environmental Impact Statement includes agency correspondence and coordination, and supplemental studies and reports prepared by the applicant.

## Project Purpose and Need

The underlying purpose and need to which the agency is responding is to develop and operate an alternative energy facility that utilizes the unique wind resources in waters offshore of New England employing a technology that is currently available, technically feasible, and economically viable, that can interconnect with and deliver electricity to the New England Power Pool, and make a substantial contribution to enhancing the region's electrical reliability and achieving the renewable energy requirements under the Massachusetts and regional renewable portfolio standards.

The Massachusetts Energy Facility Siting Board found there was a need for at least 110 megawatts of energy resources beginning in 2007 with a much greater need within the following years (Energy Facility Siting Board, Siting Decision 2004). The Massachusetts and regional Renewable Portfolio Standards mandate that a certain amount of electricity come from renewable energy sources, such as wind. Specifically, the Massachusetts Renewable Portfolio Standard requires that all retail electricity providers in the state utilize new renewable energy sources for at least 4 percent of their power supply in 2009 and increasing this percentage by one percent each year until the Massachusetts Division of Energy Resources (DOER) suspends the annual increase (http://www.mass.gov/doer/rps/regs.htm).

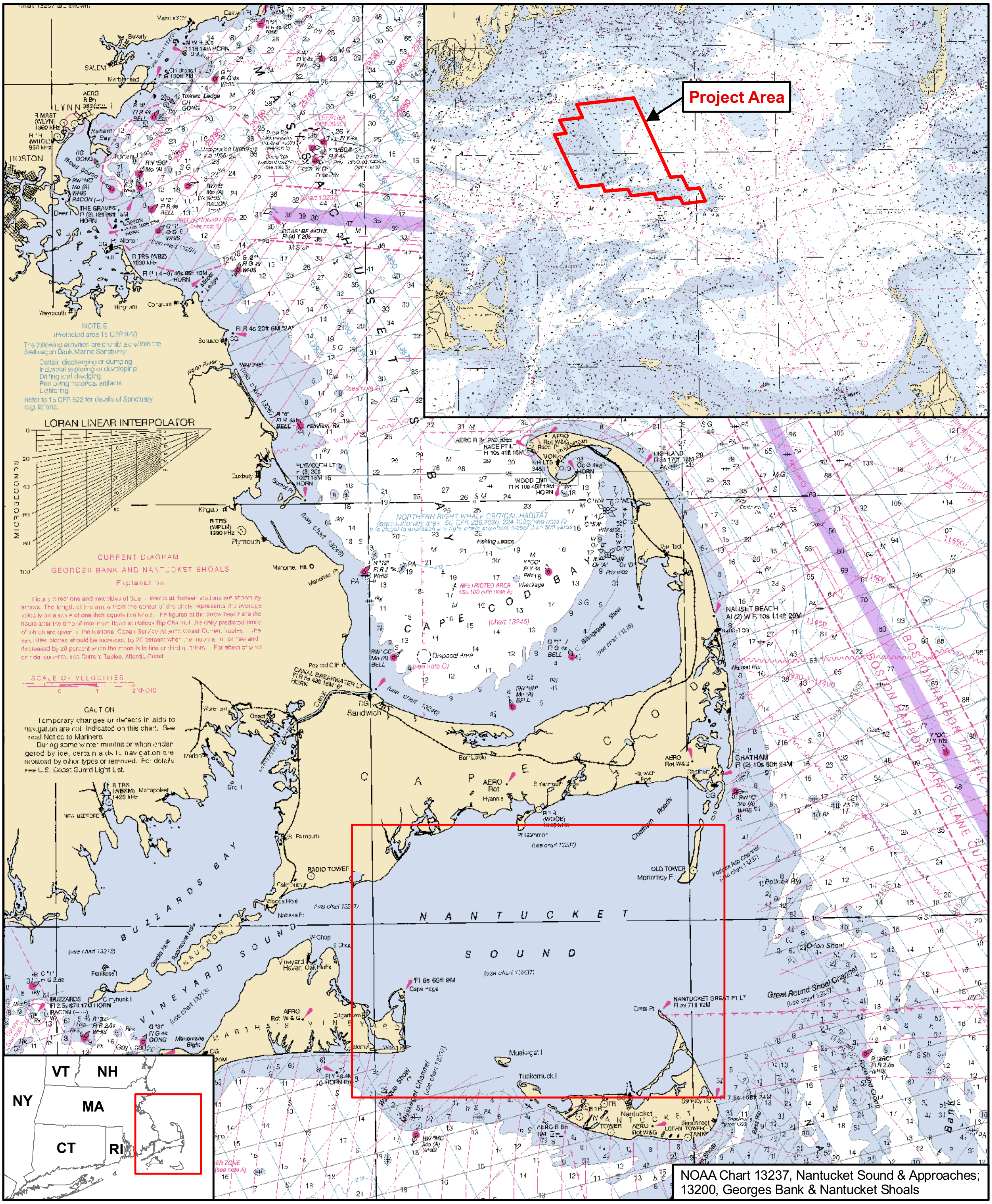
**Proposed Action Description Overview**

The proposed action entails the construction, operation and maintenance, and eventual decommissioning of an electric generating facility consisting of 130 wind turbine generators arranged in a grid pattern in the Horseshoe Shoal region of Nantucket Sound, Massachusetts (see Figure E-1). Each of the 130 wind turbine generators would generate electricity independently of each other. For this area of Nantucket Sound, the wind power density analysis conducted by the applicant determined that orientation of the array in a northwest to southeast alignment provides optimal wind energy potential for the wind turbine generators. This alignment would position the wind turbine generators perpendicular to prevailing winds, which are generally from the northwest in the winter and from the southwest in the summer for this geographic area in Nantucket Sound.

The wind turbine generators have a stated design life span of twenty years. However, this estimate is based on experience generated from land-based machines which are subject to higher levels of turbulence and arguably experience greater wear and tear than can be expected offshore where winds are less turbulent. It is possible that the proposed action could be operational beyond the minimum design life of twenty years.

Solid dielectric submarine inner-array cables (33 kilovolt) from each wind turbine generator would interconnect within the grid and terminate on an electrical service platform. The electric service platform would serve as the common interconnection point for all of the wind turbine generators. The proposed submarine transmission cable system (115 kilovolt) is approximately 12.5 miles in length (7.6 miles within the Massachusetts 3 mile territorial line) from the electric service platform to the landfall location in Yarmouth. The submarine transmission cable system consists of two parallel cables that would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue. The proposed onshore transmission cable system route from the landfall area to its intersection with the NSTAR electric right-of-way would be located entirely along existing paved right-of-ways where other underground utilities already exist. All of the roadways within Yarmouth and Barnstable in which the proposed transmission cable system would be placed are town owned and maintained roads with the exception of Routes 6 and 28, which are owned and maintained by the Massachusetts Highway Department. A portion of the onshore transmission cable system route would also be located underground within an existing maintained NSTAR Electric right-of-way.

Installation of the proposed action components would comprise five activities: (1) installation of the foundation monopiles; (2) erection of the wind turbine generators and electric service platform; (3) installation of the inner-array cables; (4) installation of the transmission cables from the electric service platform to the Barnstable Switching Station; and (5) installation of the scour protection around the monopiles and electric service platform piles. The electric service platform design is based on a piled jacket/template design with a superstructure mounting on top. The platform jacket and superstructure would be fully fabricated on shore and delivered to the work site by barges, where it would be installed.




CAPE WIND ENERGY PROJECT
Project Locus Map
Figure E-1

The proposed method of installation of the submarine cables (both the inner array cables and the submarine transmission cables) would be accomplished by the Hydroplow embedment process, commonly referred to as jet plowing. This method involves the use of a positioned cable barge and a towed hydraulically-powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from wind turbine generator to wind turbine generator and then to the electric service platform, or from the electric service platform to the landfall area.

The transition of the submarine transmission cables from water to land would be accomplished through the use of Horizontal Directional Drilling. Construction of the onshore transmission cable would occur in two phases. The first phase would consist of installing the ductbanks, conduits, and vaults. The second phase would consist of the installation of the onshore transmission cables, including splices and terminations.

It is anticipated that the main operation center would be located in the Town of Yarmouth. Here would be installed the remote monitoring and command center where all decisions concerning the operation of the offshore generating facility would be made. The service and maintenance vessels, supplies and personnel would be stationed at two additional onshore locations: a New Bedford location for parts storage and larger maintenance supply vessels and Falmouth for crew transport, since it is closer to the site.

**Project Chronology**

In November 2001, Cape Wind Associates, LLC sought permission from the U.S. Army Corps of Engineers to construct and operate a wind-powered electrical generating facility on Horseshoe Shoal in Nantucket Sound, Massachusetts. In December 2001, the U.S. Army Corps of Engineers determined that an environmental impact statement was required for the Cape Wind Energy Project. First, a Notice of Intent to prepare the environmental impact statement was published in the Federal Register and other public notices were issued. The Notice of Intent was published on January 30, 2002. Public scoping meetings were held in Boston and West Yarmouth on March 6 and March 7, 2002, respectively. Existing relevant data was then collected and reviewed to address issues discussed during scoping. The U.S. Army Corps of Engineers Draft Environmental Impact Statement was made available for public review and comment in November 2004. The public comment period lasted 60 days, commencing with a notice of availability published in the Federal Register. Public comment meetings were held on Nantucket, Martha's Vineyard, Cape Cod, and in Boston.

Prior to the enactment of the Energy Policy Act of 2005, there was a lack of clear federal regulatory authority for alternative energy projects proposed to be sited on the Outer Continental Shelf. In the absence of such authority, prior to Energy Policy Act of 2005, the U.S. Army Corps of Engineers had been acting as the lead agency for National Environmental Policy Act evaluation of the proposed Cape Wind Energy Project. Following adoption of the Energy Policy Act, and the amendments to the Outer Continental Shelf Lands Act, the Department of the Interior was given authority for issuing leases, easements, or rights-of-way for alternative energy project activities on the Outer Continental Shelf.

During the fall of 2005, the Minerals Management Service reviewed the Cape Wind application to determine its adequacy and evaluated how to proceed with its own National Environmental Policy Act evaluation. It was determined that the regulations and requirements under which the Minerals Management Service would authorize the proposed action are substantially different than those under which the U.S. Army Corps of Engineers would have authorized the proposed action, and so it was determined that a new Draft Environmental Impact Statement would need to be prepared. To ensure there was an efficient and timely National Environmental Policy Act analysis, the Minerals Management Service considered, and borrowed where appropriate, certain portions of the U.S. Army Corps of

Engineers Draft Environmental Impact Statement for the proposed action. Minerals Management Service also treated public comments on the U.S. Army Corps of Engineers Draft Environmental Impact Statement as scoping comments in Minerals Management Service's preparation of this Draft Environmental Impact Statement. The Minerals Management Service determined that an independent contractor would need to be hired to assist in the preparation of the Draft Environmental Impact Statement. A Memorandum of Understanding was prepared and signed in the spring of 2006, between Cape Wind and the Minerals Management Service, to support the environmental impact statement preparation process using an independent contractor. The contractor was selected by the Minerals Management Service in May of 2006 and work commenced on preparing a Draft Environmental Impact Statement. On May 30, 2006, the Minerals Management Service published in the Federal Register its Notice of Intent to prepare an environmental impact statement. This Notice also served to announce the initiation of the written scoping process for the environmental impact statement, and invited other Federal, State, tribal and local governments to consider becoming cooperating agencies in the preparation of the environmental impact statement.

During the remainder of 2006 and into 2007, the contractor worked with the application materials, the U.S. Army Corps of Engineers Draft Environmental Impact Statement, and other relevant and existing information to prepare the Draft Environmental Impact Statement. During this timeframe, the applicant continued to perform studies and submit new information, as well as respond to requests for additional information that were identified by Minerals Management Service and the contractor as necessary in order to prepare the Draft Environmental Impact Statement.

On January 18, 2008, the Minerals Management Service published a notice in the Federal Register stating the availability of the Draft Environmental Impact Statement. The public comment period lasted 60 days (until March 20, 2008) and then was extended another 30 days to April 21, 2008 in order to provide the public with additional time to read the DEIS and comment. MMS received comments through its public connect website on its Web page at http://ocsconnect.mms.gov/pcs-public/, via emails, via oral or hard copy comments provided at the four public hearings (i.e., the Mattacheese Middle School in West Yarmouth, Massachusetts, the Nantucket High School, in Nantucket, Massachusetts, the Martha's Vineyard Regional High School, in Oak Bluffs, Massachusetts, and at the University of Massachusetts Boston Campus, in South Boston), and via hard copy comments mailed in. In all, more than 42,000 comments were received. All comments received were logged and addressed as appropriate and are included in this Final Environmental Impact Statement.

**Summary Description of Alternatives Assessed**

In order to conduct a comprehensive evaluation of reasonable alternative locations for an offshore wind energy facility that would be capable of serving the New England region, Minerals Management Service identified and initially screened nine alternative locations (in addition to the proposed location on Horseshoe Shoal) along the coast from Maine to Rhode Island. The sites were chosen based on geographic diversity, having at least some potential in terms of wind resources, and the necessary area required for the proposed facility size. In addition, in development of the alternatives, Minerals Management Service took into account comments received as a part of the scoping process. Specifically, the Phelps Bank Alternative was selected as a result of interest expressed in this location by the Massachusetts Office of Coastal Zone Management, and Offshore Nauset Alternative was chosen as a result of public interest in a deep water alternative.

These geographically diverse sites included:

- Offshore Portland, Maine
- Offshore Cape Ann, Massachusetts
- Offshore Boston, Massachusetts
- Offshore Nauset, Massachusetts (East of Nauset Beach)
- On Monomoy Shoals (east of Monomoy, Massachusetts)
- On Nantucket Shoals (southeast of Nantucket Island, Massachusetts)
- On Phelps Bank (southeast of Nantucket Island, Massachusetts)
- South of Tuckernuck Island
- East of Block Island, Rhode Island

Of these nine sites that were chosen as geographically diverse, seven sites were not selected for further environmental analysis because of physical limitations and/or constraints due to (1) water depth (should be < approximately 100 feet [30 meters] in depth to be considered economically feasible) (TRC, 2006); (2) extreme wave height (should be less than approximately 20 feet [6.1 meters] high in 50 feet [15.2 meters] of water depth); (3) presence of bedrock or large boulders (this is problematic both for installation of the monopiles and proper burial of electrical interconnection lines); (4) distance from site to onshore transmission system (should be less than approximately 31 miles [50 kilometers]) for an underground alternating current transmission line; high voltage direct current transmission cables have not yet been proven to be a commercially available technology for offshore wind farms); and (5) the availability of technology to develop the site (development of floating platform technology for use in water depths >150 feet [45 meters] is beyond the milestones scheduled for project development) (see Section 3.3.4).

The sites which were not assessed for further evaluation include the Portland, Maine; Cape Ann, Massachusetts; Boston, Massachusetts; Nauset, Massachusetts (East of Nauset Beach); on Nantucket Shoals (southeast of Nantucket Island, Massachusetts); on Phelps Bank (southeast of Nantucket Island, Massachusetts); and east of Block Island, Rhode Island sites. Out of the group of nine geographic sites, the alternative sites selected for further environmental analysis include Monomoy Shoals and South of Tuckernuck Island.

In addition to the sites screened above, Minerals Management Service also screened three non-geographic based alternatives to the proposed action to see if they could produce electricity at a reasonable cost range to that of the proposed action. These design alternatives included:

- Smaller Project (half the megawatt capacity of the Proposed Alternative at the same location);
- Condensed Array (same number of turbines but closer together); and
- Phased Development (two phases of 65 turbines each)

The No Action Alternative was also included in the screening process. The analysis of the No Action Alternative provides a benchmark for Minerals Management Service in which to compare the magnitude of environmental impacts of the proposed action. The No Action alternative considers other strategies for addressing the demand for electricity in New England if the proposed action were not constructed, and the viability of those strategies and or impacts associated with those other strategies. This includes an assessment of energy efficiency, and the assessment of other energy options including fossil fuel technologies, and other alternative energy technologies.

Figure 3.3.5-1 shows the locations of the proposed alternatives that passed the first phase of screening and were therefore subject to an environmental resource and impact assessment. They include the proposed action, No Action, South of Tuckernuck Island, Monomoy Shoals, Smaller Project, Condensed Array, and Phased Development.

The South of Tuckernuck Island Alternative Site is located in the Atlantic Ocean southwest of Tuckernuck Island between Muskeget Channel to the west and the southwestern coast of Nantucket Island to the east in open waters. The Monomoy Shoals alternative site is approximately 3.5 miles (5.6 kilometers) southeast of Monomoy Island within the eastern approach to Nantucket Sound. The Smaller Project Alternative (a total of 65 wind turbine generators) would have the same electric service platform location and transmission cable location as the proposed action, and would be in the same foot print as the proposed action, but 65 wind turbine generators at the north, south and east sides of the proposed action configuration would be removed. The Condensed Array Alternative would be located in the same area as the proposed action but the wind turbine generators would be spaced closer together in a grid with a separation distance of 6 turbine rotor diameters by 6 turbine rotor diameters versus the proposed action which has wind turbine generator spacing of 6 x 9 turbine rotor diameters. The Phased Development Alternative involves constructing the full electric service platform and one half of the 130 wind turbine generators first, and then the remainder of the wind turbine generators later after the first phase has been installed and had a chance to operate so that monitoring of operational impacts can take place.

**Principal Issues and Concerns**

A number of comments received on the Minerals Management Service Draft Environmental Impact Statement dealt with issues and concerns about how certain information was presented or analyses performed. Minerals Management Service has taken these comments and addressed them either internally or through requests to Cape Wind during development of the Minerals Management Service Final Environmental Impact Statement. This Final Environmental Impact Statement has addressed all comments to the extent they are applicable and necessary to reach conclusions as to the scope and extent of the proposed action characteristics and potential impacts.

**Impact Level Definitions**

Anticipated impacts to physical, biological, socioeconomic resources and land use, and navigation and transportation from the proposed action are categorized as negligible, minor, moderate, or major. These impact levels are used in the impact section of the Final Environmental Impact Statement to provide consistency in the assessment of environmental impacts and socioeconomic issues.

The impact levels for biological and physical resources are used for the analysis of water quality, air quality, marine and terrestrial mammals, marine and coastal birds, fish resources, sea turtles, coastal and seafloor habitats, archaeological resources, and areas of special concern (such as essential fish habitats, marine sanctuaries, parks, refuges, and reserves). The four impact levels are defined as follows:

**(1) Negligible**

- No measurable impacts.

**(2) Minor**

- Most impacts to the affected resource could be avoided with proper mitigation, or
- If impacts occur, the affected resource would recover completely without any mitigation once the impacting agent is eliminated.

**(3) Moderate**

- Impacts to the affected resource are unavoidable, and
- The viability of the affected resource is not threatened although some impacts may be irreversible, or
- The affected resource would recover completely if proper mitigation is applied during the life of the proposed action or proper remedial action is taken once the impacting agent is eliminated.

**(4) Major**

- Impacts to the affected resource are unavoidable, and
- The viability of the affected resource may be threatened, and
- The affected resource would not fully recover even if proper mitigation is applied during the life of the proposed action or remedial action is taken once the impacting agent is eliminated.

The impact levels for socioeconomic issues are used for the analysis of demography, employment, and regional income; land use, visual and infrastructure; fisheries; tourism and recreation; socio-cultural systems; and environmental justice. Although impact levels for direct physical impacts to archaeological resources use the definitions above, indirect visual impacts to archaeological resources are defined by the following criteria. The four impact levels are defined as follows:

**(1) Negligible**

- No measurable impacts.

**(2) Minor**

- Adverse impacts to the affected activity or community could be avoided with proper mitigation, or
- Impacts would not disrupt the normal or routine functions of the affected activity or community, or
- Once the impacting agent is eliminated, the affected activity or community would return to a condition with no measurable effects from the proposed action without any mitigation.

**(3) Moderate**

- Impacts to the affected activity or community are unavoidable, and
- Proper mitigation would reduce impacts substantially during the life of the proposed action, or
- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the proposed action, or
- Once the impacting agent is eliminated, the affected activity or community would return to a condition with no measurable effects from the proposed action if proper remedial action is taken.

**(4) Major**

- Impacts to the affected activity or community are unavoidable.
- Proper mitigation would reduce impacts somewhat during the life of the proposed action.
- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, and
- Once the impacting agent is eliminated, the affected activity or community may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

### Summary of Impacts

A summary of overall impacts organized by resources is provided in Table E-1 and a full presentation of impacts is located in Section 5.0. A description of mitigation measures under consideration can be found in Section 9.0.

### Supporting Reports

The Final Environmental Impact Statement draws directly from numerous technical and environmental reports (refer to the bibliography at Section 10.1) and also takes into consideration information in many more additional reports (refer to the bibliography in Section 10.3), as well as a substantial amount of other available scientific and technical information (refer to the bibliography in Section 10.2). Reports referenced in Section 10.1 are included directly following applicable sections of text, appearing as "(Report No.)" and include hyperlinks so that the reader of the electronic version can click on the report referenced in the text and immediately have access to the full referenced report (the CD copy of the Final Environmental Impact Statement contains the full text of all the reports referenced in this manner). In an effort to conserve paper and reduce the bulk of the Final Environmental Impact Statement, hard copies of the reports are not provided. The reports and Final Environmental Impact Statement are also available on the Minerals Management Service's web site at: http://www.mms.gov/offshore/AlternativeEnergy/CapeWind.htm, or the reports and Final Environmental Impact Statement can be obtained by calling either of the following contacts:

**For further information regarding this statement please contact:**

James F. Bennett
Chief, Branch of Environmental Assessment
Minerals Management Service
U.S. Department of the Interior
381 Elden Street
Mail Stop 4042
Herndon, VA 20170
Phone: 703-787-1656

**For further information regarding the project please contact:**

Office of Offshore Alternative Energy Program
Minerals Management Service
U.S. Department of the Interior
381 Elden Street
Mail Stop 4080
Herndon, VA 20170
Phone: 703-787-1300

Hard copies of the Final Environmental Impact Statement have also been sent to the following libraries:

- Edgartown Free Public Library
- Boston Public Library
- Hyannis Public Library
- Falmouth Public Library
- Eldredge Public Library
- Nantucket Atheneum

**Table E-1**

**Summary of Impacts**

| **Resource** | **Impacts** | |
|---|---|---|
| | ***Construction Impacts*** | ***Operation Impacts*** |
| **Regional Geologic Setting** | minor | minor |
| **Noise** | *Onshore:* minor<br>*Offshore:* minor<br>*Underwater:* minor | *Onshore:* negligible<br>*Offshore:* negligible<br>*Underwater:* negligible |
| **Oceanography** | *Currents:* negligible<br>*Waves:* negligible<br>*Salinity:* negligible<br>*Temperature:* negligible<br>*Sediment Transport:* minor<br>*Water depth/bathymetry:* minor | *Currents:* minor<br>*Waves:* negligible<br>*Salinity:* negligible<br>*Temperature:* negligible<br>*Sediment Transport:* minor<br>*Water depth/bathymetry:* minor |
| **Climate and Meteorology** | minor | negligible |
| **Air Quality** | *Public Health:* negligible<br>*Visibility:* negligible<br>*Emissions:* minor | *Public Health:* negligible<br>*Visibility:* negligible<br>*Emissions:* minor (beneficial to climate change) |
| **Water Quality** | minor | negligible (with the exception of spills) |
| **Electric and Magnetic Fields** | negligible | negligible |
| **Terrestrial Vegetation** | negligible to minor | negligible to minor |
| **Coastal and Intertidal Vegetation** | negligible to minor | negligible (negligible to minor for repairs, depending on location) |
| **Terrestrial and Coastal Faunas other than Birds** | negligible to minor | negligible (minor for migratory bats) |
| **Avifauna** | *Terrestrial Birds:*<br>Raptors - negligible<br>Passerines - minor<br>*Coastal Birds:* negligible to minor<br>*Marine Birds:* minor to moderate<br>Pelagic Species - minor<br>Waterfowl and Non-Pelagic Water Birds - moderate | *Terrestrial Birds:*<br>Raptors - negligible.<br>Passerines – minor to moderate.<br>*Coastal Birds:* negligible to moderate<br>*Marine Birds:* negligible to major<br>Pelagic Species - minor<br>Waterfowl and Non-Pelagic Water Birds - moderate |
| **Subtidal Offshore Resources** | *Soft-Bottom Benthic Invertebrate Communities:* minor<br>*Shellfish:* minor<br>*Meiofauna:* minor<br>*Plankton:* negligible | *Soft-Bottom Benthic Invertebrate Communities:* minor<br>*Shellfish:* minor<br>*Meiofauna:* minor<br>*Plankton:* minor |
| **Non-ESA Marine Mammals** | *Acoustical Harassment:* minor<br>*Vessel Strikes:* minor<br>*Vessel Harassment:* minor<br>*Temporary Reduced Habitat:* minor<br>*Turbidity:* negligible to moderate (due to pile driving)<br>*Pollution/ Potential Spills:* minor | *Acoustical Harassment:* negligible<br>*EMF:* negligible<br>*Pollution/ Potential Spills:* minor to moderate<br>*Vessel Strikes:* minor<br>*Vessel Harassment:* minor<br>*Fouling Communities:* negligible to minor |

**Table E-1**

**Summary of Impacts**

| **Resource** | **Impacts** | |
|---|---|---|
| | ***Construction Impacts*** | ***Operation Impacts*** |
| **Fisheries** | *Finfish:* minor<br>*Finfish (juveniles)*: minor<br>*Demersal Eggs and Larvae: minor*<br>*Commercial & Recreational Fishing/Gear:* minor | *Commercial & Recreational Fishing/Gear:* negligible to minor<br>*Sound and Vibration:* negligible to minor<br>*Vessel Traffic:* minor to moderate<br>*EMF:* negligible<br>*Lighting:* negligible/none<br>*Alterations to Waves, Currents, Circulation:* negligible<br>*Habitat Change:* minor<br>*Displacement of Prey:* none |
| **EFH** | *Benthic/Demersal:* minor<br>*Water Column:* negligible to minor<br>*SAV/Eelgrass:* negligible to minor | *Benthic/Demersal:* minor<br>*Water Column:* negligible to minor<br>*SAV/Eelgrass:* negligible to minor |
| **T&E** | *Sea turtles:* negligible to minor<br>*Cetaceans:* negligible to minor<br>*Avifauna:* negligible to minor<br>*Eastern Cottontail Rabbit:* negligible | *Sea Turtles:* negligible to minor<br>*Cetaceans:* negligible to minor<br>*Avifauna:* minor to moderate<br>*Eastern Cottontail Rabbit:* negligible |
| **Urban and Suburban Infrastructure** | negligible to minor | negligible |
| **Population and Economics** | minor | minor |
| **Environmental Justice** | Negligible (i.e., not a disproportionately high impact on minority or low income populations) | negligible (i.e., not a disproportionately high impact on minority or low income populations) |
| **Visual Resources** | minor | moderate Impacts on Shore (Major impacts on-water in close proximity to proposed action) |
| **Cultural Resources** | minor | Pending on the outcome of Section 106 process |
| **Recreation and Tourism** | minor | minor |
| **Competing Uses of Waters and Seabed** | minor | minor (except for impacts to Figawi Race which are moderate) |
| **Overland Transportation Arteries** | minor | negligible |
| **Airport Facilities and Aviation Traffic** | negligible to minor | minor |
| **Port Facilities and Vessel Traffic** | minor | *Ship, Container and Bulk Handling Facilities:* negligible<br>*Cruise Ship Traffic:* negligible<br>*Ferry Operations:* minor<br>*Marinas and Recreational Boating:* minor to moderate<br>*Commercial fishing:* minor to moderate<br>*Search and Rescue:* negligible<br>*Ice:* negligible |
| **Communications: Radar, EMF, Signals, and Beacons** | minor | minor (moderate for radar) |

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# ABBREVIATIONS, ACRONYMS, AND SYMBOLS

| | |
|---|---|
| °C | Degrees Celsius |
| °F | Degrees Fahrenheit |
| ACK | Nantucket Memorial Airport |
| AC | Alternating Current |
| ACEC | Area of Critical Environmental Concern |
| ADCP | Acoustic Doppler Current Profiler |
| ACHP | Advisory Council on Historic Preservation |
| Alliance | Alliance to Protect Nantucket Sound |
| AMPS | amperes |
| AMSL | Above Mean Sea Level |
| ANG | Massachusetts Air National Guard |
| APE | Area of Potential Effect |
| APPEs | Areas of Potential Physical Effects |
| ARNG | Massachusetts Army National Guard |
| ARPA | Archeological Resource Protection Act |
| ARTCC | Air route Traffic control Center |
| ASA | Applied Science Associates, Inc. |
| ASFMC | Atlantic States Marine Fisheries Commission |
| ATC | Air Traffic Control |
| ATON | Additional Aids-to-Navigation |
| BA | Biological Assessment |
| BACI | Before Action Control Impact |
| BIA | Bureau of Indian Affairs |
| BMPs | Best Management Practices |
| BO | Biological Opinion |
| BOS | Boston's Logan Airport |
| BVW | Bordering Vegetated Wetland |
| CAA | Clean Air Act |
| CCCA | Cape Cod Commission Act |
| CCCT | Combined Cycle Combustion Turbines |
| CEQ | Council on Environmental Quality |
| CERCLIS | Comprehensive Environmental Response Compensation and Liability Information System |
| CFR | Code of Federal Regulations |
| CGP | Construction General Permit |
| CI | Confidence Interval |
| C/I | Construction and Installation |
| CIOS | Cape and Islands Ocean Sanctuary |
| cm | Centimeters |
| CMR | Code of Massachusetts Regulations |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| CPA | Closest Point of Approach |
| CPT | Cone Penetrometer Testing |
| CWA | Clean Water Act |
| CZM | Coastal Zone Management |
| CZMA | Coastal Zone Management Act |

| | |
|---|---|
| CZMP | Coastal Zone Management Program |
| dB | Decibels |
| dBA | Decibels A-Weighted Scale |
| dBL | Decibels (Linear) |
| $dB_{ht}$ | Hearing Threshold Sound Level |
| DC | Direct Current |
| DCA | Washington D.C. Reagan National Airport |
| DO | Dissolved Oxygen |
| DOD | Department of Defense |
| DOE | Department of Energy |
| DOER | Massachusetts Division of Energy Resources |
| DOI | Department of the Interior |
| DPA | Designated Port Areas |
| DPW | Department of Public Works |
| draft EIS | Draft Environmental Impact Statement |
| draft EIR | Draft Environmental Impact Report |
| DRI | Development of Regional Impact |
| DPU | Department of Public Utilities |
| DWPC | Division of Water Pollution Control |
| EERE | Energy Efficiency and Renewable Energy |
| EEZ | Exclusive Economic Zone |
| EFH | Essential Fish Habitat |
| EFHA | Essential Fish Habitat Assessment |
| EFSB | Massachusetts Energy Facilities Siting Board |
| EIR | Environmental Impact Report |
| EIS | Environmental Impact Statement |
| ELF-EMF | Extremely Low Frequency Electromagnetic Fields |
| EMF | Electro Magnetic Field |
| EMF-RAPID | Electric and Magnetic Fields Research and Public Information Dissemination Program |
| ELMR | Estuarine Living Marine Resources |
| EMS | Environmental Management System |
| EOEA | Executive Office of Environmental Affairs |
| EPAct | Energy Policy Act of 2005 |
| EPRI | Electric Power Research Institute |
| ER-L | Effects Range-Low |
| ER-M | Effects Range-Median |
| ERP | Emergency Response Plan |
| ES | Electrical Services |
| ESA | Endangered Species Act |
| ESP | Electrical Service Platform |
| ESW | Extreme Storm Wave |
| ETF | Electric Transmission Facilities |
| EUIRA | Electric Utility Industry Restructuring Act |
| EWB | New Bedford Regional Airport |
| FAA | Federal Aviation Administration |
| FAD | Fish Attracting Devices |
| FCC | Federal Communications Commission |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| final EIR | Final Environmental Impact Report |

| | |
|---|---|
| FIRM | Flood Insurance Rate Map |
| FPM | Flashes Per Minute |
| FR | Federal Register |
| ft | Feet |
| $ft^2$ | Square Feet |
| $ft^3$ | Cubic Feet |
| ft/s | Feet per Second |
| G | Gauss |
| GE | General Electric |
| G&G | Geotechnical and Geophysical |
| GHG | Greenhouse Gas |
| GMI | Geo-Marine, Inc. |
| GPS | Global Positioning System |
| GSA | Geological Survey of Alabama |
| GW | Giga Watts |
| GWh | Gigawatt Hour |
| GWh/y | Gigawatt Hour per Year |
| HAB | Harmful Algal Bloom |
| HAPC | Habitat Areas of a Particular Concern |
| HAPs | Hazardous Air Pollutants |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| HDD | Horizontal Directional Drilling |
| HDPE | High Density Polyethylene |
| HF | High Frequency |
| HG | Mercury |
| Horns Rev | Horns Rev Offshore Wind Farm |
| HRGS | High Resolution Geophysical Survey |
| HSS | Horseshoe Shoal |
| HVDC | High Voltage Direct Current |
| HYA | Hyannis' Boardman-Polando Field |
| Hz | Hertz |
| IALA | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IARC | International Agency for Research on Cancer |
| IBA | Important Bird Area |
| IFR | Instrument Flight Rule |
| IHA | Incidental Harassment Authorization |
| ISO-NE | Independent System Operation New England |
| ITS | Incident Take Statement |
| KC | Keulagan-Carpenter |
| kcmil | Thousand Circular Mils |
| kg | Kilograms |
| kHz | Kilohertz |
| km | Kilometers |
| $km^2$ | Square Kilometers |
| km/h | Kilometers Per Hour |
| kV | Kilovolt |
| kV/m | Kilovolts per meter |
| kW | Kilowatts |
| kWhr | Kilowatt Hour |
| $L_{90}$ | The Level of Noise Exceeded for 90% of the Time |

| | |
|---|---|
| lbs | Pounds |
| $L_{dn}$ | Day-Night Sound Level |
| LEDs | Light-Emitting Diodes |
| LGA | New York LaGuardia Airport |
| $L_{eq}$ | Equivalent Continuous Noise Level |
| $L_{eq(24)}$ | 24-Hour Equivalent Sound Level |
| $L_{max}$ | Maximum Sound Level |
| LIPA | Long Island Power Authority |
| LNG | Liquefied Natural Gas |
| LOA's | Length Overall |
| LORAN | Long Range Navigation |
| LUWW | Land Under Waterbodies and Waterways |
| m | Meter |
| $m^2$ | Square Meters |
| $m^3$ | Cubic Meters |
| MAFMC | Mid-Atlantic Fishery Management Council |
| Magnuson-Stevens Act | Magnuson-Stevens Fishery Conservation and Management Act |
| MARMAP | Marine Resources Monitoring Assessment and Prediction Program |
| MAS | Massachusetts Audubon Society |
| MassDEP | Massachusetts Department of Environmental Protection |
| MassDEP-DWPC | Massachusetts Department of Environmental Protection-Division of Water Pollution Control |
| MassDMF | Massachusetts Division of Marine Fisheries |
| MassGIS | Massachusetts Geographic Information System |
| MassHighway | Massachusetts Highway Department |
| MATidal | Massachusetts Tidal Energy Company |
| MBUAR | Massachusetts Board of Underwater Archaeological Resources |
| MDCR | Massachusetts Department of Conservation and Recreation |
| MEPA | Massachusetts Environmental Policy Act |
| MESA | Massachusetts Endangered Species Act |
| mG | MilliGauss |
| mg/L | Milligrams Per Liter |
| M.G.L. | Massachusetts General Law |
| MHC | Massachusetts Historical Commission |
| MHD | Massachusetts Historic District |
| MHW | Mean High Water |
| MHz | Megahertz |
| MLLW | Mean Lower Low Water |
| $mm^2$ | Square Millimeters |
| mm | Millimeters |
| MMA | Massachusetts Maritime Academy |
| MMPA | Marine Mammal Protection Act |
| MMR | Massachusetts Military Reservation |
| MMS | Minerals Management Service |
| MOU | Memorandum of Understanding |
| mph | Miles Per Hour |
| MRA | Multiple Resource Area |
| MRFSS | Maine Recreational Fisheries Statistics Survey |
| m/s | Meters Per Second |
| MSA | Metropolitan Statistical Areas |

| | |
|---|---|
| MSD | Marine Sanitation Device |
| MSL | Mean Sea Level |
| MTC | Massachusetts Technology Collaborative |
| MVA | Megavolt amp |
| MW | Megawatt |
| NAAQS | National Ambient Air Quality Standards |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NCDC | National Climatic Data Center |
| NDA | No Discharge Areas |
| NEFMC | New England Fishery Management Council |
| NEFSC | New England Fisheries Science Center |
| NEISO | New England Independent System Operator |
| NEPA | National Environmental Policy Act of 1969 |
| NEPOOL | New England Power Pool |
| NGVD | National Geodetic Vertical Datum |
| NHL | National Historic Landmark |
| NHESP | Natural Heritage and Endangered Species Program |
| NHPA | National Historic Preservation Act |
| NIEHS | The National Institute of Environmental Health Sciences |
| NIH | National Institute of Health |
| NMFS | National Marines Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAA Fisheries Service | NOAA National Marines Fisheries Service |
| NOI | Notice of Intent |
| $NO_x$ | Nitrogen Oxides |
| NPC | Notice of Project Change |
| NPDES | National Pollutant Discharge Elimination System |
| NPL | National Priorities List |
| NRCS | National Resources Conservation Service |
| NRHP | National Register of Historic Places |
| NSA | Noise Sensitive Area |
| NTHP | National Trust for Historic Preservation |
| Nysted | Nysted Offshore Wind Farm |
| OCS | Outer Continental Shelf |
| OCSLA | Outer Continental Shelf Lands Act of 1953 |
| O&M | Operation & Maintenance |
| OPA | Oil Pollution Act of 1990 |
| OSA | Ocean Sanctuaries Act |
| OSI | Ocean Surveys, Inc. |
| OSHA | Occupational Safety and Health Administration |
| OSRP | Oil Spill Response Plan |
| OTEC | Ocean Thermal Energy Conversion |
| OWEC | Ocean Wave Energy Converter |
| PAL | Public Archaeological Laboratory |
| PCBs | Polycarbonate Biphenyls |
| PHL | Philadelphia, Pennsylvania |
| PM | Particulate Matter |
| PMSA | Primary Metropolitan Statistical Area |
| ppm | Parts Per Million |
| ppt | Parts Per Thousand |
| psi | Per Square Inch |

| | |
|---|---|
| PSP | Paralytic Shellfish Poisoning |
| PV | Photovoltaic |
| PVA | Population Viability Analysis |
| PVC | Polyvinyl Chloride |
| REC | Renewable Energy Credit |
| REIDC | Rhode Island Economic Development Corporation |
| RF | Radio Frequency |
| RGGI | Regional Greenhouse Gas Initiative |
| RIDOT | Rhode Island Department of Transportation |
| RIEDC | Rhode Island Economic Development Corporation |
| ROD | Record of Decision |
| ROI | Region of Impact |
| ROVs | Remote Operated Vehicles |
| ROW | Right-Of-Way |
| RPM | Revolutions Per Minute |
| RPP | Cape Cod Regional Policy Plan |
| RPS | Renewable Portfolio Standards |
| RSP05 | 2005 Regional System Plan |
| SAR | Search and Rescue |
| SAV | Submerged Aquatic Vegetation |
| SCADA | Supervisory Control and Data Acquisition |
| Seabees | U.S. Navy Construction Battalion |
| SHF | Super High Frequency |
| SHPO | State Historic Preservation Officer |
| SIP | State Implementation Plan |
| SMDS | Scientific Measurement Devises Station |
| $SO_2$ | Sulfur Dioxide |
| SPCC | Spill Prevention Control and Countermeasure |
| SSA | Steam Ship Authority |
| SSCS | Seabed Scour Control System |
| SWPPP | Storm Water Pollution Prevention Plan |
| T | Tesla |
| T&D | Transmission and Distribution |
| T&E | Threatened and Endangered |
| The Applicant | Cape Wind Associates, LLC |
| THPO | Tribal Historic Preservation Officer |
| TISEC | Tidal In-Stream Energy Conversion |
| TSS | Total Suspended Solids |
| TRACON | Terminal Radar Approach Control |
| TV | Television |
| TWh | Terawatt Hour |
| UHF | Ultra High Frequency |
| U.S. | United States |
| USACE | U.S. Army Corps of Engineers |
| USCG | U.S. Coast Guard |
| USDA | U.S. Department of Agriculture |
| USDOI | U.S. Department of the Interior |
| USEPA | U.S. Environmental Protection Agency |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| V | Volts |

| | |
|---|---|
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| Vibracores | Vibratory cores |
| V/m | Volts per meter |
| VOC | Volatile Organic Compounds |
| VP | Viewpoint |
| VTR | Vessel Trip Report |
| WAMS | Waterways Analysis and Management System |
| WARP | Wind Amplifier Rotor Platform |
| WEC | Wave Energy Conversion |
| WPA | Wetlands Protection Act |
| WPR | Yarmouth Wetlands Protection Regulations |
| WQC | Water Quality Certification |
| WTG | Wind Turbine Generators |
| WTGHA | Wampanoag Tribe of Gay Head/Aquinnah |
| XLPE | Cross-Linked Polyethylene |
| $yd^3$ | Cubic Yard |
| $\mu g/m^3$ | Micrograms Per Cubic Meter |
| µT | Microtesla |

# 1.0 INTRODUCTION

## 1.1 PURPOSE AND NEED

The underlying purpose and need to which the MMS is responding is to provide an alternative energy facility that utilizes the unique wind resources in waters offshore of New England using a technology that is currently available, technically feasible, and economically viable, that can interconnect with and deliver electricity to the New England Power Pool (NEPOOL), and make a substantial contribution to enhancing the region's electrical reliability and achieving the renewable energy requirements under the Massachusetts and regional renewable portfolio standards (RPS).

Cape Wind Associates, LLC (the applicant) proposes to build, operate, and eventually decommission a wind energy facility with a maximum electric output of 454 megawatts (MW) in Nantucket Sound off the coast of Massachusetts. The proposed action would generate electricity from wind energy resources on the Federal OCS. The applicant seeks to commence construction of the proposed action in 2009 and begin full operation in 2011.

The applicant requests a lease, easement, right-of-way (ROW) and any other related approvals from Minerals Management Service (MMS) necessary to authorize construction and operation of the proposed action. The MMS's authority to approve, deny, or modify the Cape Wind Energy Project derives from the Energy Policy Act of 2005 (EPAct – http://www.mms.gov/offshore/PDFs/hr6_textconfrept.pdf). Section 388 of the EPAct amended the OCS Lands Act by adding subsection 8(p), which authorizes the Department of the Interior (DOI) to grant leases, easements or ROWs on OCS lands for activities that produce or support production, transportation, or transmission of energy from sources other than oil and gas, such as wind power.

The Massachusetts and other regional RPSs mandate that a certain amount of electricity come from renewable energy sources, such as wind. Specifically, the Massachusetts RPS regulations at 225 CMR 14.00 require that all retail electricity providers in the state utilize new renewable energy sources for at least four percent of their power supply in 2009 and increasing this percentage by one percent each year until the Massachusetts Division of Energy Resources (DOER) suspends the annual increase.

Since 1995, the Massachusetts Energy Facilities Siting Board (EFSB) has authorized more than a dozen fossil fueled power plants with nominal generating capacities that range from approximately 200 MW to 1500 MW, with an average generating capacity of approximately 500 MW. The applicant seeks to construct a similar large size "commercial" scale project that would satisfy a substantial portion of the projected Massachusetts 2009 RPS requirements,[1] while also providing the generation capacity needed to respond to the magnitude of the regional reliability requirements.[2]

The NEPOOL operates as a tightly integrated system for purposes of both dispatch and compliance with reliability standards, including standards as to adequacy of generation resources. The Independent System Operation New England (ISO-NE) 2005 Regional System Plan (RSP05) for NEPOOL considered

[1] Based on the distribution of wind speeds monitored at the site, the net annual energy production the proposed action would deliver to the regional transmission grid would be 1,600 giga watt hours (GWh) (equivalent to an average of 182.6 MW), which would be approximately 75 percent of the 2009 projected RPS requirement of 2,100 GWh (2004, MA RPS Annual Compliance Report).

[2] NEISO conducted a system-wide analysis of energy demand and concluded that New England needs approximately 170 MW of additional electricity production resources before the summer of 2010 and increasing annually to 2100 MWs of additional capacity by 2014 to meet New England's electricity reliability requirements (ISO Regional System Plan, 2005).

the constraints upon potential energy imports into NEPOOL and found that in order to adequately supply operable capacity, New England will need to begin to supply its own resources and rely less heavily on neighboring systems for capacity during the 2009 through 2013 planning period (ISO-NE, 2005).

The EFSB found there was a need for at least 110 MW of energy resources beginning in 2007 with a much greater need within the following years (EFSB Siting Decision, 2004). The EFSB also found a need in New England for the capacity that would be provided by the proposed action for reliability and economic purposes.

The New England region is heavily dependent on natural gas to meet its increasing demand for energy. In New England natural gas accounts for 18 percent of the region's total energy consumption and approximately 40 percent of the fuel used to generate electricity, and consumption of natural gas is expected to increase 31.6 percent by 2024 (The Power Planning Committee of the New England Governor's Conference, 2005). In addition, more than 9,000 MW of planned gas-fired power plants are considered likely to be built in New York, Ontario, and Quebec, which would in turn compete with New England's limited gas supply and delivery infrastructure. The ISO-NE has stated that over-reliance on natural gas subjects the New England region to substantial price fluctuations that are influenced by a variety of market-based factors (i.e., exercising of natural gas contractual rights, tight gas spot-market trading), and physical factors (i.e., pipeline maintenance requirements and limited pipeline capacity). Over-reliance on natural gas and other fossil fuel sources (e.g., coal) for the generation of electricity also subjects the region to adverse air quality impacts associated with ground level ozone. There is, therefore, a need for projects in New England that aid in diversifying the region's energy mix in a manner that does not significantly contribute to the region's existing air quality concerns.

In summary, this final Environmental Impact Statement (final EIS) assesses the physical, biological and socioeconomic, and human impacts of this proposed action and all reasonable alternatives, including no action, in order to determine if the proposal is environmentally sound. A final decision would account for the regional, state and local benefits and impacts as well as for the overall public interest of the United States.

## 1.2 STATUTORY AND REGULATORY FRAMEWORK

The following information provides a discussion of Federal and State reviews required, including legal authority, jurisdiction of the agency, and the regulatory process involved. The information is also summarized in Table 1.2-1 (Tables are included in Appendix A). Cape Wind would be required by MMS to construct, operate and decommission the proposed action in compliance with the terms and conditions of required permits and approvals.

### 1.2.1 Federal Review

#### *1.2.1.1 Outer Continental Shelf Lands Act of 1953 (OCSLA) as Amended on August 8, 2005*

In November 2001, the applicant filed a permit application with the U.S. Army Corps of Engineers (USACE), New England District, under Section 10 of the Rivers and Harbors Act of 1899, in anticipation of constructing a wind energy facility located on Horseshoe Shoal in Nantucket Sound, Massachusetts. However, the EPAct[3] amended the OCSLA (67 Stat. 462, as amended, 43 U.S.C. §1331 et seq.) to grant primary authority to the DOI to authorize alternative energy projects on the OCS (43 U.S.C. 1337(p)(1)(C7)). The Secretary of the Interior has delegated primary responsibility for the environmental analysis and regulatory oversight of such projects, including the proposed action, to the MMS.

[3] Enacted on August 8, 2005.

In September 2005, the applicant requested from MMS a lease, easement, ROW and any other related approvals to construct and operate the proposed action located on Federal submerged lands offshore of Cape Cod, Massachusetts. This final EIS is prepared relevant to the authority granted to the Secretary of the Interior under Section 388 of the EPAct (Pub. L. 109-058) and in accordance with the National Environmental Policy Act of 1969 (NEPA).

#### *1.2.1.2 National Environmental Policy Act of 1969*

The NEPA of 1969 (42 U.S.C. 4321 et seq.) was implemented to ensure that Federal agencies consider the environmental impacts of their actions, and protect the quality of the environment through consideration of alternatives that would serve to avoid or minimize damage to the environment. The Council on Environmental Quality (CEQ) Regulations for implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508) state that Federal agencies shall integrate the NEPA process at the earliest possible time to ensure that the agency makes informed permitting decisions to avoid delays later in the process, and to head off potential conflicts.

The NEPA requires that Federal agencies produce detailed statements on the environmental impacts of proposed major Federal actions significantly affecting the quality of the human environment. On May 30, 2006, the MMS published a Notice of Intent (NOI) to prepare an EIS in the *Federal Register* (FR) requesting written scoping comments and inviting participation by cooperating agencies. As the lead agency in the NEPA process, the MMS is required to prepare the final EIS, accept public and agency comments, and produce a Record of Decision (ROD). Based on the findings of the NEPA documentation and other information, the MMS would determine whether to authorize the proposed action.

#### *1.2.1.3 Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of the Clean Water Act (CWA)*

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 401 *et seq*.) prohibits the unauthorized obstruction or alteration of any navigable water of the U.S. The construction of any structure in or over any navigable water of the U.S., the excavating from or depositing of dredged material or refuse in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful without prior approval from the USACE. The legislative authority to prevent inappropriate obstructions to navigations was extended to installations and devices located on the seabed to the seaward limit of the OCS by Section 4(e) of the OCSLA of 1953, as amended.

Section 404 of the CWA (33 U.S.C.§1344) prohibits discharges of dredge or fill material into waters of the United States, including wetlands without a permit from the USACE. Waters of the United States include those waters and their tributaries, adjacent wetlands, and other waters or wetlands where degradation or destruction could affect interstate or foreign commerce. Section 404 of the CWA defines the landward limit of jurisdiction as the high tide line in tidal waters and the ordinary high water mark as the limit in non-tidal waters. When adjacent wetlands are present, the limit of jurisdiction extends to the limit of the wetland. The seaward limit is the 3.5 mile (5.6 km) state limit.

The installation of the Wind Turbine Generators (WTGs) and ESP, the installation of the submarine cable systems, and the cable landfall transition structures would be subject to regulatory permitting review and approvals under Section 10 jurisdiction, because the proposed action would be located in designated navigable waters of the United States.

An Individual Permit application requesting Section 10 approval was filed on November 22, 2001, and the applicant provided the USACE with information with respect to project modifications on June 30, 2005. In addition, the applicant will be required to update the USACE application to reflect Section 404 jurisdiction, which would be triggered as a result of the backfilling of a dredged area in the ocean. The dredged area would be temporarily used for the horizontal directional drill operations associated with the installation of the submarine transmission cable where it comes ashore and then backfilled after construction is completed (see Section 2.3.6). Based on a recent decision by the New England Division, USACE, Section 404 jurisdiction is also now required to address impacts associated with jet plowing.

Note that in November 2001, the applicant filed an application with the USACE under the Rivers and Harbors Act of 1899 ("Section 10 Permit") to construct and operate a Scientific Measurement Devices Station (SMDS) in Nantucket Sound. The USACE issued a Section 10 Permit for the SMDS on August 19, 2002, stating that "the data tower shall be completely disassembled and removed from the waterway within five years of the start of construction." On August 3, 2006, the applicant requested that the USACE modify the condition in the Section 10 Permit to require the removal of the SMDS by October 31, 2012, and the USACE approved the time extension.

#### *1.2.1.4 Clean Water Act - National Pollutant Discharge Elimination System*

The U.S. Environmental Protection Agency (USEPA) is responsible for implementing certain provisions of the CWA regulations, 40 CFR Part 122 to 125. The CWA prohibits the discharge of pollutants into waters of the United States unless a National Pollutant Discharge Elimination System (NPDES) permit has been issued (33 U.S.C. § 1342). The NPDES storm water permit program requires operators of a construction site one acre or larger to obtain authorization to discharge storm water under a NPDES Construction Storm Water Permit. The overall goal of this permit is to protect the quality and beneficial uses of the surface water resources from pollution in storm water runoff from construction activities. This goal is achieved through the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP) and associated Best Management Practices (BMPs).

Installation of the proposed onshore transmission lines and associated components would require a NPDES General Stormwater Construction permit. The proposed onshore transmission line route is approximately 5.9 miles (9.5 kilometers [km]) in length and therefore construction activities would result in the alteration of more than one acre. A NPDES NOI for construction activities that includes general project information and certification that the activity would not impact endangered or threatened species would be submitted to the NPDES permitting authority. An application for a NPDES General Stormwater Construction Permit would be filed prior to commencement of construction.

#### *1.2.1.5 Section 7627 of the Clean Air Act (CAA)*

The USEPA is also responsible for implementing sections of the CAA (42 U.S.C. 7627) relating to air emissions from certain OCS activities. Section 7627 was added to the CAA by amendment in 1990 in order to establish requirements for controlling air emissions from "sources" on the OCS in order to attain and maintain Federal and State ambient air quality standards. The regulations of the USEPA under Section 7624 (40 CFR 55.1, et seq.) define an "OCS Source" subject to such provisions as any equipment, activity, or facility that: (1) emits or has the potential to emit any air pollutant; (2) is regulated under the OCSLA; and (3) is located on the OCS or in or on waters above the OCS. With respect to vessels, Section 55.2 of the Regulations specifies that vessels shall not constitute an "OCS Source" unless they are: (1) permanently or temporarily attached to the seabed and erected thereon and used for the purpose of exploring, developing or producing resources there; or (2) physically attached to an OCS facility. It further provides, however, that the emissions of vessels associated with an OCS Source shall be considered direct emissions of such a source while at the source, and while en route to or from the source when within 25 miles (40.2 km) of the source.

The applicant is seeking a permit from the USEPA under the foregoing provisions for its activities on the OCS during construction.

Section 55.4 of the USEPA regulations requires an applicant to submit an NOI to the USEPA, with copies to the air pollution control agencies of the nearest onshore areas adjacent, not more than 18 months prior to submitting an application for a preconstruction USEPA permit. The NOI information includes the facility description and estimates of potential emissions, and emissions from vessels associated with the proposed OCS Source when at or en route to or from the OCS Source, as referenced above. The applicant filed an NOI with the USEPA on December 7, 2007. The EPA will review the NOI and determine whether air modeling is required, and coordinate the establishment of an appropriate air quality modeling protocol as necessary.

#### *1.2.1.6 United States Code 49, Section 44718*

The Federal Aviation Administration's (FAA's) authority to promote the safe and efficient use of the navigable airspace, whether concerning existing or proposed structures, is predominantly derived from 49 U.S.C. 44718. Title 14, CFR, Part 77, Objects Affecting Navigable Airspace, was adopted to establish notice criteria for proposed construction or alteration that would protect aircraft from encountering unexpected structures. The regulations apply to structures located within any state, territory, or possession of the United States, within the District of Columbia, or within territorial waters (13.8 miles [22.2 km]) surrounding such states, territories, or possessions.

Any vertical structure greater than 200 feet (ft) (61 meters [m]) in height must have FAA approval to avoid or minimize obstruction to navigable air space. The height of individual WTGs would exceed this 200-foot threshold (overall height of 440 ft [134 m] mean sea level [MSL]), and therefore require FAA approved lighting/marking. All 130 WTGs are subject to FAA review and authorization. On September 25, 2002, the applicant filed a Notice of Proposed Construction or Alteration (FAA Form 7460-1) with the FAA, pursuant to 14 CFR Part 77, Objects Affecting Navigable Airspace, for each proposed WTG location. The FAA issued a Determination of No Hazard to Air Navigation on April 9, 2003 (Appendix B).

On August 27, 2004 the applicant requested an extension on the April 9, 2003 Determination due to delays in obtaining permits to start construction. The FAA granted the extensions on October 5, 2004. The FAA initiated an appeal of the original April 9, 2003 determinations based on their receipt of two petitions requesting discretionary review of the determinations. The FAA reviewed the new information submitted and upheld the original Determination of No Hazard on August 2, 2005 which expired on February 7, 2007. As a result of the reconfiguration of the WTG's, design changes that increased rotor height from 417 ft (127 m) to 440 ft (134 m), and the release of new lighting guidelines by the FAA, the applicant has submitted a request for a new Determination of No Hazard. The revised configuration was circulated as Aeronautical Studies #2006-ANE-1078-OE through 2006-ANE-1207-OE. FAA issued a public notice on April 25, 2007 and has stated that those determinations are pending. MMS has also requested a new letter from FAA to confirm that the proposed turbine locations would not have a negative impact on aviation. FAA provided a response to MMS in late summer 2008, indicating their evaluation is not complete (see Appendix B).

#### *1.2.1.7 U.S. Coast Guard (USCG) Regulations*

Pursuant to 33 CFR part 66.0, Subpart 66.01 and under the provisions of 46 U.S.C. and 33 U.S.C. 30, the USCG has safety and regulatory jurisdiction over projects located in navigable waters of the United States. The proposed action constitutes a fixed structure in navigable waters of the United States, which requires private aids to navigation marking. A permit application to establish and operate Private Aid-to-Navigation to a Fixed Structure has not yet been filed.

All 130 WTGs and the ESP are subject to USCG review for authorization to mark and light the WTGs and ESP. USCG Sector Southeastern New England (formally Marine Safety Office, Providence), which has jurisdiction over general navigation in the site of the proposed action, has coordinated a Navigational Risk Assessment. This Risk Assessment prepared at the direction of, and in consultation with, the USCG provides a qualitative assessment of navigational risks related to the proposed action. The analyses required by the USCG are outlined in a letter to the USACE dated February 10, 2003 (Appendix B). Subsequent to the release of the USACE draft EIS/draft Environmental Impact Report (draft EIR) in November of 2004, the applicant was required to revise the 2003 Navigational Risk Assessment to incorporate design changes and new information and to address topics requested by the USCG in its letter of February 14, 2005. In addition, several more recent radar impact studies have been undertaken that has resulted in the development of additional navigation safety impact mitigation measures by the applicant, as well as the USCG (see Section 9.0).

#### 1.2.1.8 USCG Reauthorization Act of 2006

Section 414(a) of the Coast Guard and Maritime Transportation Act of 2006 (Public Law 109-241, H.R. 5681) requires the Commandant of the Coast Guard to "not later than 60 days before the date established by the Secretary of the Interior for publication of a draft environmental impact statement... specify the reasonable terms and conditions… necessary to provide for navigational safety with respect to the proposed lease, easement, or ROW and each alternative to the proposed lease, easement, or ROW considered by the Secretary (of the Interior)." The USCG has provided terms and conditions (see Appendix B) in response to this Congressional mandate. The terms and conditions are considered by the Coast Guard to be reasonable and the minimum necessary to provide for navigational safety. The provision of the terms and conditions to MMS does not imply or indicate that the Coast Guard summarily approves or disapproves of the proposed action. The USCG also provided responses to comments on navigation.

#### 1.2.1.9 Executive Order 12898

The USEPA Headquarters Office of Environmental Justice defines environmental justice as the following:

> *"Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies."* (Executive Order 12898, February 11, 1994)

The need to perform an environmental justice analysis for the proposed action is related to the establishment of Executive Order 12898, entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations" (February 11, 1994). The order requires Federal agencies to consider disproportionate adverse human health and environmental impacts on minority and low-income populations.

The focus of an environmental justice analysis is the determination of whether the construction and operation of a proposed action would have both adverse and disproportionate impacts on minority and low income populations. Minority populations are generally defined by USEPA as areas that have a "meaningfully greater" percent of minorities than the general population in the surrounding area, and low income populations are defined based on the U.S. Census poverty statistics. In performing the environmental justice analysis, the MMS has used the methodology in USEPA's "Final Guidance for Incorporating Environmental Justice Concerns in USEPA's NEPA Compliance Analyses, April 1998."

Refer to the results of the Environmental Justice Review that are provided in the Socioeconomic section at 5.3.3.3. Information on agency consultations is provided in Section 7.0.

### 1.2.1.10 Coastal Zone Management Act Federal Consistency Review

Pursuant to 16 USC 1454 and 1465, the Coastal Zone Management Act (CZMA) requires that it be national policy to preserve, protect, develop, and where possible, to restore or enhance, the resources of the nation's coastal zone. The mapped coastal zone of Massachusetts includes the lands and waters within an area defined by the seaward boundary of the state's mapped territorial sea (generally 3.5 miles [5.6 km] from shore), extending from the Massachusetts/New Hampshire border south to the Massachusetts/Rhode Island border, and landward to 100 ft (30.5 m) inland of specified major roads, rail lines, or other visible ROWs. The coastal zone includes all of Cape Cod, Martha's Vineyard and Nantucket. Federal consistency jurisdiction extends to any federally licensed or permitted activities occurring in the OCS that may have a reasonably foreseeable effect on land or water uses or natural resources of the Massachusetts coastal zone (15 CFR 930.11(b)). The applicant filed with the Massachusetts Executive Office of Environmental Affairs, Coastal Zone Management Program for a Federal Consistency Certification on July 23, 2008. The Rhode Island Coastal Resources Management Council requested that the applicant file for Federal Consistency Certification in Rhode Island to address work associated with the staging area in Quonset and any transportation of equipment that takes place in Rhode Island waters. The applicant filed the Rhode Island consistency statement and on July 30, 2008, the Rhode Island Coastal Resources management council sent notification that it concurred with the determination that the proposed action was consistent with its federally approved management program. MMS will process the Cape Wind Energy Project under the Coastal Zone Management Act implementing regulations 15 CFR part 930 subpart D - Consistency for Activities Requiring a Federal License or Permit. As such, MMS would not be able to grant the proposed lease, license, or permit until 1) the effected States concur with the applicant's Consistency Certification (CC), 2) concurrence by the States is conclusively presumed (if no State objection within 6 months of State receipt of the CC), or 3) the applicant would successfully appeal any objection to the Secretary of Commerce.

### 1.2.1.11 Oil Pollution Act of 1990

The Oil Pollution Act of 1990 (OPA) (33 U.S.C. 2701 to 2761) amended the CWA and addressed the wide range of problems associated with preventing, responding to, and paying for oil pollution incidents in navigable waters of the United States. It created a comprehensive prevention, response, liability, and compensation regime to deal with vessel- and facility-caused oil pollution to U.S. navigable waters. The OPA greatly increased federal oversight of maritime oil transportation, while providing greater environmental safeguards by: setting new requirements for vessel construction and crew licensing and manning, mandating contingency planning, enhancing federal response capability, broadening enforcement authority, increasing penalties, creating new research and development programs, increasing potential liabilities, and significantly broadening financial responsibility requirements. The OPA requires oil storage facilities and vessels submit to the authorizing Federal agency, plans detailing how they will respond to their worst case discharge. The OPA also requires the development of Area Contingency Plans to prepare and plan for oil spill response on a regional scale.

The Oil Spill Response Plan must also comply with the MMS regulations at 30 CFR 254, "Oil Spill Response Requirements for Facilities Located Seaward of the Coastline." These regulations require owners/operators of oil handling, storage, or transportation facilities located seaward of the coastline to submit a spill response plan to MMS for approval prior to facility operation.

### 1.2.1.12 Endangered Species Act (ESA)

The Endangered Species Act of 1973 defines "endangered" as "any species which is in danger of extinction throughout all or a significant portion of its range." "Threatened" is defined as "any species which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range." Section 7 of the ESA (P.L. 93-205, 16 U.S.C. 1531 et seq.) directs all federal agencies to use their existing authorities to conserve threatened and endangered (T&E) species and, in consultation with the United States Fish & Wildlife Service , a branch of the Department of the Interior, and NOAA Fisheries Service (NOAA Fisheries) (formerly the National Marine Fisheries Service), found in the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), to ensure that their actions do not jeopardize listed species or destroy or adversely modify critical habitat. Section 7(a) of the Endangered Species Act requires that Federal agencies ensure that activities they authorize, fund or carry out do not jeopardize the continued existence of listed species nor adversely modify any designated critical habitat of such species.

Any takings of marine mammals listed as threatened or endangered under the ESA must be authorized under both the ESA and the Marine Mammal Protection Act (MMPA). The ESA takes are authorized by either an Incidental Take Statement (ITS) under Section 7 (for Federal agency actions) or a Section 10 permit (for private citizens). If the USFWS or NOAA Fisheries determines an action is likely to adversely affect a species (this would include any taking actions under the MMPA), formal consultation is required. The Federal action agency prepares a Biological Assessment (BA) to present the analysis of the project to USFWS and NOAA Fisheries. USFWS and NOAA Fisheries then use the BA and any other information they deem necessary to prepare a "Biological Opinion" (BO) which assesses whether the action is likely to jeopardize the existence of the species. The BO may include binding and/or discretionary recommendations to reduce impact. An ITS is a component of the BO, and it is this statement which allows the incidental take.

In regards to the proposed action, MMS has been in informal consultation under Section 7(a)(2) of the ESA with both the FWS and NMFS since January 2006 and has been in formal consultation since May 2008 when the BA was issued.

#### *1.2.1.13 The Marine Mammal Protection Act (MMPA)*

The MMPA of 1972 protects all marine mammals. The primary government agency responsible for enforcing the MMPA is NOAA Fisheries. Under the MMPA, the Secretary of Commerce is responsible for ensuring the protection of cetaceans (whales, porpoises, and dolphins) and pinnipeds (seals and sea lions) except walruses. The Secretary of the Interior is responsible for ensuring the protection of sea otters, polar bears, walruses, and manatees.

Section 101(a)(5) (A-D) of the MMPA prohibits, with certain exceptions, the taking of marine mammals in United States waters and on the high seas, and the importation of marine mammals and marine mammal products into the U.S. Congress defines "take" as "harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal." In 1986, Congress amended both the MMPA, under the incidental take program, and the ESA to authorize takings of depleted (and endangered or threatened) marine mammals, again provided the taking (lethal, injurious, or harassment) was small in number and had a negligible impact on marine mammals. In 1994, MMPA section 101(a)(5) was further amended to establish an expedited process by which citizens of the U.S. can apply for an authorization to incidentally take small numbers of marine mammals by "harassment", referred to as Incidental Harassment Authorizations or IHAs.

Harassment, injury or mortality may be authorized through the Small Take Authorization Program if: the total taking will: occur in a specified geographical area; have a negligible impact on the species or stock; be small in number; and would not have an adverse impact on Arctic subsistence users.

MMS has been informally consulting with NOAA Fisheries regarding the applicant's proposal since January 2006 and has been in formal consultations since May 2008 when the BA was issued. This has included individual phone calls and emails between MMS and NOAA Fisheries.

The applicant has informed MMS that it intends to seek authorization from NOAA Fisheries under the MMPA. Therefore, MMS will require that the MMPA authorization be completed and a copy provided to MMS before activities are allowed to commence under any MMS issued lease or other authority that may result in the taking of marine mammals.

#### *1.2.1.14 The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act)*

The purposes of the Magnuson-Stevens Act (P.L. 94-265, 16 U.S.C. 1801 et seq.) are to conserve and manage the fishery resources off the U.S. coasts; manage the U.S. anadromous species and continental shelf fishery resources; support the implementation and enforcement of international fishery agreements for the conservation and management of highly migratory species; promote domestic commercial and recreational fishing under sound conservation and management principles; provide for preparation and implementation of fishery management plans to achieve and maintain the optimum yield of each fishery on a continuing basis; establish Regional Fishery Management Councils to protect fishery resources through preparation, monitoring, and revision of plans that allow for participation of states, fishing industry, consumer and environmental organizations; encourage the development of underutilized U.S. fisheries; and promote the protection of essential fish habitat (EFH). To promote the protection of EFH, Federal agencies are required to consult on activities that may adversely affect designated EFH. The responsible agency is NOAA Fisheries, Department of Commerce. This assessment includes a list and description of species with designated habitat, potential impacts to those species and their habitat, and proposed mitigation.

#### *1.2.1.15 Migratory Bird Treaty Act and Migratory Bird Executive Order 13186*

The Migratory Bird Treaty Act (16 U.S.C. 703-712) is a domestic law that implements the United States' commitment to international conventions with Canada (1916), Mexico (1936), Japan (1972) and Russia (1978) for protection of shared migratory bird resources (USFWS, 2002). The Act prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the Act has no provision for allowing an unauthorized take, it must be recognized that some birds may be killed at structures such as wind turbines even if all reasonable measures to avoid it are implemented. The USFWS Office of Law Enforcement carries out its mission to protect migratory birds through investigations and enforcement, and also through fostering relationships with individuals and industries that proactively seek to eliminate their impacts on migratory birds. While it is not possible under the Act to absolve individuals, companies, or agencies from liability if they follow recommended interim guidelines established by USFWS, May 13, 2003, the Office of Law Enforcement and Department of Justice have used enforcement and prosecutorial discretion in the past regarding individuals, companies, or agencies who have made good faith efforts to avoid the take of migratory birds.

Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds", was issued in 2001 and is designed to create a more comprehensive strategy for migratory bird conservation by the Federal government (USFWS, 2007). The Executive Order provides a specific framework for the Federal government's compliance with treaty obligations to Canada, Mexico, Japan, and Russia.

Executive Order 13186 requires any Federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations to develop and implement, within two years, a Memorandum of Understanding (MOU) with the USFWS that shall promote the conservation of migratory bird populations. The MOU shall support the conservation of migratory birds through integrating bird conservation principles, measures and practices into agency activities and by avoiding or minimizing the impacts of activities to migratory birds. In addition, it shall restore and enhance the habitat of migratory birds, as practical; prevent or minimize the pollution or destruction of the environment for the benefit of migratory birds; design migratory bird habitat and population conservation principles, measures and practices into agency plans and planning processes; ensure environmental analyses of Federal actions or other environmental review processes; evaluate the effects of actions on migratory birds; and promote research and information exchange related to the conservation of migratory birds. Even before completion of a MOU Federal agencies are encouraged to immediately begin implementing migratory bird conservation measures.

The USFWS would lead coordination and implementation of the Executive Order and the Act and provide training opportunities to other Executive Branch agencies and departments. An interagency Council for the Conservation of Migratory Birds would monitor and oversee progress in the implementation of the Executive Order. The Council is to include representation, at the bureau director/administrator level, from the Departments of the Interior, State, Commerce, Agriculture, Transportation, Energy, Defense, USEPA, and from such other agencies as appropriate.

#### *1.2.1.16 National Historic Preservation Act (NHPA)*

The goal of the NHPA (P.L. 89-665, 16 U.S.C. 470, et seq.), established in 1966, is to have federal agencies act as responsible stewards of our nation's resources when their actions affect historic properties. Section 106 of the NHPA requires federal agencies, including MMS, to take into account the effects of their undertakings (including the issuance of leases) on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. Historic properties include districts, sites (both prehistoric and historic), buildings, structures, and objects that are included in or eligible for inclusion in the National Register of Historic Places.

After reviewing and evaluating the comments received on the draft EIS, MMS initiated formal consultation and held meetings on July 23, 2008 and September 8 an 9, 2008, under Section 106 of the National Historic Preservation Act with the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officers of the federally recognized Wampanoag tribes of Mashpee and Aquinnah, the ACOE, the National Trust for Historic Preservation, local governmental agencies, and other interested parties pursuant to the regulations at 36 CFR 800. MMS is not utilizing 36 CFR 800.8 for conducting formal consultations under Section 106 concurrently with NEPA, but rather is pursuing the consultation independently. Because it was determined that National Historic Landmarks (i.e., the Kennedy Compound and the Nantucket Historic District) may suffer adverse visual effects from the proposed project, the Advisory Council for Historic Preservation and the National Park Service (representing the Secretary of Interior) were also invited to consult. Further details on the 106 consultation process are provided in Section 7.0 of this final EIS.

### 1.2.2 State Regulatory Permitting and Consistency

#### *1.2.2.1 Massachusetts Environmental Policy Act (MEPA)*

The MEPA (G.L.c.30 §§ 61 through 62H, 301 CMR 11.00) jurisdiction occurs when an entity undertakes certain activities in the Commonwealth of Massachusetts that requires one or more State permits but does not involve financial assistance. The scope of an Environmental Impact Report (EIR) document, if required, is generally limited to those aspects within the subject matter of any required State permits that are likely, directly or indirectly, to cause damage to the environment. The MEPA review process includes an alternative analysis, environmental impact assessments, analyses of consistency with applicable state regulations and policies, and implementation of appropriate mitigation measures.

The applicant filed an Environmental Notification Form with the MEPA Office on November 15, 2001. The Secretary of Environmental Affairs issued an ENF Certificate on April 22, 2002 calling for an EIR and defining the scope of the required EIR. On May 28, 2003, the Secretary expanded the Scope of the April 22, 2002 EIR requirements to include Chapter 91 variance considerations and the Massachusetts Ocean Management Initiative. The applicant filed a draft EIR with the MEPA Office on November 15, 2004. The Secretary issued a DEIR Certificate on March 3, 2005 calling for a Notice of Project Change (NPC) and a final EIR, defining the scope of the required final EIR (Appendix B).

A NPC was filed with the MEPA office on June 30, 2005. The change involved the relocation of turbines from state waters to Federal waters due to changes in the state territorial 3.5 mile (5.6-km) limits. The effect of the boundary change expanded the 3.5 mile (5.6 km) state territorial boundary further into Nantucket Sound, resulting in 10 proposed turbine locations and an additional 1 mile (1.6 km) of 115 kV submarine cable system falling within the new boundary. MEPA issued a Certificate on the NPC on August 8, 2005. A Final EIR was filed with MEPA on February 15, 2007 and on March 29, 2007 the FEIR Certificate was issued inclusive of Section 61 findings that provide for Project mitigation (see Appendix B).

It should be noted that Massachusetts recently passed the Oceans Act, which requires the Secretary of Energy and Environmental Affairs to develop a comprehensive ocean management plan, following a scientific and stakeholder process that leads to a draft plan by summer of 2009, and the final promulgation of the plan by December 31, 2009. As the plan has not yet been drafted, it would not be applicable to the proposed action.

#### *1.2.2.2 Energy Facility Siting Board (EFSB) Review*

The EFSB is an independent state review board within the Department of Public Utilities (DPU). The EFSB reviews proposals to construct certain energy facilities, including large power plants, electric transmission lines, and natural gas pipelines. Pursuant to G.L. Chapter 164, § 69J and the regulations at 980 CMR 1.00, 2.00, 6.00, and 9.00, no applicant shall commence construction of a "facility" unless a petition for approval of construction has been granted by the EFSB. Pursuant to G.L. Chapter 164, § 69G, a jurisdictional "facility" includes "a new electric transmission line having a design rating of 69 kV or more and which is one mile or more in length on a new transmission corridor."

In accordance with G.L. c. 164, § 69H, the EFSB is responsible for implementing energy policies to provide a reliable energy supply for the Commonwealth with a minimum impact on the environment at the lowest possible cost. When reviewing proposals to construct electric transmission lines, the EFSB is required to consider several things. First, it must evaluate the need for new transmission resources. Second, it must consider whether activities will be consistent with the enforceable policies of Massachusetts coastal management plan.

The applicant and Commonwealth Electric Company d/b/a NSTAR Electric filed a joint Petition to the EFSB, on September 17, 2002, for an approval of construction for a new electric transmission line located within the mapped 3.5 mile (5.6 km) state territorial sea boundary. The Petition was for electric transmission lines to serve the public interest by transmitting wind-generated alternative energy to the Commonwealth of Massachusetts and New England from the offshore proposed action located in Federal waters in Nantucket Sound. The Petition sought approval for construction of the two jurisdictional 115 kV transmission lines approximately 18 mile (29 km) and 12.5 mile (20.1 km) within the Massachusetts Coastal Zone in length in order to transmit the generated electricity to the New England transmission grid.

In their May 11, 2005 Final Decision[4], the EFSB approved the joint petition of the applicant and NSTAR Electric to construct two new 115 kV electric transmission lines, approximately 18 mile (29 km) in length, for the purpose of interconnecting a proposed offshore wind energy generating facility in Nantucket Sound with the regional electric grid in New England. This decision was upheld on appeal in December 2006.

In addition to the above approval, the applicant filed a petition on November 19, 2007 with the Massachusetts EFSB a request a three year extension of the commencement of construction date and, pursuant to G.L. c. 164 § 72, a determination that the transmission line was necessary, would serve the public convenience and would be consistent with the public interest. Approval of the section 72 request was granted on May 2, 2008.

#### *1.2.2.3 Massachusetts Chapter 91 Waterways Regulations*

The Massachusetts Department of Environmental Protection (MassDEP) requires written authorization in the form of a license or permit to perform any construction, placement, excavation, addition, improvement, maintenance or removal of any fill or structures in tidelands or other waterways of the Commonwealth. The geographic areas subject to Chapter 91 jurisdiction include certain filled tidelands, flowed tidelands, and submerged lands out to the mapped, 3.5 mile (5.6 km) state territorial sea boundary.

In Chapter 91, the Massachusetts Waterfront Act (G.L. c. 91, 310 CMR 9.00), the Legislature specified its intention to protect the rights of the public in tidelands by ensuring that the uses and activities of tidelands are limited to water-dependent uses or otherwise serve a proper public purpose. The basic goals of the Waterways Program administered by MassDEP include protecting and promoting tidelands for fishing, shipping, marine transportation, infrastructure facilities, marine terminals, and other activities and facilities that cannot reasonably be located away from tidal or inland waters.

Chapter 91 jurisdiction applies to the proposed action relative to the installation and construction of the proposed submarine transmission cables located in and over the submerged lands and flowed tidelands of the Commonwealth in Lewis Bay and Nantucket Sound, as well as the intertidal shoreline area of Lewis Bay at the proposed cable landfall location in the Town of Yarmouth. These cables are located within the Massachusetts Cape and Islands Ocean Sanctuary (CIOS). The applicant filed a Chapter 91 Waterways License application on October 6, 2008.

#### *1.2.2.4 Massachusetts Water Quality Certification (WQC) Regulations*

The MassDEP requires that any dredging or dredged material disposal of more than 100 cubic yards ($yd^3$) must obtain a WQC pursuant to 314 CMR 9.04(12) and is subject to the criteria at 314 CMR 9.07 and the requirements at 314 CMR 4.00 (314 CMR 4.00 and 314 CMR 9.00 are adopted pursuant to § 27 of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53).

The transition of the interconnecting 115 kV submarine transmission lines from water to land would be accomplished through the use of horizontal directional drilling (HDD) methodology. To facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes. The cofferdam would be approximately 65 ft (20 m) wide and 45 ft (14 m) long and would be open at the seaward end to allow for manipulation of the HDD conduits. Approximately 840 $yd^3$ of sediment would be dredged from within the cofferdam pit temporarily and replaced upon completion of the submarine cable system. No removal of sediment outside of the cofferdam would be required. This dredging and backfilling

[4] The Final Decision can be downloaded from the DPU’s website at http://www.mass.gov/dte/siting_board.htm.

component would be subject to a 401 Water Quality Certificate. In addition, a Section 401 Water Quality Certificate would also be required for the jet plow embedment of the submarine cable. A 401 WQC application was filed with the MassDEP on November 2, 2007 and was issued on August 15, 2008.

#### *1.2.2.5 Massachusetts Highway Department (MassHighway) Access Agreements and Massachusetts General Law (M.G.L.) Chapter 30, Section 61 Findings*

The MassHighway primary responsibilities are the design, construction, and maintenance of the Commonwealth's state highways and bridges. The MassHighway jurisdiction would apply to the installation of the onshore transmission line route via trenchless technologies (i.e., HDD, horizontal boring, or pipe jacking) under the State highways Route 28 and Route 6. In addition, the applicant would require MassHighway access agreements for maintenance access to the onshore cable system occurring within state highway ROWs.

The applicant is required to file a Permit to Access State Highway from the MassHighway. Engineering plans and specifications must show that there is safe and efficient access to the state highways thereby protecting the operational integrity of these roadways. Plan review and approval are based on the standards presented in the Manual on Uniform Traffic Control Devices, and any technical policies issued by MassHighway. The applicant must also receive the M.G.L. Chapter 30, Section 61 findings of MassHighway. The applicant filed for an Application for a Permit to Access State Highway on November 1, 2007 and was approved July 22, 2008.

#### *1.2.2.6 M.G.L c. 9 § 27C and Chapter 254 of the Acts of 1988, Per Regulations at 950 CMR 70.00 and 71.00*

The Massachusetts Historical Commission (MHC) was established by legislature in 1963 to identify, evaluate, and protect the historical and archaeological assets of the Commonwealth and maintain the State Register of Historic Places. The MHC contains 18 members appointed by the Governor and the Secretary of State. The Secretary of State serves as the MHC chair and appoints the State Archaeologist, who issues permits for onshore archaeological field investigations. The Massachusetts Board of Underwater Archaeological Resources (MBUAR), part of the Executive Office of Environmental Affairs (EOEA), issues permits for underwater archaeological investigations in state waters. These entities ensure field investigations are conducted to applicable standards. The MHC contains the office of the SHPO, who is designated by the Federal Secretary of the Interior to implement Section 106 of the NHPA, as amended. The SHPO nominates significant historic resources in Massachusetts to the NRHP, and reviews Federal projects for their impact on historic properties, in accordance with Section 106 and the Federal regulations of the ACHP.

The MHC provides comments to EOEA, under M.G.L c. 9 § 27C and Chapter 254 of the Acts of 1988, per regulations at 950 CMR 70.00 and 71.00. The MHC advises EOEA as to the presence or absence of significant archaeological or historic resources that could be affected within the state territorial boundaries, and, if those effects are determined to be adverse, would comment on measures to avoid, minimize and/or mitigate those effects. The MHC has been invited to participate as a cooperating agency in the preparation of this EIS and is a consulting agency in the NHPA process (Refer to Section 7.2 for further information).

#### *1.2.2.7 Section 1856 of the Magnuson-Stevens Act*

Massachusetts Division of Marine Fisheries (MassDMF) is primarily responsible for the protection and enhancement of the Commonwealth's marine fishery resources and for the promotion and regulation of commercial and sport fishing. In addition, for the exclusive purpose of managing highly migratory and OCS fishery resources, state regulatory jurisdiction extends to that part of the pocket of water west of the seventieth meridian west of Greenwich in Nantucket Sound necessary to establish consistent fishing regulations throughout the Sound.

During the MEPA Review Process, the MassDMF performed an analysis of proposed action effects on existing fisheries resources. In addition, MassDMF also reviewed and considered potential effects of the proposed action on highly migratory and/or OCS fishery resources.

The proposed action area is designated as EFH for several fishery resources. An EFH assessment has been completed to address the requirements of the Magnuson-Stevens Act. In addition, MassDMF had the opportunity to participate and comment on the EFH Assessment process under the MMS NEPA process.

#### *1.2.2.8 302 CMR 5.00 and M.G.L. c. 132A, §§ 13, 16 and 18*

The Massachusetts Department of Conservation and Recreation (MDCR) is responsible for the protection of the ecology and appearance of the waters in the five (5) state-designated ocean sanctuaries (out to the mapped 3.5 mile state territorial sea boundary) pursuant to 302 CMR 5.00 and M.G.L. c. 132A, §§ 13, 16 and 18. Portions of Nantucket Sound are located within the CIOS.

The WTG array, inner-array cables and ESP would be located outside of MDCR's Ocean Sanctuaries' jurisdiction. However, portions of the submarine cable connecting the ESP to the landfall would be within the CIOS.

No separate permit or authorization is required by the Ocean Sanctuaries Act (OSA); rather the provisions of the OSA are implemented by the state agencies with permitting authority for a project subject to the OSA, for example, the EFSB, MassDEP (Chapter 91) and the Massachusetts CZMP review process. A transmission line is a permitted use in an Ocean Sanctuary if approved by the EFSB pursuant to the OSA at c.132A §16 and 3.02 CMR 5.08(3).

#### *1.2.2.9 Interconnection Approval by ISO-NE*

In New England, the connection of a bulk power generation system into the electricity grid requires a System Impact Study to assess the impact on functionality and reliability of the grid electric system and to assess what if any improvements need to be made to the electric system to safely accommodate the proposed action. On April 2, 2002, the applicant entered into a System Impact Study Agreement with ISO-NE, the independent operator of New England's bulk power generation and transmission system. On October 6, 2005, ISO-NE approved the applicant's application for interconnection pursuant to Section I.3.9 of ISO-NE Transmission, Markets and Services Tariff. The applicant, by letter dated June 19, 2006, requested that ISO-NE revise the projected Commercial Operation Date and Initial Synchronization Date for the Cape Wind Project. On November 9, 2006, the ISO-NE granted the applicant's request to revise the Commercial Operation Date of the Cape Wind Project to November 2010 and the Initial Synchronization Date to June 2009.

#### *1.2.2.10 Compliance with 1997 Electric Utility Industry Restructuring Act (EUIRA)*

The EUIRA at Section 50, codified at G.L. c. 25A §11F, introduced a State RPS that requires that specified minimum percentages of retail sales within Massachusetts must come from new renewable resources, which are defined to include wind energy proposals such as the proposed action. Such minimum percentages commence in 2003 with one percent, and increase annually at a rate of one-half of one percent through 2009, and increase thereafter at the discretion of the Massachusetts Division of Energy Resources (DOER).

### 1.2.3 Local and Regional Regulatory Jurisdictions and Reviews

#### *1.2.3.1 The Massachusetts Wetlands Protection Act - Yarmouth*

To protect the Commonwealth's wetland resources, the Massachusetts Wetlands Protection Act (WPA), Rivers Protection Act and regulations, and the Yarmouth Wetlands By-laws require approval from the Yarmouth Conservation Commission before activities can take place that would impact jurisdictional wetlands.

MassDEP and the Town of Yarmouth jurisdiction would include the submarine portion of the transmission line located within the mapped 3.5 mile (5.6 km) state territorial sea boundary and onshore cable components of the proposed action. Wetlands have been identified in the vicinity of the transmission cable route seaward and within the State territorial limit of Nantucket Sound and in the town of Yarmouth waters in Lewis Bay, and along the onshore transmission cable route. The Yarmouth Conservation Commission would exercise jurisdiction over the installation of the onshore cable located within the statutory 100 foot (30.5 m) buffer zone abutting wetland resources, and the submarine portion of cable located in Lewis Bay and out to the mapped 3.5 mile (5.6 km) state territorial sea boundary. In Massachusetts, the permit application is called a NOI. An NOI was filed with the Yarmouth Conservation Commission on November 15, 2007.

#### *1.2.3.2 The Massachusetts Wetlands Protection Act - Barnstable*

To protect the Commonwealth's wetland resources, the Massachusetts WPA, Rivers Protection Act, and regulations and the Barnstable Wetlands Ordinance require approval from the Barnstable Conservation Commission before activities can take place that would impact jurisdictional wetlands.

The MassDEP and the Town of Barnstable jurisdiction would include the submarine portion of the transmission line located within the mapped 3.5 mile (5.6 km) state territorial sea boundary and the onshore cable components of the proposed action. The Barnstable Conservation Commission jurisdiction covers the installation of the portion of the submarine cable route located in the town of Barnstable waters in Lewis Bay. The onshore cable route located in Barnstable would not be located within any wetland resource areas and/or buffer zones. An NOI was filed with the Barnstable Conservation Commission on November 15, 2007.

#### *1.2.3.3 Cape Cod Commission*

The Cape Cod Commission was created in 1990 by the Massachusetts General Court (state legislature) pursuant to the Cape Cod Commission Act (CCCA). The mission of the Commission is to manage growth, protect Cape Cod's unique environment and character, and foster a healthy community for present and future generations. The Commission acts as a regional planning and land use agency in the region known as Cape Cod – Barnstable County. As required by the CCCA, the commission created a Regional Policy Plan (RPP) that was then approved by the Assembly of Delegates of Barnstable County. The RPP, which is also implemented by the Commission, sets goals for development of Cape Cod. In order to safeguard the unique environment and cultural landscape of Cape Cod, the RPP sets forth Minimum Performance Standards, regulatory standards, in addition to any local, state, or federal regulations, which must be met by developments that have potential impact on the entire region.

According to the CCCA, numerous factors trigger Commission review for proposed developments. Generally, these include: (1) the impact of the proposed development on the environment and natural resources, including but not limited to air, ground and surface water supply and quality; ecological, coastal, historical, cultural, architectural, archaeological, and recreational resources; endangered species habitats, open space, agriculture and aquaculture; and (2) the impact of the proposed development on existing capital facilities, including but not limited to transportation and infrastructure, sewage, waste disposal, water supply, fair affordable housing, and meaningful employment.

The applicant submitted a request to the Cape Cod Commission for approval for the proposed interconnection cables located in state jurisdiction (Cape Cod Commission File No. JR20084), and the Commission issued a procedural denial of the applicant's request for approval on October 18, 2007 due to lack of information. However, an exemption from Cape Cod Commission review is available following a successful petition to the EFSB. The applicant sought such an exemption by filing a petition on November 21, 2007.

**Other Local Permits**

In addition to the Wetland Permits described above, there are other local permits that may be required, that are not necessarily considered environmental permits but rather engineering permits. These could include local Department of Public Works (DPW) curb cut and street opening permits, building permits, zoning, planning board approval, etcetera.

## 1.3 REGULATORY HISTORY

### 1.3.1 Public Scoping

In order to develop the scope of study for the MMS draft EIS, MMS requested comments on the proposed action via a public notice in the FR on May 30, 2006 (71 FR 30693). The MMS extended the time limit for the comment period from March 20, 2008, to April 21, 2008 at the request of commenters to allow extra time for development and submittal of scoping comments.

In addition, the proposed action had previously undergone a partial NEPA review with the USACE as the lead agency. During the USACE review process, a draft EIS was issued, and the USACE received approximately 5000 comment letters and email comments on the USACE draft EIS. For purposes of MMS' independent NEPA evaluation, the MMS incorporated all the previous comments originally made on the USACE draft EIS as scoping comments for this draft EIS. MMS also took into account in the scoping process, comments that were made at the USACE public hearings held in Yarmouth, Martha's Vineyard, Cambridge, and Nantucket, Massachusetts. As a result, there are an extensive number of comments, which have been used to develop the content or "scope" of this MMS draft EIS. The comments were considered in aggregate from both the MMS and the USACE comment and scoping processes. The draft EIS had addressed these comments to the extent they were applicable and necessary to reach conclusions as to the scope and extent of potential impacts.

### 1.3.2 Draft EIS Public Comment Period

On January 18, 2008, the Minerals Management Service published a notice in the Federal Register stating the availability of the Draft Environmental Impact Statement. The public comment period was initially noticed as lasting 60 days (until March 20, 2008) but was then extended another 30 days to April 21, 2008 in order to provide the public with additional time to read the DEIS and comment. MMS received comments through its public connect website on its Web page at http://ocsconnect.mms.gov/pcs-public/, via emails, via oral or hard copy comments provided at the four public hearings (i.e., the Mattacheese Middle School in West Yarmouth, Massachusetts, the Nantucket High School, in Nantucket, Massachusetts, the Martha's Vineyard Regional High School, in Oak Bluffs, Massachusetts, and at the University of Massachusetts Boston Campus, in South Boston), and via hard copy comments mailed in. In all, more than 45,000 comments were received. All comments received were logged and addressed as appropriate and are included in this Final Environmental Impact Statement.

## 1.4 AGENCY CONSULTATION AND COOPERATIVE AGENCY STATUS

Agency consultation meetings were held in Boston, Massachusetts on November 2, 2005; June 27, 2006; and February 28, 2007, and July 24, 2008. The purpose of the meetings was to solicit comment and concerns about the project and the scope of the DEIS and FEIS. MMS received informal comments on a host of issues including the extent of environmental resources impacts, the adequacy of data to address those impacts, and the scope of the alternatives analysis. The agencies/tribes consulted include:

- Wampanoag Tribe of Gay Head (Aquinnah)
- Mashpee Wampanoag Tribe
- NOAA Fisheries Service, formerly National Marine Fisheries Service
- US Army Corps of Engineers
- U.S. Coast Guard
- U.S. Department of Energy
- U.S. Environmental Protection Agency
- U.S. Federal Aviation Administration
- U.S. Air Force
- U.S. Fish and Wildlife Service
- Cape Cod Commission
- Massachusetts Department of Environmental Protection
- Massachusetts Energy Facilities Siting Board
- Massachusetts Executive Office of Environmental Affairs
- Massachusetts Historical Commission
- Town and County of Nantucket
- Town of Barnstable
- Barnstable Municipal Airport

In accordance with the Council on Environmental Quality Regulations at 40 CFR 1501.6, MMS filed letters inviting agencies to become cooperating agencies in the DEIS process (see MMS consultation letters in Appendix B). The purpose of bringing cooperative agencies into the process is to assist in the review and development of information and matters related to project design, characterization of resources, assessment of environmental impacts, and mitigation. The following formal cooperating agencies have provided a written request to become a cooperating agency (see cooperating agency request letters in Appendix B):

- U.S. Coast Guard
- U.S. Department of the Army, Corps of Engineers New England District
- U.S. Environmental Protection Agency
- Cape Cod Commission

In accordance with Executive Order 13175 the MMS has formally met on a government-to-government basis at the headquarters of the Wampanoag Tribe of Gay Head and the Mashpee Wampanoag Tribe in July of 2007. Consultation included explanation of the proposed action and its potential impacts on tribal government. Comments made by the tribal groups are addressed in this EIS. Impacts on tribal governments are discussed under the Environmental Justice and Cultural sections of this EIS (Section 5.3.3.5).

Since publication of the draft EIS, MMS has continued to meet with the cooperative agencies and tribes to obtain additional input to improve the DEIS and resolve remaining issues with respect to impacts on the environment and humans (see Section 7.0). Further details on the agency consultation process and issues of concern are discussed in Section 7.2.

## 1.5 DEFINITIONS OF IMPACT LEVELS

The following impact levels are used in the impact section of the draft EIS to provide consistency in the assessment of environmental impacts and socioeconomic issues. The conclusions for most analyses in this EIS use a four-level classification scheme to characterize the impacts predicted, if the proposed action or an alternative is implemented and activities occur as assumed.

### 1.5.1 Impact Levels for Biological and Physical Resources

The impact levels for biological and physical resources are used for the analysis of water quality, air quality, marine and terrestrial mammals, marine and coastal birds, fish resources, sea turtles, coastal and seafloor habitats, cultural resources, and areas of special concern (such as EFHs, marine sanctuaries, parks, refuges, and reserves). The four impact levels are defined as follows:

**(1) Negligible**

- No measurable impacts.

**(2) Minor**

- Most impacts to the affected resource could be avoided with proper mitigation, or
- If impacts occur, the affected resource would recover completely without any mitigation once the impacting agent is eliminated.

**(3) Moderate**

- Impacts to the affected resource are unavoidable, and
- The viability of the affected resource is not threatened although some impacts may be irreversible, or
- The affected resource would recover completely if proper mitigation is applied during the life of the proposed action or proper remedial action is taken once the impacting agent is eliminated.

**(4) Major**

- Impacts to the affected resource are unavoidable, and
- The viability of the affected resource may be threatened, and
- The affected resource would not fully recover even if proper mitigation is applied during the life of the proposed action or remedial action is taken once the impacting agent is eliminated.

### 1.5.2 Impact Levels for Socioeconomic Issues

The impact levels for socioeconomic issues are used for the analysis of demography, employment, and regional income; land use, visual and infrastructure; fisheries; tourism and recreation; socio-cultural systems; and environmental justice. Although impact levels for direct physical impacts to cultural resources are defined under Section 1.4.1, indirect visual impacts to cultural resources are covered by the criteria below. The four impact levels are defined as follows:

**(1) Negligible**

- No measurable impacts.

**(2) Minor**

- Adverse impacts to the affected activity or community could be avoided with proper mitigation, or
- Impacts would not disrupt the normal or routine functions of the affected activity or community, or
- Once the impacting agent is eliminated, the affected activity or community would return to a condition with no measurable effects from the proposed action without any mitigation.

**(3) Moderate**

- Impacts to the affected activity or community are unavoidable, and
- Proper mitigation would reduce impacts substantially during the life of the proposed action, or
- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the proposed action, or
- Once the impacting agent is eliminated, the affected activity or community would return to a condition with no measurable effects from the proposed action if proper remedial action is taken.

**(4) Major**

- Impacts to the affected activity or community are unavoidable.
- Proper mitigation would reduce impacts somewhat during the life of the proposed action.
- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, and
- Once the impacting agent is eliminated, the affected activity or community may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

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# 2.0 DESCRIPTION OF PROPOSED ACTION

## 2.1 PROJECT DESCRIPTION

The proposed action entails the construction, operation, and decommissioning of 130 WTGs located in a grid pattern on and near Horseshoe Shoal in Nantucket Sound, Massachusetts, as well as an ESP, inner-array cables, and two transmission cables. Each of the 130 WTGs would generate electricity independently of each other. Solid dielectric submarine inner-array cables from each WTG would interconnect within the grid and terminate at their spread junctions on the ESP. The ESP would serve as the common interconnection point for all of the WTGs. The proposed submarine transmission cable system is approximately 12.5 mile (20.1 km) in length (7.6 mile [12.2 km] within the Massachusetts 3.5 mile [5.6 km] territorial line) from the ESP to the landfall location in Yarmouth. The two submarine transmission cables would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue. The applicant seeks to commence construction in 2009 and begin operation in 2010.

### 2.1.1 Wind Turbine Generator

Each turbine is pitch-regulated with active yaw to allow it to turn into the wind, and has a three-blade rotor. The main components of the WTG are the rotor, transmission system, generator, yaw system, and the control and electrical systems, which are located within the nacelle (see Figure 2.1.1-1, in Appendix A). The nacelle is the portion of the WTG that encompasses the drive train and supporting electromotive generating systems that produce the wind-generated energy. The WTGs nacelle would be mounted on a manufactured tubular conical steel tower, supported by a monopile foundation system. A pre-fabricated access platform and service vessel landing (approximately 32 ft [10 m]) from mean lower low water (MLLW) would be provided at the base of the tower. The rotor has three blades manufactured from fiberglass-reinforced epoxy, mounted on the hub. The monopiles within the proposed action area would utilize two different diameter foundation types depending on water depth. The proposed action is designed for a maximum electrical energy capacity of 468 MW (130 WTG's each capable of producing up to 3.6 MW), however the maximum delivered capacity is approximately 454 MW (due to line losses, etc.) Water depths up to 40 ft (0 to 12.2 m) would utilize a 16.75 ft (5.1 m) diameter monopile and water depths of 40 to 50 ft (12.2 to 15.2 m) would utilize an 18.0 ft (5.5 m) diameter monopile.

Each WTG has an energy generating capacity of 3.6 MW ± and the proposed action is designed for a maximum delivered electrical energy capacity of approximately 454 MW. The generating capacity is based on the design wind velocity of 30 miles per hour (mph) (13.4 meters per second [m/s]) and greater, up to the maximum operational velocity of 55 mph (24.5 m/s). Based on the average wind speed in Nantucket Sound of 19.75 mph (8.8 m/s), there would be an average generation capacity of approximately 182.6 MW, and the net energy production delivered to the regional transmission grid would be approximately 1,600 gigawatt hours/year (GWh/y). The actual amount may vary depending upon the actual turbines in the supply chain at the time of construction, which have varying cut-in and cut-out speeds.

In order to generate maximum wind energy production, the WTGs would be arranged in specific parallel rows in a grid pattern. For this area of Nantucket Sound, the wind power density analysis conducted by the applicant determined that orientation of the array in a northwest to southeast alignment provides optimal wind energy potential for the WTGs. This alignment would position the WTGs perpendicular to prevailing winds, which are generally from the northwest in the winter and from the southwest in the summer for this geographic area in Nantucket Sound. The WTGs would have a computer-controlled yaw system that ensures that the nacelle is always turned into the wind and perpendicular to the rotor. In addition to maximizing potential wind energy production, the WTGs must also be sufficiently spaced within the array in order to minimize power losses due to wind shear and turbulence caused by other WTGs within the array. The optimal WTG spacing within the array is 0.39 mile (629 m) by 0.62 (1,000 m) between each WTG based on wind direction analysis. The spacing of the wind turbines is discussed further in Section 3.3.6 under “Condensed Array Alternative.”

As a result of technological advancements and design changes by the manufacturers of the GE 3.6 MW wind turbines, the overall dimensions of the machines have changed since the publication of the USACE draft EIS. At present, the primary change involves the use of larger rotor blades, which require mounting on a taller tower to maintain the desired 75 ft (23 m) of clearance to the sea surface. The 75 ft (23 m) of clearance beneath the WTGs was initially chosen, and will be maintained, in order to minimize any impacts to the use of the water sheet area by boats. It should be noted that the applicant may choose to use another manufacturer other than GE to produce similar WTGs as described herein depending on availability and other considerations. The following describes the other changes in the turbine specifications since the publication of the USACE draft EIS (Figure 2.1.1-1).

a. Rotor Diameter: As a result of technological advancements that allow for greater efficiencies, 3.6 MW WTGs are presently produced with a rotor diameter of 364 ft (111 m) (originally 341 ft [104 m]).

b. Nacelle Hub Height: In order to maintain the previously stated 75 ft (23 m) of clearance between the sea surface and a rotor blade tip in its lowest position, the nacelle hub has been raised to a height of 257.5 ft (78.5 m) (originally 246 ft [75 m]).

c. Overall WTG Height: As a result of the larger rotor blades and the desire to maintain the previously stated 75 ft (23 m) of clearance beneath the turbines, the maximum overall WTG height has increased to 440 ft (134 m) (originally 417 ft [127 m]).

d. Rotor Swept Zone: As a result of the changes noted above, the resulting rotor swept zone is now 75 to 440 ft (23 to 134 m) (originally 75 to 417 ft [23 to 127 m]).

The northernmost WTGs would be approximately 3.8 mile (6.1 km) from the dry rock feature (offshore near Bishop and Clerks) and approximately 5.2 mile (8.4 km) from Point Gammon on the mainland; the southernmost WTG would be approximately 13.8 miles (22.2 km) from Nantucket Island (Great Point), and the westernmost WTG would be approximately 9.0 miles (14.5 km) from the island of Martha’s Vineyard (Cape Poge) (Figure 2.1.1-2). The proposed action area as presented in the application submitted to MMS on September 14, 2005, includes an expanded perimeter around the site of the proposed action in order to ensure that a sufficient buffer exists between the proposed action area and any other subsequent wind projects authorized by MMS in the future that could impact the ability of the proposed action to produce power at the anticipated level.

The water depths within Nantucket Sound range from 0.5 to 70 ft (0.15 to 21.3 m) at MLLW. Depths on Horseshoe Shoal range from as shallow as 0.5 ft (0.15 m) to 60 ft (18.3 m) at MLLW. Along the transmission cable interconnection corridor, between Horseshoe Shoal and the Cape Cod shoreline, water depths vary from 16 to 40 ft (4.9 to 12.2 m) at MLLW, with an average depth of approximately 30 ft (9.1 m) at MLLW. Water depths within Lewis Bay and Hyannis Harbor range from 8 to 16 ft (2.4 to 4.9 m) at MLLW in the center of the bay to less than 5 ft (1.5 m) at MLLW along the perimeter and between Dunbar Point and Great Island.

### 2.1.2 Inner Array Cables

Within the nacelle of each turbine, a wind-driven generator would produce low voltage electricity, which would be “stepped up” by a transformer to produce 33 kV electric transmission capacity. Submarine cables from each WTG would interconnect within the turbine array and terminate at their spread junctions on the ESP. The inner array submarine cable system would use a three-conductor cable with all phases under a common jacket. The inner-array cables would consist of solid dielectric alternating currents (AC) cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable would consist of three copper conductors (extruded XLPE insulation) plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers. The entire cable assembly would be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings.

The inner-array cables would be arranged in strings, each of which would connect up to approximately 10 WTGs to a 33 kV circuit breaker on the ESP. The electrical current in the cable segments within each string would vary depending on WTG's location within the string. Cable segments closer to the ESP would provide greater transmission capacity compared to cables further away from the ESP. It is anticipated that three different cable sizes (0.23 square inched [150 $mm^2$], 0.6 square inches [400 $mm^2$], and 0.9 square inches [600 $mm^2$]) would be used to accommodate this variation in transmission capacity related to the distance of the WTG from the ESP. The conductor cross sections would be 3x0.23 square inches (150 $mm^2$), 3x 0.6 square inches (400 $mm^2$), and 3x0.9 square inches (600 $mm^2$)and the overall diameter of the cable would be 5.19 inches (132 mm), 5.75 inches (146 mm) , and 6.45 inches (164 mm) respectively. The inner-array cables would be installed 6 ft (1.8 m) below the seafloor by jet plow embedment.

See Figure 2.1.2-1 for the location of the revised turbine array showing the inner-array cable layout.

### 2.1.3 115 Kilovolt (kV) Transmission Cable System

Two 115 kV transmission circuits would interconnect the ESP with the existing NSTAR Electric transmission grid serving Cape Cod. Two AC circuits are necessary to provide the required electric transmission capacity when operating at high capacity to the NSTAR Electric transmission system and to provide increased reliability and redundancy in the event of a circuit outage. Each circuit consists of two (2) three-conductor cables, resulting in a total of four (4) cables.

The submarine transmission line would consist of solid dielectric AC cable specifically designed for installation in the marine environment. These types of cables do not require pressurized dielectric fluid circulation for insulating or cooling purposes. Each cable would consist of three 1.24 square inch (800 $mm^2$) copper conductors, XLPE insulated to 123 kV and lead/PE sheathed, plus an interstitial fiber optic cable equipped with 24 single mode ITU-T G.652 fibers, with an overall diameter of 7.75 (197 mm). The entire cable assembly would be wound and protected by a single layer of galvanized steel wire armor and an outer sheathing of polypropylene strings (see Figure 2.1.3-1). The four submarine transmission cables would be installed as two circuits by bundling two cables per circuit together during installation and installing the two circuits.

The proposed transmission cable system would be approximately 12.5 miles (20.1 km) in length (7.6 miles [12.2 km] within the Massachusetts 3.5 mile [5.6 km] territorial line) from the ESP to the landfall location in Yarmouth. The transmission cables would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue (see Figure 2.1.3-2). The transmission cables would be installed 6 ft (1.8 m) below the seafloor by jet plow embedment. See Figure 2.1.3-3 for a typical cross section of a submarine cable trench using jet plow embedment. The submarine transmission cables would transition to the onshore transmission cable by using HDD methodologies to drill shafts for pulling of conduits, pulling the cable through the conduits, and then transition into a vault positioned at the end of New Hampshire Avenue.

Upon making landfall, the proposed transmission cable route would then follow New Hampshire Avenue north, merging with Berry Avenue. The route continues north on Berry Avenue, crossing Route 28 and continuing north on Higgins Crowell Road to Willow Street. Proceeding north on Willow Street, the route passes under Route 6 to the proposed intersection point with the existing NSTAR Electric 115 kV transmission cable ROW, approximately 500 ft (152.4 m) north of Summer Street. The route then turns westerly within the NSTAR Electric's existing ROW to the Barnstable Switching Station, crossing under Route 6. The proposed onshore transmission cable would be located within the existing public roadways for a length of approximately 4 miles (6.4 km) from landfall to NSTAR Electric transmission cable ROW located on the west side of Willow Street. The onshore transmission cable would then continue underground approximately 1.9 miles (3.1 km) along existing NSTAR Electric ROW and running from Willow Street to the Barnstable Switching Station (see Figure 2.1.3-2).

The onshore cables would be joined to the submarine cables at the landfall in Yarmouth. The onshore transmission cable system would utilize 12 single-conductor 115 kV cables. The 12 cables would be segregated into two circuits, each composed of two cables per phase. The cables would run in a concrete encased duct bank. The conductor cross bank would be 1.24 square inches (800 $mm^2$). See Figures 2.1.3-4 and 2.1.3-5 for typical duct bank cross sections.

Installation of the proposed onshore transmission cable includes constructing a utility easement within and along four roadways: New Hampshire Avenue, Berry Avenue, Higgins Crowell Road, and Willow Street. The easement would also include the crossing of Route 28 and Route 6. The onshore transmission cable would affect several intersections.

**New Hampshire Avenue**

New Hampshire Avenue is a two-lane residential road allowing vehicle access in a north-south direction. The roadway is a dead-end with a concrete retaining wall at its southern end. There are no sidewalks on either side of the roadway. In addition, there is no on-street parking. The transmission cable would be installed within the east side of the roadway.

**Berry Avenue**

Berry Avenue is a two-lane residential road allowing vehicle access in a north-south direction. There are sidewalks on both sides of the roadway. The transmission cable would cross to the west side of Berry Avenue off of New Hampshire Avenue.

**Intersection 1 - Route 28 between Berry Avenue and Higgins Crowell Road**

At the intersection with Berry Avenue and Higgins Crowell Road, Route 28 is a two-lane roadway with a painted divider. Vehicles on Route 28 travel in an east-west direction. The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is signalized. There are sidewalks on both sides of Route 28. The transmission cable would be installed underneath Route 28 using trenchless technologies.

**Higgins Crowell Road**

Higgins Crowell Road is a two-lane road with a painted divider and vehicle travel is in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. The transmission cable would be placed on the east side of Higgins Crowell Road.

**Intersection 2 - Buck Island Road**

At the intersection with Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle on Buck Island Road travels in an east-west direction. The intersection of Buck Island Road with Higgins

Crowell Road is signalized. The transmission cable would be installed beneath Buck Island Road using trenchless technologies.

**Willow Street**

Willow Street is a two-lane road with a painted divider. Vehicle travel is in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. The transmission cable would be placed on the west side of Willow Street.

**Route 6 Crossings**

The transmission cable would be installed using trenchless techniques as it passes underneath the Route 6 overpass. Approximately 0.5 mile (0.8 km) past the Route 6 overpass, the transmission cable would enter the NSTAR Electric ROW. The transmission cable would also cross under Route 6 from the NSTAR Electric ROW from north to south to connect with the Barnstable Switching Station. This crossing would also be accomplished using trenchless techniques.

***Ancillary Structures***

The duct system enclosing the onshore transmission and related cables would consist of a single duct bank system with a total of sixteen 6 inch polyvinyl chloride (PVC) ducts encased within a concrete envelope. The duct bank would be constructed within a trench beneath existing roadway corridors along the majority of the route. Twelve of the 16 ducts would be occupied with the onshore transmission cables, two ducts would contain fiber optic line for protective relaying and communications, and two vacant ducts would be reserved for future use as spares.

In addition to the landfall transition vault at the landfall site, the proposed transmission facility would include underground vaults along the public roadway and NSTAR Electric's ROW. These vaults would be required at locations utilizing trenchless techniques as well as typical splice vaults. All vault locations would include two parallel vaults constructed of reinforced concrete.

### 2.1.4 Electrical Service Platform (ESP)

An ESP would be installed and maintained within the approximate center of the WTG array and serve as the common interconnection point for all of the WTGs. The inner-array cable system would interconnect with circuit breakers and transformers located on the ESP in order to transmit wind-generated power through the 115 kV shore-connected submarine cable system. The ESP would provide electrical protection and inner-array cable sectionalizing capability in the form of circuit breakers. It would also include voltage step-up transformers to increase the 33 kV inner-array transmission voltage up to the 115 kV voltage level of the transmission cable connection to the land-based system.

The ESP would be a fixed template type platform consisting of a jacket frame with six 42-inch diameter (1.1 m) driven piles to anchor the platform to the ocean floor. The platform would consist of a steel superstructure supporting a platform of 100 ft by 200 ft (30.5 m by 61 m). The platform would be placed approximately 40 ft (12.2 m) above MLLW in 28 ft (8.5 m) of water. An enclosed 82 ft by 185 ft (25 m by 56.4 m) structure for the housing of transformers, circuit breakers, and the interconnection of the cable system rests atop the platform. The enclosed structure rises 49 ft (14.9 m) above the platform. The entire ESP (including a helicopter deck) rises approximately 100 ft (30.5 m) above the waterline at MLLW.

In addition to the electrical equipment, the ESP would include fire protection, battery backup units, and other ancillary systems. These systems would include ventilation, safety, communications, and temporary living accommodations. The living accommodations are for emergency periods when maintenance crews cannot be removed due to weather issues. These accommodations would utilize waste storage holding tanks that would be pumped to the service vessel for proper disposal. All equipment would be contained within an enclosed weather-protected service area.

Maintenance and service access to the ESP would normally be by service boat. A boat landing dock consisting of a fender structure with ladder is attached to the ESP to allow boat landing and transfer of personnel and equipment and temporary docking of the service craft. The ESP would have a helicopter deck to allow personnel access when conditions preclude vessel transport, and for emergency evacuation. Equipment and material transfer would be by a crane mounted on the ESP.

## 2.2 SPACE REQUIREMENTS

**Submerged Land**

The 130 WTGs and the ESP would occupy 0.67 acres (0.003 square kilometers [$km^2$]) of submerged land. The 33 kV inner-array cables (ranging in diameter from 5.19 in [132 millimeters [mm]] to 6.45 in [164 mm] depending on the required current load for sections of the cable) would occupy approximately 4.35 acres (0.018 $km^2$). The 115 kV transmission line, consisting of two circuits of two 7.75 in (197 mm) cable would occupy 1.54 acres (0.006 $km^2$) beneath federal waters. An additional 2.38 acres (0.01 $km^2$) beneath Massachusetts state waters would be occupied by the 115 kV transmission line. Scour protection for the WTGs would include a combination of scour mats and rock armor. Under the proposed scour protection plan, scour mats to be used at 106 WTGs would cover 1.96 acres (0.008 $km^2$) and rock armor to be used at 24 WTGs would cover 8.75 acres (0.04 $km^2$). Should the scour mats prove ineffective in any area, they would be replaced with rock armor. The worst case scenario would be replacement of the scour mats around all WTGs and the ESP. Under this scenario, the scour protection would cover 47.82 acres (0.19 $km^2$). The project facilities would occupy 0.12 percent (19.41 acres) of the total project area of 25 square miles (64.7 $km^2$) with scour mats and 0.35 percent (56.76 acres) with rock armor (see Table 5.3.2-3 for additional information).

During installation of the WTGs, ESP, cable, and scour protection, it is anticipated that between 820 and 866 acres (3.31 and 3.5 $km^2$) (depending on the method of scour protection) would be temporarily disturbed. This represents between 5.1 and 5.4 percent of the total project area.

**Onshore**

The proposed onshore transmission cable route to its intersection with the NSTAR Electric ROW would be located entirely along existing paved ROWs where other underground utilities already exist. All of the roadways within Yarmouth and Barnstable in which the proposed transmission cable would be placed are town owned and maintained roads with the exception of Routes 6 and 28, which are owned and maintained by MassHighway. A portion of the onshore transmission cable route would also be located underground within the existing maintained NSTAR Electric ROW.

## 2.3 CONSTRUCTION METHODOLOGY AND SCHEDULE

### 2.3.1 Schedule

The anticipated schedule for the permitting of the proposed action and its construction is provided in Figure 2.3.1-1. The anticipated construction sequence is as follows: (1) the onshore ductbanks would be installed; (2) the ESP and onshore 115 kV cables would be installed; (3) the monopiles, scour protection, WTGs, and submarine 33 kV and 115 kV cables would be installed; and (4) full operation would begin.

### 2.3.2 Wind Turbine Generator Installation

The installation of the WTGs would comprise four activities: (1) installation of the foundation monopiles; (2) erection of the WTGs; (3) installation of the inner-array cables; and (4) installation of the scour protection mats or rock armor.

#### *2.3.2.1 Quonset Staging Area*

The major construction activities would be supported by onshore facilities, which are anticipated to be located in Quonset, Rhode Island (see Figure 2.3.2-1). Material and equipment would be staged onshore, at existing port facilities in Quonset, Rhode Island, and then loaded onto various vessels for transportation to the offshore site, and ultimately installation. Construction personnel would be ferried by boat and/or helicopter depending upon weather conditions and other factors. Once loaded, the vessels would travel from Quonset through Narragansett Bay to Rhode Island Sound to Vineyard Sound, North of Martha's Vineyard to the Main Channel, a distance of about 63 miles (102 km).

The applicant has identified an existing, industrial port facility in Quonset, Rhode Island as having the attributes required for staging an offshore construction project of the magnitude of the Project. The Quonset Davisville Port & Commerce Park is located on Narragansett Bay in the town of North Kingstown, Rhode Island. It is owned and controlled by the Rhode Island Economic Development Corporation (RIEDC). This site is a portion of what once was a much larger government facility known as the U.S. Naval Reservation–Quonset Point, part of which is still actively utilized as a civilian airport and base for an Air National Guard Reserve squadron.

The Quonset Davisville Port & Commerce Park is an active marine industrial site that houses several industrial businesses such as General Dynamics (shipbuilding) and Senesco (marine construction). Following the downsizing of the U.S. Naval Reservation – Quonset Point, the commerce park was created in order to develop prime industrial sites, create job opportunities, and to improve the economic conditions throughout the region.

The entire park consists of approximately 3,150 acres (12.75 $km^2$), of which 817 acres (3.3 $km^2$) have been sold for such uses as industrial, offices, and transportation/utility (railroad and highways). Another 463 acres (1.9 $km^2$) have current leases, 605 acres (2.45 $km^2$) are used for a civilian airport (Quonset State Airport - OQU) operated by the State of Rhode Island, approximately 600 acres (2.4 $km^2$) are designated open space, about 200 acres (0.8 $km^2$) are utilized for recreation including a golf course, and the remaining 465 (1.9 $km^2$) acres are vacant, open land available for industrial and commercial activities.

The site has deep-water capacity (30 ft [9.1 m] depth) and two piers that are 1,200 ft (365.9 m) in length and capable of servicing large ships. One of the piers (Pier 1) is currently leased by a company as an automobile unloading and transfer operation. The other pier (Pier 2) has intermittent use as a staging area for the Rhode Island Department of Transportation bridgework. Pier 2 would become available in the near future; however, based on timing, either pier may be available for lease.

The applicant has been actively pursuing the use of Pier 2 because it has a load bearing capacity of over 1,000 pounds (lbs) per square feet ($ft^2$) (4890 $kg/m^2$) and is 1,200 ft (365.9 m) long by 650 ft (198.2 m) wide. This Pier would be used for the receiving, storing and assembly of the large turbine parts such as the monopiles, towers, nacelles, transition pieces, hubs, and blades. The applicant and RIEDC have started discussions pertaining to leasing all or part of Pier 2 and the land contiguous to it, which consists of approximately 33.5 acres (0.14 $km^2$) zoned for industrial or commercial activity. Additional land is also available within the park, approximately 3,000 ft (914.6 m) away, which is accessible by a public road approximately 40 ft (12.2 m) in width. These satellite parcels consist of approximately 25 plus acres (0.1 $km^2$) that could be used for other components of the wind turbines and associated infrastructure if needed. One of the parcels has two large buildings, which were utilized by the U.S. Navy Construction Battalion (Seabees) during the 1940's, 1950's and 1960's, which may be capable of handling certain requirements of the project for covered storage and enclosed workspace. Some modifications to the buildings and roadways may be required to accommodate the specialized equipment and wind turbine components. The deep-water piers are adequate to accommodate anticipated construction vessels and are not expected to require any additional dredging or modification.

Monopile installation would begin by loading individual monopiles onto a barge, three to four at a time, for transport to the work site. Depending upon the actual barge utilized and other logistical requirements, approximately 43 trips are anticipated to move monopiles to the work site.

Information on general types and estimated numbers of vessels expected to be involved during various phases of the proposed action is presented below. During pile driving activities, it is estimated that approximately 4-6 vessels would be present in the general vicinity of the pile installation. Most of these vessels will be stationary or slow moving barges and tugs conducting or supporting the installation. Other project vessels will be delivering construction materials or crew to the site and will be transiting from the various points on the mainland to the Project site and back. Barges, tugs and vessels delivering construction materials will travel at 10 knots (19 km/hour) or below and may range in size from 90 to 400 ft (27.4 to 122 m). The only vessels that are anticipated to be traveling at greater speeds are crew boats that will deliver and return crew to the Project site twice per day. Crew boats are anticipated to be approximately 50 ft (15.2 m) in length and may travel at speeds up to 21 knots (39 km/hour). These crew boats are similar to typical vessel traffic occurring in Nantucket Sound already on a regular basis.

Based upon site specific bathymetric survey there are no proposed turbine locations in water depths less than approximately 12 ft (3.7 m) MLLW (mean lower low water). All monopile sites are constructible at the proposed locations. Construction vessel access to each of these sites is available from at least one direction. Drafts of current equipment used for installation of similar projects are approximately 10 ft (3.0 m).

As a contingency, Cape Wind's normal construction sequence may be altered to accommodate water depths, dependent upon post-lease, site specific, pre-construction bathymetric data. For those few sites where the water depth approaches the 12 ft (3.7 m) MLLW it may require careful coordination with tides, construction sequencing and vessel loading. Once the vessel is in place and jacked up (which can occur at high tide), it will be unaffected by water depths.

#### *2.3.2.2 Installation of Monopiles*

A jack-up barge with a crane would be utilized for the actual installation of the monopiles. The jack-up barge would have four legs with pads a minimum of four meters on a side (approximately 172 $ft^2$ [16 $m^2$]). The crane would lift the monopiles from the transport barge and place them into position. The monopiles would be installed into the seabed by means of a pile driving ram or vibratory hammer to an approximate depth of 85 ft (26 m). This would be repeated at all WTG locations. Only two pieces of pile driving equipment would be present within the proposed action area at any one time, and they are not planned to be operated simultaneously. Since the monopiles are hollow, sediments would be contained within them.

Length of monopile, insertion distance, and finished elevation would vary by individual location due to water depth and structural and geotechnical parameters. Monopiles to be installed would range in length from approximately 122 ft (37 m) for those installed in the shallowest locations to more than 172 ft (52.4 m) at the deepest sites. The anticipated time to install all of the monopiles is expected to be approximately eight months plus any delays due to weather.

#### 2.3.2.3 Installation of Wind Turbine Generators

The installation of the WTG itself would be from a specialized vessel configured specifically for this purpose (see Figure 2.3.2-2 for an example of a typical vessel). Work vessels for the proposed action would comply with applicable mandatory ballast water management practices established by the USCG in order to avoid the inadvertent transport of invasive species.

This vessel would be loaded at Quonset, Rhode Island with the necessary components to erect six to eight WTGs. The components include transition pieces to place on the monopiles, towers, nacelles, hubs, and blades.

The vessel would transit from Quonset to the work site as described above and set up adjacent to one of the previously installed monopiles. A jacking system would then stabilize the vessel in the correct location. Depending on the actual circumstance, four or six jacking legs would raise the vessel to a suitable working elevation. A transition piece unique to the specific WTG, is placed by the vessel's crane onto the monopile, leveled and set at the precise elevation for the tower. This piece would be a fabricated steel structure complete with a turbine tower flange, J-tubes for cable connections and a boat landing device. The transition piece is then grouted in place to the foundation monopile using a product such as Ducorit® D4 by Densit. The crane would then place the lower half of the tower onto the deck of the transition piece. Once this piece is secured, the upper tower section is raised and bolted to the lower half. In order, the nacelle, hub and blades are raised to the top of the tower and secured. Several of these components may be pre-assembled prior to final installation. This process is anticipated to take approximately 30 to 40 hours to cycle through one complete WTG and would be repeated for each of the 130 WTG locations. Including the twenty or so trips from Quonset to Horseshoe Shoal, this process would take approximately nine months plus any delays due to weather. The installation of the WTGs would overlap with the installation of the monopiles.

As the monopiles and WTGs are completed, the submarine inner-array cables would be laid in order to connect each string of wind turbines (up to 10 WTGs), and then the seabed scour control system would be installed on the seabed around each monopile. The scour control system would help to prevent underwater currents from eroding the substrate adjacent to the WTG foundation. The scour control system would consist of either a set of six mats arranged to surround the monopile or rock armor.

Each scour control mat is 16.5 ft by 8.2 ft (5 m by 2.5 m) with eight anchors that securely tied to the seabed (see Figure 2.3.2-3 for the arrangement of the mats). It is anticipated that the process of completing one string of WTGs (10 WTGs with associated inner-array cable and scour mats) would take up to approximately one month. The scour mats are placed on the seabed by a crane or davit onboard the support vessel. Final positioning is performed with the assistance of divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. The mats are removed with divers and a support vessel in a similar manner to installation, and are expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats.

At 24 WTGs rock armor scour protection would be used for an alternative approach to scour control. Figure 2.3.2-4 shows the turbines for which rock armor would be used. Rock armor design is driven by wave action (wind-driven and ocean swell) and currents (tidal and wind-driven). The armor stones are sized so that they are large enough not to be removed by the effects of the waves and currents, while being small enough to prevent the stone fill material placed underneath it from being removed.

At location where it would be used, the rock armor and filter layer material would be placed on the seabed using a clamshell bucket or a chute. The rock armoring would also be removed following project decommissioning.

The transition piece of the WTGs, which would be located within the submerged/splash zone, would be coated with a product equal or similar to Dupont Interzone 954. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower, would be coated with an epoxy-polyamide. A cathodic protection system using a galvanic (sacrificial) aluminum anode system would be employed to assist in preventing corrosion.

### 2.3.3 Electric Service Platform Installation

The ESP design is based on a piled jacket/template design with a superstructure mounted on top. The platform jacket and superstructure would be fully fabricated on shore and delivered to the work site by barge.

The jacket would be removed from the barge by lifting with a crane mounted on a separate derrick barge. The jacket assembly would then be sunk and leveled in preparation for piling. The six piles would then be driven through the pile sleeves to the design tip elevation of approximately 150 ft (46 m) below the surface of the sea bottom. The piles would be vibrated and hammered as required.

The superstructure would be installed by lifting it from the transport barge onto the jacket. It would then be connected to the jacket in accordance with the detail design requirements. After attachment, additional components including ladders, heliport and vessel docking structure would be lifted from a barge and set onto the superstructure for attachment. The installation of the ESP is anticipated to take approximately one month to complete (Figure 2.3.3-1, sheets 1 and 2).

After the ESP is fully constructed, installation of the inner-array cables and the high voltage transmission cables would take place. These cables would be routed through J-tubes located on the outside of the support jackets. Once the inner-array cables are connected to the ESP, the scour mats would be installed to the ESP piles utilizing a similar design as the WTG foundations.

The ESP would be coated with a similar paint system as the WTG. A cathodic protection system utilizing a galvanic (sacrificial) aluminum anode system would be utilized.

### 2.3.4 33 Kilovolt Inner-Array Submarine Cable System Installation

The 33 kV cable would be transported to Quonset Point, Rhode Island in a special cable transport vessel. The cable would be transferred onto the cable installation barge. The linear cable machines on-board the barge would pull the cables from coils on the transport vessel onto the barge, and into prefabricated tubs. The installation barge and auxiliary barge loading take place in Quonset, Rhode Island. After the cable has been transferred, the installation barge would be towed to the Horseshoe Shoal site. This would be repeated as required to deliver and install all the required cable.

The proposed method of installation of the submarine cable is by the hydroplow embedment process, commonly referred to as jet plowing (see Figure 2.1.3-3). This method involves the use of a positioned cable barge and a towed hydraulically-powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from WTG to WTG and then to the ESP. The barge would propel itself along the route with the forward winches, and the other moorings holding the alignment during the installation. The four point mooring system would allow a support tug to move anchors while the installation and burial proceeds uninterrupted on a 24-hour basis.

When the barge nears the ESP, the barge spuds would be lowered to secure the barge in place for the final end float and pull-in operation. The cable would be pulled into the J-tube and terminated at the switchgear.

### 2.3.5 115 Kilovolt Submarine Transmission Cable System Installation

The transmission cable system consists of the two 115 kV solid dielectric AC submarine transmission circuits (two three-conductor cable systems per trench equals one circuit, for a total of four cables). The two circuits of interconnecting transmission cables linking the ESP to the landfall location would be embedded by jet plow approximately 6 ft (1.8 m) below the sea floor, with approximately 20 ft (6.1 m) of horizontal separation between circuits.

Jet plow embedment methods for submarine cable installations are considered to be the most effective and least environmentally damaging when compared to traditional mechanical dredging and trenching operations. This method of laying and burying the cables simultaneously ensures the placement of the submarine cable system at the target burial depth with minimum bottom disturbance and with much of the fluidized sediment settling back into the trench. For these reasons, it is the installation methodology that appears to be preferred by state and federal regulatory agencies based on review of past precedent-setting projects, including the roughly 40 miles of electric cable installed between Cape Cod and Nantucket.

Jet plow equipment uses pressurized sea water from water pump systems on board the cable vessel to fluidize sediments. The jet plow device is typically fitted with hydraulic pressure nozzles that create a direct downward and backward “swept flow” force inside the trench. This provides a down and back flow of re-suspended sediments within the trench, thereby “fluidizing” the *in situ* sediment column as it progresses along the predetermined submarine cable route such that the submarine cable settles into the trench under its own weight to the planned depth of burial. The jet plow’s hydrodynamic forces do not work to produce an upward movement of sediment into the water column since the objective of this method is to maximize gravitational replacement of re-suspended sediments within the trench to bury or “embed” the cable system as it progresses along its route. The pre-determined deployment depth of the jetting blade controls the cable burial depth.

Due to the relatively shallow water depths in Nantucket Sound, shallow draft vessels/barges which typically use anchors for positioning are most likely to be used for installation. Deeper draft vessels equipped with dynamic positioning thrusters are less likely to be utilized in shallow water locations.

The cable laying barge is specifically designed for installations of submarine cable. It is used for both transport and installation. The submarine cable is installed in continuous lengths delivered from the cable factory and loaded directly onto a revolving turntable on the vessel. The cable system location and burial depth will be recorded during installation for use in the preparation of as built location plans. The jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. This information is monitored continually on the installation vessel; therefore the use of an ROV is not required. This information will be forwarded to appropriate agencies and organizations as required for inclusion on future navigation charts.

A skid/pontoon-mounted jet plow, towed by the cable-laying barge, is proposed for the Project’s submarine installation. This jet plow has no propulsion system of its own. Instead, it depends on the cable vessel for propulsion. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The cable system is deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, pump systems are initiated, and the jet plow progresses along the pre-selected submarine cable route with the simultaneous lay and burial operation. It is anticipated that, to install each transmission line circuit to the required depth providing a minimum of

6 ft (1.8 m) of cover in the sediments that are generally found along the proposed submarine transmission line route into Lewis Bay, the jet plow tool will fluidize a pathway approximately 4 to 6 ft (1.2 to 1.8 m) wide at the seabed and 8 ft (2.4 m) deep into which the cable system settles through its own weight. As mentioned above, the jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. The pontoons can be made buoyant to serve different installation needs.

The geometry of the trench is typically described as trapezoidal with the trench width gradually narrowing with depth. Temporarily re-suspended in situ sediments are largely contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediment traveling outside of the trench. Any re-suspended sediments that leave the trench tend to settle out quickly in areas immediately flanking the trench depending upon the sediment grain-size, composition, and hydraulic jetting forces imposed on the sediment column necessary to achieve desired burial depths.

This interconnection will involve the installation of approximately 12.5 circuit miles (20.1 km) (of which 7.6 miles (12.2 km) are within Massachusetts' waters) of transmission cable for each of the two circuits. The installation of the submarine transmission line via jet plow embedment is anticipated to take approximately two to four weeks to complete. As the jet plow progresses along the route, the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth. In the unlikely event that the minimum burial depth is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth.

The 115 kV cable would be transported from the manufacturer to Quonset Point, Rhode Island, the mobilization point. The cable would be transferred to the installation barge by pulling via the linear cable machines mounted on the barge. After the cable has been transferred, the installation barge would be towed to the Lewis Bay installation site offshore of the New Hampshire Avenue landfall (described in Section 2.3.6 of this document). A second smaller barge, capable of operating in shallow water, would also be used in conjunction with the larger installation barge.

Prior to pulling the cable ashore to the sea-land transition vault, the jet plow would be set up in the pre-excavation pit located at the offshore end of the drilled conduit. The cable would then be floated from the barge with assistance of small support vessels. The cable end would be anchored in place after being pulled through the Hydroplow and into the High Density Polyethylene (HDPE) conduits installed during the HDD and secured beyond the transition vault.

From the HDD exit point, the cable is embedded across the shallows by means of towing the jet plow along the cable route from the smaller barge's winch. The cable and jet hose would be supported by cable floats to maintain control of cable slack and the amount of hose out.

When the cable embedment has proceeded into deeper water and nears the larger installation barge, the operation would be transferred, and the barge would lift its spuds and begin winching along the cable route, with the six point mooring system towing the jet plow and feeding cable off the barge and into the plow funnel as it moves along the route at a rate equal to the barge movement. This would be repeated for the second circuit.

The barge would propel itself along the route with the forward winches, and the other moorings holding the alignment of the route. When the barge nears the ESP, the barge spuds would be lowered to secure the barge in place for the final end float and pull-in operation. The transmission cable would be pulled into the J-tube and terminated at the switchgear.

The following is a list of the primary installation equipment:

- Hydroplow cable burial machine designed for 6 ft burial depth;
- Installation barge 100 ft (30.5 m)wide x 400 ft (122 m) long x 24 ft (7.3 m) height;
- Anchor handling tugs - two 3000 hp twin screw (would be with the barge for the duration of the installation);
- Six-point mooring system with two 60-inch (1.52 m) spuds. The mooring system would consist of 3 double winches, plus another double drum winch for controlling the two spuds. Each winch drum would contain approximately 2,000 ft (610 m) of 1 1/8 inch (28.6 mm) mooring cable and have an anchor attached. Mid-line buoys would be attached to minimize anchor cable scour. Pendant wire with 58-inch (1.48 m) steel ball buoys would be attached to anchors for deployment and quick recovery;
- Cable burial support system including pumps, and Hydroplow accessories;
- Cable laying support system including cable machines, chute, tubs and complete diving operations center to support divers;
- Auxiliary trencher pulling barge - a barge of 40 x 100 ft (12.2 x 30.5 m) dimensions outfitted with spuds; and
- Auxiliary vessels - there would be a crew boat, two inflatable boats, and several skiffs.

Jet plow equipment uses pressurized sea water from water pump systems on board the cable vessel to fluidize sediments. The jet plow device is typically fitted with hydraulic pressure nozzles that create a direct downward and backward “swept flow” force inside the trench. This provides a down and back flow of re-suspended sediments within the trench, thereby “fluidizing” the in situ sediment column as it progresses along the predetermined submarine cable route such that the submarine cable settles into the trench under its own weight to the planned depth of burial. The jet plow’s hydrodynamic forces do not work to produce an upward movement of sediment into the water column since the objective of this method is to maximize gravitational replacement of re-suspended sediments within the trench to bury or “embed” the cable system as it progresses along its route. The pre-determined deployment depth of the jetting blade controls the cable burial depth.

A skid/pontoon-mounted jet plow, towed by the cable-laying barge, is proposed for the submarine installation. This jet plow has no propulsion system of its own. Instead, it depends on the cable vessel for propulsion. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The cable system is deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, pump systems are initiated, and the jet plow progresses along the pre-selected submarine cable route with the simultaneous lay and burial operation, creating a fluidized sediment trench approximately 4 to 6 ft (1.2 to 1.8 m) wide (top width) to a depth of 8 ft (2.4 m) below the present bottom into which the cable system settles through its own weight. The jet plow does not create an open trench of these dimensions but rather fluidizes the sediment with enough injected water that the cable can settle into the “soupy” sediments to a minimum depth of six feet below the bottom. The jet plow device is equipped with horizontal and vertical positioning equipment that records the laying and burial conditions, position, and burial depth. The pontoons can be made buoyant to serve different installation needs.

The installation of the submarine transmission cable via jet plow embedment is anticipated to take approximately two to four weeks to complete. As the jet plow progresses along the route, the water pressure at the jet plow nozzles would be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 ft (1.8 m). In the event that the minimum burial depth of 6 ft (1.8 m) below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes would be utilized to achieve the required depth.

### 2.3.6 Landfall Transition Installation

The transition of the interconnecting 115 kV submarine transmission cables from water to land would be accomplished through the use of HDD methodology in order to minimize disturbance within the intertidal zone and near shore area. The HDD would be staged at the onshore landfall area and involve the drilling of the boreholes from land toward the offshore exit point. Conduits would then be installed the length of the boreholes and the transmission cable would be pulled through the conduits from the seaward end toward the land. A transition manhole/transmission cable splicing vault would be installed using conventional excavation equipment (backhoe) at the onshore transition point where the submarine and land transmission cables would be connected.

There would be four 18-inch (457 mm) diameter HDPE conduit pipes (one for each three-conductor 115 kV cable and fiber optic cable set) installed to reach from the onshore transition vaults to beyond the mean low water level. The offshore end would terminate in a pre-excavated pit where the jet plow cable burial machine would start. The four conduits would have an approximately 10 ft (3 m) separation within the pre-excavation area. The four boreholes would be approximately 200 ft (61 m) long (borehole diameters would be slightly larger than the conduit diameter to allow the conduit to be inserted in the borehole).

A drill rig would be set up onshore behind a bentonite pit where a 40 ft (12.1 m) length drill pipe with a pilot-hole drill bit would be set in place to begin the horizontal drilling. A bentonite and freshwater slurry would then be pumped into the hole. The HDD construction process would involve the use of bentonite and freshwater slurry in order to transport drill cuttings to the surface for recycling, aid in stabilization of the in situ sediment drilling formations, and to provide lubrication for the HDD drill string and down-hole assemblies. This drilling fluid is composed of a carrier fluid and solids. The selected carrier fluid for this drilled crossing would consist of water (approximately 95 percent) and inorganic bentonite clay (approximately 5 percent). The bentonite clay is a naturally occurring hydrated aluminosilicate composed of sodium, calcium, magnesium, and iron.

After each 40 ft (12.1 m) of drilling, an additional length of drill pipe is added, until the final drill length is achieved. To minimize the release of the bentonite drilling fluid into Lewis Bay, freshwater would be used as a drilling fluid to the extent practicable for the final section of drilling just prior to the drill bit emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. When the drill bit emerges in the pre-excavated pit, the bit is replaced with a series of hole opening tools called reamers, to widen the borehole. Once the desired hole diameter is achieved a pulling head is attached to the end of drill pipe and then the drill pipe is used to pull back the 18-inch (457 mm) diameter HDPE conduit pipe into the bored hole from the offshore end. As with the pilot hole drilling process, freshwater would be utilized to the maximum extent practicable as the reaming tool nears the pre-excavated pit.

Smaller conduits with pulling wires would be placed inside the 18-inch (457 mm) diameter HDPE pipe to house the submarine cable system. Once the internal cable conduits have been inserted into the 18-inch (457 mm) HDPE conduit, a clay/bentonite medium would be injected into the conduit system to fill the void between the cable conduits and the 18-inch (457 mm) pipe. The conduits would be sealed at both ends until the submarine cable system is ready to be pulled through the conduit. After submarine cable system installation, the conduits would be permanently sealed at each end to complete the installation process.

The HDD operation would include an onshore based HDD drilling rig system, drilling fluid recirculation systems, residuals management systems, and associated support equipment. The HDD drilling material handling equipment would be located on New Hampshire Avenue. The drilling would take place from the onshore to Lewis Bay. Excavated soils would be temporarily stored near the HDD drill rig during construction, and would then be reused onsite or removed and disposed of as required.

To further facilitate the HDD operation, a temporary cofferdam would be constructed in Lewis Bay. The cofferdam would be approximately 65 ft (19.8 m) wide and 45 ft (13.7 m) long and would be open at the seaward end to allow for manipulation of the HDD conduits. The area enclosed by the cofferdam would be approximately 2,925 $ft^2$ (271.7 $m^2$). The cofferdam would be constructed using steel sheet piles driven from a barge-mounted crane. The top of the sheet piles would be cut off approximately 2 ft (0.61 m) above mean high water (MHW). The cofferdam is intended to help reduce turbidity associated with the dredging and subsequent jet plow embedment operations and to provide a visual reference to its location for mariners. While the cofferdams would be located outside of areas normally subject to vessel traffic, the location of the cofferdam would be appropriately marked to warn vessels of the temporary cofferdam presence.

The area inside the cofferdam would be excavated to expose the seaward end of the borehole. Sediment inside the cofferdam would be excavated to expose the area where the HDD borehole would end at an elevation of approximately -10 ft (-3 m) MLLW, with a 1 ft (0.3 m) allowable overdredge. A 20 ft (6.1 m) long level area would be created at the closed end of the cofferdam at this elevation. From that point, the bottom of the excavated area would be sloped at 4 horizontal:1 vertical until it meets the existing seafloor bottom contour. Approximately 840 $yd^3$ (642.2 $m^3$) of sediment would be excavated from within the cofferdam. At the end of cable installation, the cofferdam excavation would be backfilled, rather than allowed to in-fill over time. The dredged material would be temporarily placed on a barge for storage, and then the dredged area of the cofferdam would be backfilled with the dredged material. If necessary, the dredged material backfill material would be supplemented with imported clean sandy backfill material to restore the seafloor to preconstruction grade.

The drilling fluid system would recycle drilling fluids and contain and process drilling returns for offsite disposal, and while the intention is to minimize the discharge or release of drilling fluids to marine or tidal waters in Lewis Bay, the HDD operation would be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay. It is likely that some residual volume of bentonite slurry would be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater "silt fence." This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

It is expected that the HDD conduit systems would be drilled through sediment overburden at the landfall location. However, it is anticipated that drilling depths in the overburden would be sufficiently deep to avoid pressure-induced breakout of drilling fluid through the seafloor bottom based primarily on estimates of overburden thickness and porosity. Nevertheless, a visual and operational monitoring program would be implemented during the HDD operation to detect a fluid loss. This monitoring includes:

- visual monitoring of surface waters in the adjacent Lewis Bay by drilling operation monitoring personnel on a daily basis to observe potential drilling fluid breakout points;
- drilling fluid volume monitoring by technicians on a daily basis throughout the drilling and reaming operations for each HDD conduit system;
- implementation of a fluid loss response plan and protocol by the drill operator in the event that a fluid loss occurs. The response plan could include drill stem adjustments, injection of loss circulation additives such as Benseal that can be mixed in with drilling fluids at the mud tanks, and other mitigation measures as appropriate; and
- use of appropriate bentonite drilling fluids that would gel or coagulate upon contact with sea water.

In the event of an unexpected drilling fluid release, the bentonite fluid density and composition would cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment.

Each of the two landfall transition vaults would be approximately 8 ft (2.4 m) wide by 35 ft (10.7 m) long (outside dimensions). The submarine transmission cables would be spliced to the onshore transmission cables within these transition vaults. The transition vault would contain two 38-inch (965 mm) manholes for access and be installed approximately with its bottom 10 ft (3 m) below grade. The submarine transmission cables would enter through the four 18-inch (457 mm) HDPE conduits and the onshore transmission cables would exit the landfall transition vault to the ductbank system through 6 inch diameter PVC conduits. There would be a total of 16 PVC conduits encased within concrete: 12 transmission cable conduits, two conduits for 96 fiber fiber optic cables for telecommunications, Supervisor Control and Data Acquisition (SCADA) and protective relaying, and two spare conduits for the onshore transmission cable.

It is anticipated that the installation of the borehole and conduit by HDD techniques would take approximately two to four weeks.

Upon completion of the installation of the conduit pipes and submarine cable system, the HDD equipment would be removed and New Hampshire Avenue would be restored to its pre-construction grades and conditions. Standard stormwater erosion and sedimentation controls would be installed on the site prior to the initiation of construction activities, and would be inspected and maintained throughout construction operations. Once construction is completed, all equipment and construction materials would be removed from the site and the area would be returned to its original condition.

### 2.3.7 Onshore Transmission Cable Installation

Construction of the onshore transmission cable would occur in two phases. The first phase would consist of installing the ductbanks, conduits, and vaults. The second phase would consist of the installation of the onshore 115 kV transmission cables, including splices and terminations. Phase I is anticipated to take approximately five months to complete. Phase II is also anticipated to take approximately five months. Once the installation of the duct bank and vaults (Phase I) has progressed significantly from the landfall (approximately 2-3 months), the pulling and splicing of the onshore 115 kV cable (Phase II) would commence behind the duct bank installation crews. Assuming onshore construction commences in September, both Phases of installation are expected to be completed in the 9 month period prior to the following Memorial Day. Therefore, the installation of the onshore components would occur outside of the summer tourist season.

The onshore transmission cable installation, from the transition vault at the landfall to the Barnstable Switching Station, would involve installation of the transmission cable in the underground splice vaults and ductbanks within existing public ways and ROWs. Most excavation would be performed with standard machinery, including excavators and backhoes, with the exception of four railroad/state highway intersection crossings which would be accomplished using trenchless techniques. All work would be performed in accordance with local, state, and/or Federal safety standards. To minimize potential impacts to wetlands, waterbodies, and groundwater during on land construction, particularly trenching activities, Cape Wind has prepared a Draft Stormwater Pollution Prevention Plan (see Appendix C), that includes measures for erosion control, managing stormwater, and soil handling and stockpiling.

Underground onshore transition vaults would be constructed approximately every 500 to 1,700 ft (152.4 to 518 m) (the approximate length of transmission cable that can be effectively transported by truck and pulled within manufacturer's tension specifications). These vaults would accommodate cable splicing and cross-bonding of cable metallic sheaths. Each of the two parallel underground onshore splice vaults utilized at each splice location would be approximately 8 ft (2.4 m) wide by 35 ft (10.7 m) long (outside dimensions) (see Figure 2.3.7-1). The underground onshore transition vaults would be placed approximately 10 ft (3 m) deep (bottom of vault) and each underground vault would contain two 38-inch (965 mm) manholes.

The transmission cables would be installed within a ductbank consisting of PVC conduits spaced approximately eight inches apart (on center) encased in unreinforced concrete (minimum of 2,000 lbs per square inch [psi]), which is backfilled with native material or suitable backfill to original grade. In addition, there would be two copper ground wires placed within the encasement. The trench opening would be a minimum of 10 ft (3 m) wide within the roadways and a minimum of 8 ft (2.4 m) wide within the ROW and supported by temporary trench boxes. The ductbank would be approximately 2 feet high by 5 feet 8 inches wide. Burial depth to the top of the ductbank would be a minimum of 56 inches (1.42 m) within the roadways to allow passage under existing water and gas lines and a minimum of 24 inches (610 mm) within the NSTAR Electric ROW (with the exception of road-crossings along the ROW where the burial depth would revert to 56 inches [1.42 m]). A warning tape would be placed approximately one ft below the surface of the trench opening for dig-in protection. There would be a total of 16 six-inch (152 mm) diameter PVC conduits inside the concrete ductbank. The ductbank would be installed in a single trench (see Figures 2.1.3-4 and 2.1.3-5).

The excavated soil from the trench and vaults would be temporarily stored adjacent to the worksite or transported off-site if on-site storage is not possible. Where soil is stored at the site, it would be stabilized with erosion and sedimentation controls. Following the completion of the installation of the transmission cable, the excavation would be backfilled and repaved. Stormwater erosion and sedimentation controls would be in place prior to the initiation of construction activities. Once construction is completed, all equipment and construction debris would be removed from the site and the area would be returned to its original condition.

To minimize the potential for erosion during construction, mitigation measures, such as hay bales and silt fences would be placed as appropriate around disturbed areas and any stockpiled soils. Prior to commencing construction activities, erosion control devices would be installed between the work areas and downslope water bodies and wetlands to reduce the risk of soil erosion and siltation. Erosion control measures would also be installed downslope of any temporarily stockpiled soils in the vicinity of waterbodies and wetlands. These mitigation measures would be fully described in an Erosion and Sedimentation Control and Storm Water Management Plan, which would incorporate applicable BMPs for erosion control and stormwater management during construction. It is possible that dewatering of the excavated trench or vault locations close to the transition point would be required because of high groundwater. A de-watering plan would be prepared to address the procedures for handling of any water encountered during excavation.

Trenchless technologies would be employed in several areas along the onshore cable route to cross heavily traveled state highway layouts and railroad beds and avoid the disturbances caused by standard construction methods. Trenchless technologies may include HDD, Horizontal Boring, or Pipe Jacking.

In all instances where trenchless technology is used a starting pit would be excavated to initiate the advancement of a casing or carrier pipe. Both boring and pipe jacking require pre-excavated pits on either end of the cable segment to be installed. Shoring of the pit walls and dewatering may be necessary depending upon soil and groundwater conditions. The receiving pit is excavated at the receiving end to accept the casing or carrier pipe. Four carrier pipes would be used to accommodate all the conduits from the duct bank. Depending on the method used the casing is advanced by drilling, boring or simply pushing the casing pipe through the soil. Drilling would be similar to the HDD process discussed above for the shoreline crossing. Boring involves using an auger type drill head that removes soil from the drill hole into the pit, which is then stockpiled or removed from the site, in a manner similar to drilling a hole through a piece of wood. Pipe Jacking involves pushing a casing pipe into the soil, along the desired alignment, and removing the soil from within the casing pipe. The trenchless technology utilized would be selected on a case-by-case basis at each location and would depend on the distance required to advance the carrier pipe beyond the roadway or railroad in question, the nature of the soils at the location, and the space available for mobilization and excavation of starting and receiving pits.

Following the installation of the carrier pipes, transition vaults would be installed to transition between the standard duct bank installation and the carrier pipes.

## 2.4 OPERATION AND MAINTENANCE REQUIREMENTS AND PROCEDURES

### 2.4.1 Introduction

Any WTG, whether operating as an individual unit or within an array, is designed to operate without attendance by any operators. The monitoring is conducted over a SCADA system from a remote location. Such a monitoring station could be within a short radius of the wind turbine, or hundreds of miles away.

The local or regional monitoring center would have an effective level of control allowing remote intervention in the operation of the turbine. Sensors within the turbine’s nacelle gather and transmit data via the SCADA system not only on the electrical performance of the generator itself but also on much of the critical associated equipment. Sensors include thermal, visual (web-cams), audio (microphones), vibrations (accelerometers) and a host of electrical measurements which combine to provide an accurate picture of the operating state of the turbine.

Bearing sensors are now configured throughout the drive train, including within the gearbox casing itself. Not only is the temperature of the gearbox oil monitored, but also the metallic content of it circulating within the cooling system. Changes in bearing temperature, vibration levels, acoustic profile and metallic content within the oil are all early indicators of potential failure. This level of information enables the remote operator to make decisions that would affect the degree of remedy that may be eventually required. Without remote intervention, such as shutting down the turbine, catastrophic failure of the gearbox may occur requiring an expensive and time consuming complete change-out of the gearbox. With early warning it is also possible for the remote operator to decide to reduce the output of the particular wind turbine until such time as a technician can gain physical access in order to determine the precise nature of the problem.

The SCADA system also monitors elements such as navigation and aviation warning lights. However, with today's common use of multiple light-emitting diodes (LEDs) it is very rare that any illumination would be lost completely. Within the same area each access door lock is wired to monitor any attempt to gain unauthorized access to the wind turbine tower and its equipment.

The use of wave height radar detectors and vertically aligned web-cams are also useful to the shore based maintenance crew in determining the actual sea state at the site and judging their ability to gain marine access.

The operation and maintenance (O&M) of an offshore wind farm also includes those elements pertaining to the seabed and its environs. Scouring around the base of the turbine foundation and movement of the marine electrical cables are the most significant elements requiring periodic inspection in order to determine if anything has occurred either as a result of continuous strong currents or, a significant storm.

Service and maintenance falls into two distinctive categories:

(1) The work that only requires personnel activity; and
(2) The work requiring large marine vessel operation.

The latter requires a harbor base that can accommodate vessels with a significant draft whereas crew boats can operate from a typical sailing harbor located as close to the wind farm as possible. While much of the routine service and maintenance operations would likely occur during summer months because of the greater number of days with lower wave heights, other weather windows (approximately three days duration for maintenance of a single WTG) would be used throughout the year in order to minimize wear and tear and the potential for excessive equipment breakdown or parts replacement."

### 2.4.2 Operation

It is anticipated that the main operation center for the proposed offshore farm would be located in the town of Yarmouth. The remote monitoring and command center where all decisions concerning the operation of the marine generating facility would be made would be located here. These operational decisions would also include any instructions received either manually or automatically from the operator of the ISO-NE. It is also to this center that all commands, instructions or requests would be received from government entities with marine and aviation safety and protection jurisdiction, such as the USCG, MMS and the FAA. All operations would be in accordance with MMS requirements, as well as the USCG terms and conditions received for this project (Appendix B).

The service and maintenance personnel would be stationed at one of two additional onshore locations: one for the parts storage and larger maintenance supply vessels and the second located closer to the site for crew transport. The maintenance operation would be based in New Bedford, Massachusetts and would also deploy several crew boats out of Falmouth, Massachusetts.

The New Bedford facility would be located on Popes Island. It would include dock space for two 65 ft (19.8 m) maintenance vessels, as well as a warehouse for parts and tool storage, and crew parking. An off-site warehouse would also be utilized to increase parts storage. The New Bedford facility would house tools, spare parts and maintenance materials and would be organized to support daily work assignments. These would be loaded into small containers, assigned to each of the work teams and loaded onto the maintenance vessel for deployment to the wind farm site. The maintenance vessel would then go to either the WTG or the ESP and offload the containers for the work crews. During maintenance operations, one vessel per day would leave the New Bedford facility, go to the site of the proposed action, and then return.

Additional dock space would be rented in Falmouth Inner Harbor. From this facility work crews would be deployed to either the WTG and/or the ESP in 35 to 45 ft (10.7 to 13.7 m) long crew boats manned by professional mariners. In addition, a high-speed emergency response boat (20 to 25 ft long boat) would be maintained at this harbor ready to respond whenever there is marine activity taking place.

The Control and Monitoring center in Yarmouth would maintain a 24/7 telecommunication protocol with all members of the operation both at management level as well as the engineers. As is normal with such operations a roster system is in place whereby designated personnel are on emergency call-out during the night, weekends and holidays. Night and holiday watch staff at the center would normally be restricted to two persons.

Depending upon the chosen manufacturer of the WTGs the SCADA system would normally monitor the following parameters through remote access:

- **Electrical:**
  - Power (Output/reactive)
  - Voltage
  - Frequency
  - Recorded Power Curve
- **Climate:**
  - Wind speeds
  - Wind direction
  - Temperature
  - Humidity
  - Atmospheric pressure/s
  - Wave heights
- **Turbine:**
  - Temperatures
  - Humidity levels
  - Acoustics
  - Particulates
  - Transformer gases
  - Other

**Service**

While much of the routine service and maintenance operations would likely occur during summer months because of the greater number of days with lower wave heights, other weather windows (approximately three days duration for maintenance of a single WTG) would be used throughout the year in order to minimize wear and tear and the potential for excessive equipment breakdown or parts replacement.

If a WTG required this level of repair, a longer period of low wave heights and suitable weather conditions would be required in order to allow access and suitable working conditions. The duration necessary to complete a repair would be determined and the next available opportunity would be capitalized upon to complete the repair. Given the typically more suitable conditions during summer months, more repairs may occur during summer than winter months.

Planned preventative service and maintenance of a WTG would include:

- Testing of fog horns;
- Cleaning of the machine rooms;
- Changing of carbon brushes;
- Changing of filters for air and all liquids as necessary;
- Topping up of all fluids;[5]
- Replacement of defective instruments;
- Change-out of calibrated anemometers;
- Cleaning of lenses;
- Recharging of auto-grease systems;
- Appropriate local measurements;
- Control of dehumidifiers;
- Torquing of bolts;[6]
- Replacement of brake pads;
- Control / replacement of hazard warning lights; and
- Heavy duty electrical connections.

Routine service, excluding the 100 percent bolt torquing and major oil change is usually a two day exercise for three to four persons. Such a three to four man crew would normally consist of an electrical technician, an electronics/instrumentation technician, a mechanical technician and a general helper.

All personnel would be trained in maritime operations and survival including emergency evacuation of the turbine nacelle. Every operative is equipped with a life jacket and survival suit. Provisions for emergency stays are provided in the event that conditions occur suddenly which precludes offloading of maintenance personnel.

In the event of a medical emergency it would be normal for affected personnel to be evacuated via the access platform near the base of the tower.

Servicing of the offshore ESP would be conducted by the crew of a specialist sub-contractor trained in the service and maintenance of HV equipment. The platform would be similarly equipped with survival equipment and rations to be used in the event of weather prevented egress. As this structure would include a helicopter landing platform, emergency evacuation can be affected by direct conveyance onto the aircraft.

[5] Depending on manufacturers, gearbox oil is usually changed after one year of operation and thereafter every two years. Some manufacturers have longer intervals. For this operation a larger vessel is required than the regular crew boats. Drums of oil must be transported, lifted to the transition platform and hoisted up the tower to the nacelle machine room. Equally, the old oil must be transported in reverse. This operation is usually conducted by a separate team taking approximately one day per turbine. The Project would have a detailed Oil Spill Response Plan (OSRP) (Appendix D) to ensure proper oil handling procedures are used and to provide procedures to address possible contingencies in the use of oil or other potential pollutants.

[6] Torquing of all tower flange bolts is typically conducted after the first 100 hours of operation, and then again after twelve months of operation. Thereafter 10 percent of the bolts of each flange are torque tested on an annual basis.

**Oils, Lubricants, and Coolants**

Operation of the WTGs and ESP requires the use of a variety of oils, lubricants and coolants. The exact manufacturer, products, and quantities to be used will not be known until equipment suppliers are under contract. However, the Draft Cape Wind Oil Spill Response Plan (see Appendix D) provides an initial estimate of the types and volumes to be used during operations and maintenance of the proposed action (ESS, 2007). The largest source is the 40,000 gallons of naphthenic mineral oil to be used on the WTGs for transformer cooling. For the WTGs, several types of bearing and gear lubricants could be used, ranging in quantity from less than 1 gallon to 140 gallons, as well as small amounts of brake, hydraulic, and transmission fluids. Lastly, a water/glycol mix will be used for heat dissipation of the oil coolers.

#### *2.4.2.1 Security Plan*

A detailed security plan will be developed to monitor the Project. This plan will include both video surveillance and visual observations by boat. A manned operations system on land will monitor and maintain communications to ensure that the security of the equipment is not compromised. Access to the turbines will be through a hatch door on the platform that will be locked at all times. The ESP will utilize a similar locked hatch system.

### 2.4.3 Maintenance

Unplanned maintenance on any part of the WTG is carried out in response to a breakdown or failure. This activity may be simple and require only hand tools, in which case the normal crew vessels would suffice. If there is a requirement to exchange larger items, the use of the 65 ft maintenance vessel would be required to transport and lift the particular items. Such items of equipment could be an electrical control cabinet, and 33 kV voltage transformer, generator, gearbox parts, etc. The ability to conduct such operations would depend heavily on the prevailing weather conditions. It is unlikely that such repairs could be carried out where significant wave heights exceed 4.9 ft (1.5 m). Accurate weather forecasting is an essential ingredient in the planning of such offshore operations where a weather window of one to two days is required to complete the task.

#### *2.4.3.1 Maintenance Intervals*

Based on both offshore and onshore WTG operational experience, five days per year per turbine has been established as the anticipated maintenance requirement. These visits cover two days of planned or preventative maintenance, and three days of unplanned or forced outage emergency maintenance. The WTG design is based on a twenty year operating life and all components have been analyzed to meet this design criterion. Based on 5 maintenance days per year for each of the 130 WTGs, the total is equivalent to 650 maintenance days. Based on 252 workdays per year (which adjusts for weather days and holidays) this results in 2.5 work teams or conservatively three teams being deployed. During these deployments, maintenance on the ESP would be included. Experience has shown that wind speeds must be less than 17.9 mph (8 m/s) to gain safe access to the WTGs, although safe access with winds up to 26.8 mph (12 m/s) is possible depending on direction and sea state. Based on these weather related concerns, the number of trips per day could be altered to take advantage of good weather.

The submarine cables would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables would be re-buried. Depending upon the extent of re-burial required, either hand jetting or re-deployment of a jet plow would be used.

#### *2.4.3.2 Number of Vessel Trips*

Based on the above analysis the normal activity would include two vessel trips per working day (252 days/year), which would include one crew boat from Falmouth and the maintenance support vessel from

New Bedford. In addition, an occasional second round trip from Falmouth could take place in times of fair weather or for emergency service.

### 2.4.3.3 Major Repairs

Major repairs are classed as those that require the intervention of a special heavy lift jack-up vessel similar to the one that would have been used during the original construction of the wind farm.

The items requiring replacement include:

- Turbine blades;
- Hub unit;
- Main drive shaft;
- Gearbox; and
- Complete nacelle.

Limitations on jack-up vessels are usually related to the sea state at the time of jacking up/down. Due to the height of their jib crane, they are restricted to lifting when wind speeds are less than 12 m/s (25 mph). If a WTG required this level of repair, a longer period of low wave heights and suitable weather conditions would be required in order to allow access and suitable working conditions. The duration necessary to complete a repair would be determined and the next available opportunity would be capitalized upon to complete the repair. Given the typically more suitable conditions during summer months, more repairs may occur during summer than winter months.

### 2.4.3.4 Inspections

Under the terms of any MMS authorization, MMS would require inspections to take place to ensure worker, structural, engineering and environmental safety. Such inspections would be carried out on a regular basis, as determined by MMS and set forth in the authorizing instrument.

***Blades***: The WTG blades operating in a marine environment tend to be self-cleaning. Deterioration of the measured power curve is an indicator that blade surfaces have become excessively pitted or have a high level of salt encrustation, at which point cleaning of the blades would be undertaken. The degradation mechanisms that affect the structural stability of the blade (and hence also safety) will be inspected on a regular basis.

***Towers***: The WTG tower would normally be inspected externally once every five years unless there are obvious signs of corrosion developing that were not predicted. These visual inspections are conducted from a manned basket lowered from and with the nacelle mounted winch.

***Foundations***: The steel monopile foundations, and their associated transition sections and platforms are inspected on an annual basis usually at the time of the planned service visit. It is the areas within the splash zone that are most prone to corrosion as a consequence of occasional instances of inferior treatment coating during manufacturing or installation.

***Cathodic Protection***: The sacrificial anodes would be inspected on an annual basis and replaced as required.

***Scour Protection***: The seabed around the base of the monopile foundations would have scour protection (scour mats or rock armor) installed in order to provide the required level of protection from scouring. It is prudent to visually inspect the seabed footing after the first year of being installed and thereafter at least on a biennial basis if no initial deterioration has been observed. It may also be prudent to conduct sample surveys after any significant storm activity. Such inspections can be carried out by divers or by the use of Remote Operated Vehicles (ROVs) carrying underwater cameras and lighting.

***Marine cables***: Though the electrical cables are to be buried to a depth of 6 ft (2 m), there would be inspections of these runs conducted during the early years following their laying. A full inspection may be appropriate after the first two years, and thereafter on a random basis conducted at the same time as the scour protection inspections. As with the scour protection, it would also be prudent to conduct such an inspection after the first major storm affecting the area.

### 2.4.4 WTG Work Crew Deployment

The work crews would be transferred from the crew boat to the WTG by exiting the stern of the vessel. This operation would be performed only when the sea conditions are within the workable range of the crew and vessels.

### 2.4.5 ESP Service

The ESP would have a helicopter-landing platform in addition to the boat dock. This would allow for maintenance crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers. The helicopter platform would also allow for emergency evacuation of any individuals who may become injured.

### 2.4.6 Submarine Cable Repair

The potential for a fault occurring during the operational lifetime of a buried cable system is minimal, based on industry experience. However, a cable repair plan would be formulated by the applicant to cover the remote possibility of a fault occurring in the offshore submarine cable system. The focus would be to repair the cable quickly, while minimizing or eliminating environmental and community impacts.

Should a cable failure occur, a cable repair plan would be implemented. Once the location of the fault is identified, should the cable fault occur in the onshore sections of the project, then typical trench, repair and backfill methods would be used and no formal fault plan required. Communication with the appropriate people would take place at least 48 hours prior to repair and would specify the location, method, and date of work. Along the submarine cable, the procedures listed below are one way of repairing a cable fault.

- Mobilize the splice boat and fine tune the location of the fault;
- The splice boat would likely be a barge, equipped with water pumps, jetting devices, hoisting equipment and other tools typically used in repairs of cables;
- Expose the cable with hand-operated jet tools and cut the cable in the middle of the damaged area;
- Position the repair vessel above the cut cable, and raise one end;
- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and one end of the spare cable onboard;
- Pay out cable and move to the other end of the spare cable, keeping a portion of the spare cable onboard;
- Retrieve the other damaged cable end;

- Cut off the damaged portion of the cable;
- Perform a cable splice between the retrieved cable and the remaining end of the spare cable onboard;
- Lower the second joint and position it on the sea bottom;
- Hand jet the repaired and exposed sections into the sea bottom; and
- Demobilize the repair vessel.

## 2.5 DECOMMISSIONING METHODOLOGY

The applicant is required to submit a decommissioning plan to MMS for approval which must comply with MMS's structural removal standards. Upon decommissioning of the facility, the applicant must implement the decommissioning plan to remove and recycle equipment and associated materials, thereby returning the area to pre-existing conditions.

The applicant would be obligated to remove the project once operations have ceased. The applicant would provide a financial instrument or other assurance to the reasonable satisfaction of the MMS, which would secure its obligations to decommission the facility to the satisfaction of MMS and pursuant to the terms of its authorization.

The decommissioning process is largely the reverse of the installation process. Decommissioning can be broken down into several steps, closely related to the major components of the facilities:

- Inner-array cables;
- Submarine transmission cables;
- Turbine generators and towers, monopile foundations, scour mats or rock armor scour protection, ESP; and
- Onshore transmission cables.

It is anticipated that equipment and vessels similar to those used during installation, would be utilized during decommissioning. For offshore work, this would likely include a jet plow, crane barges, jack-up barges, tugs, crew boats, and specialty vessels such as cable laying vessels or possibly a vessel specifically built for erecting WTG structures. For onshore work, traditional construction equipment such as backhoes and cable trucks would be utilized. The environmental impacts from the use of this equipment during decommissioning activities would be similar, although not identical, to impacts experienced during construction as described in Section 5.0.

The decommissioning of the offshore facilities would necessitate the involvement of an onshore disposal and recycling facility with the capacity and capabilities of handling the large quantities of steel, fiberglass and other materials from the Project. Acknowledging the fact that other potential onshore disposal and recycling facilities may exist 20 years from now that may prove to be more desirable, facilities do currently exist that are capable of handling the materials. Prolerized New England Inc. operates several facilities, two which are located in Everett Massachusetts, and Johnston Rhode Island. Prolerized staff has indicated that they have the capabilities and capacity to handle the disposal and recycling of the materials from the proposed action, if it were to take place today. The Everett facility has deep water access, allowing for the steel towers and monopiles to be directly offloaded from the barges, cut into manageable sections, sheared into smaller pieces and then shipped to end-users as scrap metal. For this reason, the Everett facility would be the proposed location for the onshore disposal and recycling of project materials. Currently there is no commercial scrap value for the fiberglass in the rotor blades. The fiberglass from the blades would be cut into manageable pieces and then disposed of as solid waste at an approved onshore facility.

### 2.5.1 Decommissioning Process

The initial step in the decommissioning process would involve the disconnection of the inner-array 33 kV cables from the WTGs. The cables would then be pulled out of the J-tubes, and removed from their embedded position in the seabed. Where necessary the cable trench would be jet plowed to fluidize the sandy sediments covering the cables, and the cables would then be reeled up onto barges. The cable reels would then be transported to the port area for further handling and recycling.

The WTGs would be prepared for dismantling by properly draining all lubricating fluids according to established O&M procedures, and removing the fluids to the port area for proper disposal and/or recycling. This would be followed by the WTGs being deconstructed (down to the transition piece at the base of the tower) in much the same way as they were installed. Utilizing the same or similar types of cranes and vessels as during their construction, the blades, hub, nacelle, and tower would be sequentially disassembled and removed to port for recycling.

Once the wind turbines and towers have been removed, the foundation components (transition piece, monopile, scour mats, and rock armor) would be decommissioned. Sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (4.6 m) below the existing seabottom in order to allow access for the cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. All scour mats would be recovered, brought to the surface by crane, placed on a barge and brought to port for recycling or disposal. In those locations where rock armoring has been used for scour protection, it would be excavated with a clamshell dredge, placed on a barge, and disposed of at an upland location. The monopile would then be cut from the inside at approximately 15 ft (4.6 m) below grade. The sediments previously removed from the inner space of the monopile would be returned to the depression left when the monopile is removed, using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. Depending upon the capacity of the available crane, the assembly above the cut may be further cut into more manageable sections in order to facilitate handling, and then placed on a barge for transport to the port area for recycling. Cutting of the pile would likely be done using one or a combination of underwater acetylene cutting torches, mechanical cutting, or high pressure water jet.

## 2.6 POTENTIALLY POLLUTING AND HAZARDOUS MATERIALS

Construction, operation, and decommissioning would involve the transport, handling, and disposal of material considered to be potentially polluting or hazardous to the environment and humans should they be handled, released, or disposed of in an inappropriate or illegal manner. This section presents the types of oils, lubricants, and greases that would be used, and the measures the applicant has proposed to ensure compliance with relevant regulations and laws.

### 2.6.1 Onshore Groundwater Protection

Most onshore excavation would be performed with standard machinery, including excavators and backhoes, with the exception of four railroad/state highway intersection crossings which would be accomplished using trenchless techniques.

Conduit construction activities would require the use of certain hazardous materials such as diesel fuel, lubricating oils, grease, cleaning solvents, and glues. An accidental release of large quantities of these materials into the environmental could adversely impact soil, surface waters, or groundwater quality. For this project, the on-site storage and/or use of large quantities of materials capable of impacting soil and groundwater will not be required.

Approximately 50 percent of the onshore underground transmission line traverses a Zone II groundwater protection area and two local groundwater protection districts, with the majority of the run occurring in Yarmouth, Massachusetts and the remainder in Barnstable, Massachusetts. These areas are defined as an area of the aquifer which contributes water to a well under the most severe pumping conditions. Certain land uses are restricted and hazardous material use on a permanent basis is strictly regulated. For this project, hazardous material use will be limited to small quantities to support construction. At the time of local permit submittal for road openings in the Town of Yarmouth and the Town of Barnstable, any environmental contingency planning required for hazardous material use during construction will be addressed as part of that permitting process.

### 2.6.2 WTG Fluid Containment

The WTG would utilize lubricating oil, cooling liquids, and grease, all of which would be located in the nacelle or hub. The WTG has been carefully configured to contain any fluid leakage and prevent overboard discharges. The primary WTG components and the fluids are:

- **Hub -** The hub houses the blade pitching system, which is controlled by electric motors and contains only grease to lubricate parts.
- **Main bed plate -** Inside the main bed plate (located in the nacelle) is the oil conditioning system of the gearbox, main bearing, and generator bearings. The fluid capacity of the gearbox and bearings is approximately 190 gallons. As part of the oil conditioning system an oil/water cooling system is also located in the main bedplate. In the event of leaking gear oil or a broken hose/pipe, the leaking oil would be guided through the manhole in the bottom of the bedplate and collected on the upper internal platform of the tower.
- **Tower -** The upper internal platform is designed and sealed in such a way that it can withhold the total amount of gearbox and hydraulic fluid until it can be transferred to containers for safe disposal.
- **Fluids -** The fluids utilized in the various systems include gear oil, mineral oil for the hydraulic system and a water glycol mix for the cooling system.

The possibility of leaks may occur in two different situations: (1) during service and maintenance; and (2) during operation:

- **Service -** During the servicing and maintenance of a WTG, a spill could happen during oil changes of hydraulic pump units or the gearbox oil conditioning system.
- **Operation failures -** During WTG operation, leakage may occur as the result of broken gear oil hoses/pipes, and/or broken coolant hoses/pipes. Gear oil leaks would be contained within the hub and main bed frame and/or tower as described above. Coolant leaks can occur in a number of locations within the nacelle and would be contained inside the nacelle fiberglass cover.

In order to be responsive to small spill incidents associated with maintenance activities, service vessels would be equipped with oil spill handling materials adequate to control and clean up a small accidental spill. In addition, waste collection systems would be installed on board each WTG. The waste collection system is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste would be separated (i.e., used oil, coolant liquids, filters, paper/rags, etc.) for correct disposal once the containers are off-loaded at the dock.

### 2.6.3 ESP Fluid Containment

The ESP would have small amounts of lubricating oil, greases and coolants in pumps, fans, air compressors, emergency generators, and miscellaneous equipment, plus diesel fuel. The ESP would also have four oil-cooled step up transformers.

The primary systems and fluid contained are as follows:

- **Main Transformer -** The four 110-megavolt amp (MVA) oil cooled main step up transformers would each have a capacity of approximately 10,000 gallons (37,850 liters) of dielectric cooling oil. The oil would be circulated through oil/air heat exchangers mounted on the roof of the platform. Each transformer would be mounted in a leak proof detention area that would have the capacity of holding 150 percent of the transformer oil. Each of the detention areas would be connected via valves to a storage tank that has the capacity to store 100 percent of the oil from all four transformers. The oil piping to the coolers and the coolers would be configured so that any failures would result in oil being drained to the detention area.
- **Miscellaneous Equipment -** Various pumps, fans, and an air compressor would be installed on the platform. They would be lubricated with either grease or oil in small quantities. The equipment would be installed in such a way that any leakage would be contained on the sealed deck of the ESP.

The ESP would have sealed, leak-proof decks around the transformers and other equipment where oil and/or other lubricants exist, which would act as fluid containment. In addition, spill containment kits would be available near all equipment. The details of spill containment equipment and related spill control measures would be provided in an Oil Spill Response Plan (OSRP) (see Appendix D) prior to operation of the facility.

The type of insulating oil in general use in large power transformers of the MVA and voltage class proposed for the ESP and in use in existing offshore applications is a highly refined naphthenic mineral oil. Two types are defined by ASTM D-3487: Type I, inhibited, and Type II, uninhibited. The difference is the addition of antioxidants to the Type II oil. While a final decision remains to be made in consultation with the transformer manufacturer during the transformer procurement process, it is anticipated that Type I oil is likely to be specified for the ESP transformers. The specific brand of oil is dependent on the transformer manufacturer and so will not be known until the time of purchase.

Technical data sheets and material safety data sheets (MSDS) for several commercially available brands of transformer oil, both Type I and Type II, are provided in Appendix E. These include:

- Diekan 400, Type I, produced by FINA
- Diekan 410, Type II, produced by FINA
- Diala AX, Type II, produced by Shell
- Transvolt, Type II, produced by Royal Manufacturing Company

Reference to the MSDS will show that specific information on the toxicity to marine life is lacking. What can be culled is that because it is petroleum based the transformer oil will normally float on water and will not readily biodegrade. The hazard to marine life would be from the depletion of oxygen in a slow-flowing waterway that experienced a spill because the surface layer of oil, if allowed to remain, could interfere with natural atmospheric oxygen transport into the water. Non toxic effects could occur to birds or marine mammals from oiling of feathers or fur, which can interfere with the insulating characteristics of feathers and fur and result in harm or death. A spill into the open waters could only occur in the unlikely event of a transformer tank leak and a concurrent failure of the oil containment systems that will be part of the ESP design. Other smaller leaks at the WTGs would most likely be contained within the nacelle. There is an unlikely possibility that spills could occur during transfers of oils and lubricants to and from maintenance vessels to the ESP or WTGs. Also, it should be noted that the individual transformers at each WTG will be the dry type, containing no oil.

The MSDS also note that transformer oil does not bioaccumulate. A spill is subject to reporting under the Clean Water Act (CWA); but transformer oil is not considered a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) nor under the Superfund Amendment & Reauthorization Act (SARA) Sections 302, 311, 312 or 313.

### 2.6.4 Oil Spill Planning, Preparedness, and Response

MMS is the Federal agency responsible for oversight of oil spill planning, preparedness, and response for the proposed action. Specifically, the MMS requires that owners or operators of oil handling, storage, or transportation facilities that are located seaward of the coastline submit oil spill response plans (OSRPs) to MMS for approval prior to operations of that facility. As indicated earlier, the applicant has prepared a Draft Oil Spill Response Plan (draft OSRP) located in Appendix D, dated December 2005, which is intended to satisfy this requirement, upon its finalization prior to the start of construction (ESS, 2007).

The Draft OSRP (Appendix D) provides information on the types and quantities of oils, lubricants and coolants likely to be used (ESS, 2007). The applicant intends to contract with local firms that specialize in marine spill response, with the intended purpose that larger spills will be rapidly controlled and cleaned up, should one ever occur. Additionally, the OSRP describes the processes and procedures that would be used in the event of an oil spill including, but not be limited to the following components:

- Designation of a trained qualified individual;
- Designation of a trained spill management team available on a 24-hour basis;
- Description of the spill-response operating team;
- A planned location for a spill-response operations center;
- Procedures for the early detection of a spill;
- Procedures for spill notification;
- Oil Spill Response Organizations that the plan cites;
- Contact information for Federal, State, and local regulatory agencies that must be notified when an oil spill occurs;
- Methods to monitor and predict spill movement;
- Methods to identify and prioritize the beaches, waterfowl, other marine and shoreline resources, and areas of special economic and environmental importance;
- Methods to protect beaches, waterfowl, other marine and shoreline resources, and areas of special economic or environmental importance;

- Methods to ensure that containment and recovery equipment as well as the response personnel are mobilized and deployed at the spill site; and
- An inventory of spill-response materials and supplies, services, equipment, and response vessels available locally and regionally.

In addition, for on-land construction activities involving land disturbance and the potential for the release of oil and other contaminants into surface water or groundwater, including stormwater, the applicant will have to prepare a SWPPP, which will contain an SPCCP, under the NPDES program of the CWA. In Massachusetts, this program is under the jurisdiction of the USEPA.

## 2.7 POST LEASE GEOTECHNICAL AND GEOPHYSICAL FIELD INVESTIGATIONS

If MMS grants a lease for the proposed action, following issuance of the lease, a marine shallow hazards survey and a supplemental geotechnical program would be conducted prior to construction. The geotechnical and geophysical (G&G) field investigations would be designed to collect sufficient information, coupled with previous site-specific field data, to further characterize the surface and subsurface geological conditions within the vertical and horizontal areas of potential physical effects (APPEs), in preparation for final design and construction. These areas include the offshore construction footprints and associated work areas for all facility components, including the WTGs, the ESP, the inner array cables, and the 115 kV transmission cable to shore.

The shallow hazards survey would be designed to identify and evaluate conditions that might affect the safety of proposed activities, or conditions that might be affected by proposed activities. The supplemental post-lease geotechnical program would further analyze sediments and physical conditions within the proposed action APPEs, for use in final foundation design and to develop site-specific BMPs for constructability.

The survey plan, including the geophysical trackline spacing and coverage necessary to identify and delineate potential shallow hazards, would be finalized post-lease in consultation with the applicant and MMS. The shallow hazards survey would include a detailed geophysical program and would integrate the results of the supplemental geotechnical program, to build upon the previous offshore investigations.

### 2.7.1 Shallow Hazards Survey Geophysical Program

A high resolution geophysical survey (HRGS) would be conducted such that the quality and resolution of the data is adequate to delineate the extent of shallow hazards identified. Potential hazards to be assessed include, but are not limited to (subject to final development of the plan), the following:

- **Seafloor and/or shallow subsurface conditions:** locations, sizes and orientations of sand waves; boulders; man-made anomalies and debris; areas of sub-aquatic vegetation; presence of potential mud diapirs and gas venting features, areas of slope instability, shallow faulting.
- **Subsurface conditions to a minimum target depth of 200 ft (61 m) below the seafloor at the ESP location and 100 ft (30.5 m) at the wind turbine locations:** faults; shallow gas deposits, buried channels; potential for liquefaction, submarine slides, or slumping; and risk of seismic and tsunami events appropriate to the design life of the structures.

Rectilinear geophysical tracklines would be run specifically for the purpose of the shallow hazards assessment, and are anticipated to be oriented to capture expected dip and strike of the Horseshoe Shoal structure (subject to final survey design consultations). Up-to-date bathymetry would be collected using either single-beam or swath bathymetry, depending upon water depth and conditions. Two types of subbottom profiler datasets would be collected: the shallow (Chirp) and intermediate depth (Boomer) subbottom profiler data, the latter with resolution sufficient to penetrate a minimum of 200 ft (61 m) below the seafloor. If subsurface conditions are such that the intermediate Boomer cannot penetrate to the minimum target depth of 200 ft (61 m) below the seafloor, a deep-penetration Boomer profiler system would be used. Sidescan sonar and magnetometer data would also be collected, sufficient to identify potential obstacles on or just below the seafloor within the APPEs.

The shallow hazards geophysical survey would be conducted prior to the supplemental geotechnical program. Data from the survey would be used to finalize the geotechnical sampling locations.

The types of impacts to resource categories due to the geophysical survey are comparable to those resulting from the operation of an inshore lobster-fishing sized vessel. Because the trackline spacing would be finalized post-licensing, based upon the requirements of the selected contractor, the duration of the vessel deployment remains to be determined. At this time, it is expected that the geophysical survey would take several months to complete.

During the survey, an array of geophysical tools would be towed within the water column behind the vessel at certain depths above the seafloor. There would be no disturbance of the seafloor. The vessel would operate approximately 10 hours per day during relatively calm sea conditions in the warmer seasons. The vessel would travel at approximately 15 knots (27.8 km/h) when transiting between port at Falmouth to the survey area (1 hour each way), and at approximately 3 knots (5.6 km/h) during the 8 hours of actual survey time per day. The vessel would continuously transect the area, obtaining an estimated 30 miles (48.3 km) of data each day, before returning to port each night.

### 2.7.2 Supplemental Geotechnical Program

Whereas the geophysical investigations do not involve seafloor disturbance or the collection of samples for analysis, the geotechnical program does involve the use of coring and boring equipment to collect sediment samples for laboratory analyses, which would disturb the seafloor in small discrete locations.

#### *2.7.2.1 Vibracores*

Additional vibracores would be taken along the proposed 115 kV cable route (approximately 2 vibracores per mile [1.6 km]) and along the inner array 33 kV cable routes (1 vibracore approximately every 3.5 mile [5.6 km]). Sediments from some of these vibracores would be evaluated for thermal resistivity for final cable design.

The vibracores would be advanced from a small gasoline-powered vessel likely less than 45 ft (14 m) in length. Approximately 50 additional vibracores are planned at this time, although the final number would be determined in consultation with the selected contractor and final design firm. Up to 6 vibracores can be collected in a field day with favorable bottom conditions and calm seas. The diameter of the core barrel is approximately 4 inches (102 mm), and the cores are advanced up to a maximum of 15 ft (4.6 m). The vessel is anchored during coring.

#### *2.7.2.2 Borings*

Approximately 20 borings additional to the previous 22 would be advanced at selected WTG sites, including those at the approximate corners of the site of the proposed action on Horseshoe Shoal, to span the vertical APPE of the proposed structures, and to collect site specific geotechnical data to assist in final foundation design. The analytical program would address liquefaction potential, gas concentrations in sediments, pressure regimes of gaseous sediments, and gas saturation versus shear strength properties of sediments.

The estimated 20 borings would be advanced from a truck-mounted drill rig placed upon a jack-up barge that rests on spuds lowered to the seafloor. Each of the four spuds would be approximately 4 ft (1.2 m) in diameter, with a pad approximately 10 ft (3 m) on a side on the bottom of the spud. The barge would be towed from boring location to location by a tugboat. The drill rig would be powered by a gasoline- or diesel-powered electric generator. Crew would access the boring barge daily from port using a small boat. Borings generally can be advanced to the target depth (100 to 200 ft [30.5 to 61 m] depending on location) within one to three days, subject to weather and substrate conditions. Drive and wash drilling techniques would be used; the casing would be approximately 6 inches in diameter.

#### *2.7.2.3 Cone Penetrometer Testing (CPT)*

CPT or an alternative subsurface evaluation technique (appropriate to site-specific conditions) would be conducted prior to construction as necessary, to evaluate subsurface sediment conditions. A CPT rig would be mounted on a jack-up barge similar to that used for the borings. The top of a CPT drill probe is typically up to 3 inches (76 mm) in diameter, with connecting rods less than 6 inches (152 mm) in diameter.

#### *2.7.2.4 Report and Maps*

A shallow hazards assessment report, including analytical results of the supplemental geotechnical program, would be submitted to MMS prior to commencement of operations and pursuant to the terms of the MMS authorization. The report would describe surficial and subsurface geologic conditions and geotechnical properties of sediments within the proposed action’s marine APPEs.

# 3.0 ALTERNATIVES TO THE PROPOSED ACTION

The alternatives to the proposed action must be derived from the stated purpose and need. In accordance with the CEQ regulations for implementing the NEPA, reasonable alternatives must be rigorously explored, objectively evaluated and, for those alternatives eliminated from detailed study, a brief discussion on the reasons for elimination must be provided. Additionally, reasonable alternatives not within the jurisdiction of the lead agency must be included in the analysis. Geographical and non-geographical alternatives (including No Action taken) must be analyzed and screening criteria must be clear and conclusive to insure that alternatives considered meet the basic purpose and need and are technologically feasible and economically viable. Discussion on the environmental impacts of the alternatives is first offered in a concise descriptive summary in a comparative form with associated tables. The environmental impacts of the proposed action, no action and considered alternatives are then subject to detailed analysis presented in sections on the affected environment (CEQ § 1502.15) and the environmental consequences (CEQ § 1502.16). The decision maker and the public are then provided with a description of issues and a clear basis for a choice to be made of the options available.

## 3.1 SCOPE OF ALTERNATIVES

To address the requirements under NEPA as described above, MMS conducted a comparison of other potentially reasonable alternative locations for offshore wind facilities in the New England region of the United States. CEQ §1502.14 requires the EIS to examine reasonable alternatives to the proposed action. In accordance with CEQ's guidelines for applying NEPA, reasonable alternatives are defined as those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant. Furthermore, an alternative that is outside the legal jurisdiction of the lead agency must still be analyzed in the EIS if it is reasonable. A potential conflict with local or federal law does not necessarily render an alternative unreasonable, although such conflicts must be considered (CEQ § 1506.2(d)).

The purpose and need of the proposed action is to provide a renewable energy facility that utilizes the unique wind resources offshore of New England using a technology that is currently available, technically feasible, and economically viable, that can interconnect with and deliver electricity to the NEPOOL grid, make a substantial contribution to enhancing the regions electrical reliability and achieving the renewable energy requirements under the Massachusetts and regional RPS. With consideration of this, sites potentially capable of achieving this purpose and need were included in the scope of analysis. Analyzing such sites in this EIS provides the decision-maker as well as cooperating agencies and the public, useful information for understanding the environmental impacts of potential alternatives and comparing such impacts to the impacts of the proposed action.

## 3.2 PRELIMINARY SCREENING ANALYSIS

To select its alternatives for detailed evaluation, MMS first developed a screening process aimed at eliminating those project alternatives which did not meet the purpose and need statement (see Section 1.1) of the proposed action and which were not technically feasible and economically viable with the proposed action. The geographic scope of the alternatives analysis included areas offshore of the New England States.

### 3.2.1 Define Screening Analysis Criteria and Methodology

The criteria used in the screening analysis considered the applicability to the purpose and need for the proposed action, economic viability, and technological feasibility. The alternatives were then subjected to the screening criteria. The failure to meet the described criteria was considered cause for the elimination of the alternative. The geographical and non-geographical alternatives that met the described criteria were then carried with the proposed action and no action alternative to further detailed environmental analysis. The screening criteria described below include applicability to the project's purpose and need, economic viability, and technological feasibility.

### 3.2.1.1 Applicability to the Project's Purpose and Need

Alternatives to be considered for detailed environmental analysis must meet the basic purpose and need as described in Section 1.1. Specifically, alternatives to the proposed action involve exploitation of offshore wind energy resources and the ability to operate with current technology on a scale capable of making a substantial contribution to the state's mandated percentage of energy required from renewable sources.

### 3.2.1.2 Economic Viability

In order to understand whether different alternatives were economically comparable, MMS developed an economic model to assess the economics of offshore wind facilities. The model was used to rank the alternative sites according to their relative economic performance, taking into account the projected schedule for development. The cost of energy was chosen as the measure of economic performance. A detailed description of the economic model as well as independent peer review comments on the model is available in Appendix F.

The results of the economic model show that the site of the proposed action (Horseshoe Shoal site) has the greatest economic potential and that South of Tuckernuck Island, Monomoy Shoals, and the Smaller Project alternatives are generally economically comparable in terms of their cost per kilowatt hour (kWhr), albeit somewhat higher.[7]

#### 3.2.1.2.1 ISO Operation and Cost of Electricity

Electricity producers bid on the price of electricity on an hourly basis and therefore the price paid varies during the day throughout the year. The bidding is based on each producers particular set of costs for generating the electricity and the amount of profit they are trying to make. The New England ISO bidding system has made the production and sale of electricity a highly competitive process where slight changes in generation costs or production levels can have a major affect on profitability. Wind projects are particularly vulnerable to varying production because the source of the fuel (wind) cannot be controlled and hence the instantaneous amount of generation cannot be controlled. This factor alone affects how a wind energy producer would bid into the ISO system and what price they would be paid for their electricity. Since energy production output from a wind energy facility has less certainty than conventional power plants, it is important in assessing alternatives in the siting and design of a wind energy facility to understand factors that affect the generation and the sale of electricity within the ISO operating system, as this affects the profitability and ultimately the viability of the project (Refer to Appendix F).

### 3.2.1.3 Technological Feasibility Requirement

The technological feasibility requirement describes physical criteria that set the parameters within which a project can be constructed and operated, as well as, the technology available for construction and operation. Physical site screening criteria include water depth, extreme storm wave (ESW) height, avoidance of bedrock and large boulders, distance from the generation site to the onshore transmission system, and wind speed.

[7] Cost of energy is defined for this analysis as the starting electricity sales price, in 2007 dollars per KWhr, needed to meet or exceed a specified debt coverage ratio after the project is placed in service. Debt coverage ratios were calculated as the future annual operating cash flow divided by the principal and interest payment for a given year.

#### 3.2.1.3.1 Water Depth

Water depth criteria include both a minimum and a maximum, given current construction method technologies and equipment, and foundation design. The current foundation technology limitations require that offshore wind projects be located in areas of water depths generally less than 100 ft (30 m) in depth to be considered economically feasible. Most existing commercial scale offshore wind projects are sited in areas of water depth ranging from 8 to 65 ft (2.5 to 20 m). Since offshore construction requires large vessels that typically draft at least 7 ft (2.1 m), waters shallower than this are inaccessible. The monopile is the current state of the art for offshore foundations, and this technology is limited by deeper water depths because of the horizontal loading forces of waves and wind. At water depths greater than about 70 ft (21.3 m) the monopile diameter becomes so large and the wall thickness so great in order to withstand the loading over greater height above the bottom, that it is not technologically feasible to manufacture, transport and install a monopile of this design, and a different type of foundation design is required (e.g., multi-legged foundation).

Water depths in the 65 to 147 ft (20 to 45 m) range are currently being pursued on several demonstration projects (such as the Beatrice Demonstrator Project). Depending upon the site specific characteristics of waves, water depths, and bottom conditions, a large commercial scale project could include a variety of foundation types in order to balance technology needs with costs (see Table 3.2.1-1).

#### 3.2.1.3.2 Storm Wave

Storm wave criteria actually reflect a combination of wave heights and water depths, since the energetics associated with a long period swell passing by a wind turbine foundation are different than a breaking wave. As waves come to shore or approach shallow water associated with a shoal, drag on the bottom increases, causing the wave to stack up and assume a more vertical face, which at some point becomes unstable and the top of the wave curls forward and collapses. Waves affect an offshore wind turbine in two primary ways. Either a large wave exerts tremendous horizontal loading on the foundation as it passes by, with the worst case scenario being failure of the structural integrity and collapse of the tower (Report No. 3.2.1-1) or, large waves cause repetitive horizontal movement of the tower, nacelle and rotors that creates excessive wear and tear of moving parts and necessitating increased maintenance and replacement, or a worst case scenario being fatigue and failure of moving parts so that the turbine breaks down more frequently and does not operate enough to cover costs. Also, with greater wave heights the foundation has to extend further above the sea surface before the connection with the tower can be made, since the foundation is the component designed for wave impact and contact with sea water. The larger the foundation, the more costly it becomes. Foundations generally make up roughly 1/4th to 1/3rd of the cost of an offshore wind project.

A 2003 report prepared by the firm Garrad Hassan for the US Army Corps of Engineers, New England District, assessed various environmental design parameters for existing wind projects and those proposed for construction up to 2006 (Morgan et al., 2003). Of the 13 projects for which water depths and the 50 year return storm wave height information was available, 8 had ratios of average water depth to ESW height greater than one and 5 had a ratio less than one. The average ratio of average water depth to ESW for the 13 projects is 1.29. However, if only those in the majority category are included (ratios greater than 1), then the average ratio is 2.0. Based on this, and ignoring other parameters such as geologic conditions and foundation type, it appears that the current industry practice is that the ESW height should be no more than about half of the average water depth within the turbine array for projects located in relatively shallow water. There is anecdotal information that the Blythe project in the UK, with a ratio of about 0.75, is experiencing a significantly accelerated fatigue life from the breaking waves.

A secondary aspect of wave heights that can affect offshore wind project operations and maintenance is the number of days out of the year when wave heights exceed the ability to get maintenance personnel transferred from vessels to the tower in order to do required maintenance. While multiple maintenance crews can be deployed simultaneously to make up for missed days, at some point there is a diminishing return on performing maintenance. If extended periods of time occur when a proportion of wind turbines cannot operate because of breakdown or lack of maintenance, then the generation revenue drops and the project economics suffer. Current technology for maintenance access limits the suitable wave height to approximately 4.9 ft (1.5 m) or less.

#### 3.2.1.3.3 Substrate

Since foundation design is typically 1/4 to 1/3 the total cost of a WTG installation, the type of foundation can have a substantial affect on the overall project costs and the economic viability and profitability of the project. Monopile installation would typically be accomplished by means of a pile driving ram or vibratory hammer to a substantial depth (about 85 ft [26 m] below the seafloor in the case of the proposed action). In areas of bedrock and excessive boulders, driven monopiles cannot be deployed and either a gravity based foundation or a multi-legged foundation is required in order to have a stable foundation on which to erect the tower and generating equipment. Given the greater amount of steel, increased installation costs, and potentially higher maintenance costs, gravity based and multi-legged foundations are generally more expensive than a driven hollow monopile. Also, these other types of foundations create a greater footprint which may exhibit greater environmental impacts. Finally, rocky substrate conditions can make it difficult and or cost prohibitive to bury interconnecting cables below the seafloor. Therefore site selection between alternative locations needs to consider substrate characteristics relative to the type of foundation that can be deployed to support the remaining wind generating equipment. Seabed geology for the regional alternatives was determined by the use of NOAA Charts. Detailed geotechnical data was collected for the proposed action site (see Table 3.2.1-1).

#### 3.2.1.3.4 Transmission Line Distance

Transmission line distances are dependent upon which cable design is being considered. Basically, there are three types of electric transmission cables: pressurized fluid filled AC cables, solid dielectric AC cables, and high voltage direct current (HVDC) cables. Wind projects are typically designed with solid dielectric AC cables because of the ability to relatively easily install miles of cable having low maintenance characteristics, avoiding the pumping systems needed for fluid filled cables, and avoiding the need for converter stations associated with DC current transmission. As the cable length increases, so does the cost for the cable itself as well as installation.

Since the cost of the transmission cable is only one of numerous components of a wind project that are part of the *pro forma* calculations, the determination of a distance that can be used as a criterion is site specific. Of course, there are certain technological limits to some of the cable types that come into play as the cable lengths become very long (TRC, 2006). For example, the fluid filled AC cables typically cannot exceed about 20 miles (32 km) in length because of the limitations on pumping the cooling liquid, and the additional pump stations that would be needed for greater cable lengths. The HVDC cables can be very long, if designed to handle line losses, but they require that converter stations be built to switch the DC to AC flow of electricity. The solid dielectric AC cables that are the industry standard for offshore wind energy projects typically have limits of about 31 miles (49.9 km), and geologic conditions such as thermal resistivity must be taken into consideration when assessing line losses relative to cable length for buried cables (see Table 3.2.1-1 and Report No. 3.2.1-2).

#### 3.2.1.3.5 Minimum Wind Speeds

There is no single minimum wind speed criterion that can be relied on as a siting criterion, because so many factors go into the costs for construction and operation, which must be subtracted from the revenue from the electricity generated. Modern turbines are designed with a minimum cut-in speed that balances the cost of wear and tear against the smaller amount of electricity and therefore smaller revenue generated at lower wind speeds. The typical range for cut-in wind speeds is 7 to 10 mph for commercial scale wind turbines. A project developer needs to consider the site specific wind data versus the revenue generated at low wind speeds and subtract the maintenance costs of running the turbines at lower wind speeds (see Table 3.2.1-1).

#### 3.2.1.3.6 Technology Availability

The current foundation technology limitations require that offshore wind projects be located in areas of water depths generally less than approximately 100 ft (30 m) in depth to be considered economically feasible. One demonstration project, the Beatrice Demonstrator project in the UK is targeting turbine locations in waters up to 150 ft (45 m) to allow collection of information on the design and the economics relative to long term maintenance and operation. Several companies have recently begun exploring the feasibility of floating foundations, yet none are currently available for commercial production.

Foundations for 65 to 147 ft (20 to 45 m) water depths are currently being explored in order to determine their technological feasibility within the requirements for a commercial scale project to be economically viable. Typically, it is expected that to go to these greater water depths would require tri-pod or quadra-pod foundations in order to get the anchoring and stability necessary in deeper water. The Beatrice Demonstrator project has recently completed constructing two WTG in the Miray Forth area of the North Scottish Sea. The project involves a jacketed structure as the foundation (four legs crossed braced) to support the large 5 MW turbine in a water depth of 144 ft (44 m). The economic viability for large scale commercial application of this technology has yet to be determined and most estimates place this design at least 5 to 10 years into the future (see Table 3.2.1-1).

## 3.3 ALTERNATIVES CONSIDERED

### 3.3.1 Geographic Alternatives

In order to conduct a comprehensive evaluation of reasonable alternative locations for an offshore wind energy project that would be capable of serving the New England region, MMS identified and initially screened nine wind farm sites (in addition to the proposed action) along the coast from Maine to Rhode Island. The sites were chosen based on geographic diversity, having at least some potential in terms of wind resources, and the necessary area required for the proposed facility size. The Phelps Bank site was chosen as a result of a comment/request from the Massachusetts Office of CZM that an alternative be evaluated for a site located more than 25 miles (40 km) offshore with water depths less than 150 feet. The Offshore Nauset site was chosen as a result of agency interests in comparing a deep water alternative. The ten sites including the proposed action are as follows:

1. Offshore Portland, Maine
2. Offshore Cape Ann, Massachusetts
3. Offshore Boston, Massachusetts
4. Offshore Nauset, Massachusetts (east of Nauset Beach)
5. Nantucket Shoals (southeast of Nantucket Island, Massachusetts)
6. Phelps Bank (southeast of Nantucket Island, Massachusetts)
7. East of Block Island, Rhode Island
8. Monomoy Shoals (east of Monomoy, Massachusetts)
9. South of Tuckernuck Island
10. Horseshoe Shoals (proposed action)

Figure 3.3.3-1 shows the location of these sites with respect to the New England Coast Line.

### 3.3.2 Non-Geographic Alternatives

Alternatives that include modifications to the proposed action that reduce the scope (smaller or condensed configuration) or temporal impacts (phased development schedule) should be analyzed in an EIS. Non-geographic alternatives must include design alternatives that would decrease pollution emissions, construction impacts, aesthetic intrusion, as well as relocation assistance, possible land use controls that could be enacted, and other possible efforts. Non-geographic alternatives are subjected to the same screening criteria as geographical alternatives. As with geographical alternatives, those that meet the screening criteria are carried forward for further detailed analysis.

The non-geographic based alternatives that were analyzed in reference to the proposed action include:

- Smaller Alternative (half the MW capacity of the proposed action at the same location)
- Condensed Array Alternative
- Phased Development Alternative
- No Action Alternative

### 3.3.3 Alternatives Considered But Screened Out Due to Physical Constraints

Alternative sites were selected based upon their potential to meet the basic purpose and need to utilize offshore wind resources to provide electricity to the New England Power Pool. The application of the physical criteria (Section 3.2.1) resulted in the elimination of seven of the sites from further consideration. Therefore, in accordance with CEQ §1502.14, further detailed analysis was not conducted and the reasons that each site was eliminated is provided in the following discussion (see Table 3.2.1-1).

#### *3.3.3.1 Portland, Maine*

The center of the Offshore Portland Alternative is located 19.3 miles (31 km) east of Portland, Maine. The alternative site would be located somewhere within a 197 square mile (511 $km^2$) area as shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The mean wind resources in this area are between 17.9 and 21.3 mph (8.0 and 9.5 m/s) (Figure 3.3.3-2).

The area around the outer harbor of Portland, Maine (Figure 3.3.3-3) was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to water depth, wave height, and seabed substrate. Specifically:

- Water depths are estimated to average 200 ft (61 m), which would require monopiles of such large size that their construction, transport, and installation would not be technologically feasible. Floating foundations have not been developed for deep water applications and foundation technology adapting oil and gas type floating platform substructures to wind energy applications is not likely to be proven by the date anticipated for project development;
- Open ocean exposure to the east results in ESWs of approximately 90 ft (27 m), which can cause structural failure or excessive turbine fatigue; and
- Seabed geology in this area is likely to include an abundance of shallow bedrock and rock outcroppings that would interfere with WTG foundation installation and embedment of submarine cables (NOAA Chart No. 13286).

In addition to these physical criteria, another potential concern with this site includes its potential to affect migratory movements of whales, particularly the endangered northern right whale, traveling between the Northern Right Whale critical habitats located at the northern and southern extents of the Gulf of Maine.

### 3.3.3.2 Cape Ann, Massachusetts

The center of the Offshore Cape Ann Alternative is located 8.3 miles (13.4 km) east of Cape Ann, Massachusetts. The alternative site would be located somewhere within a 196.4 square mile (508.7 $km^2$) area shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The mean wind resources in this area are between 17.9 and 20.1 mph (8.0 and 9.5 m/s) (Figure 3.3.3-2). The area around Cape Ann, Massachusetts (Figure 3.3.3-4), was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to water depth, wave height, and seabed substrate. Specifically:

- Water depths are estimated to average 150 ft (45.7 m), which would require monopiles of such large size that their construction, transport, and installation would not be technologically feasible. Floating foundations have not been developed for deep water applications and foundation technology adapting oil and gas type floating platform substructures to wind energy applications is not likely to be proven by the date anticipated for project development;
- Open ocean exposure to the east results in ESWs of approximately 62 ft (19 m), which can cause structural failure or excessive turbine fatigue; and
- Seabed geology in this location appears to be primarily gravel, boulder piles and ridges; that would interfere with WTG foundation installation and embedment of submarine cables (NOAA Chart No. 13286).

In addition to these physical criteria, an issue specific to this area which makes it less favorable is that the area is close to the Stellwagen Bank National Marine Sanctuary, and areas of dense whale congregations such as humpback and northern right whales (National Marine Sanctuary Program, 2007). The Sanctuary occupies approximately 42 square miles (108.8 $km^2$) of the OCS east of the coastline of mainland Massachusetts and north of Cape Cod.

### 3.3.3.3 Boston, Massachusetts

The center of the Offshore Boston Alternative is located 14.2 miles (22.9 km) east of Boston, Massachusetts. The alternative site would be located somewhere within a 214.2 square mile (554.8 $km^2$) area shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The mean wind resources in this area are between 17.9 and 20.1 mph (8.0 and 9.5 m/s) (Figure 3.3.3-2). The area around the outer harbor of Boston, Massachusetts (Figure 3.3.3-5) was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to water depth, wave height, and seabed substrate. Specifically:

- Water depths are estimated to average 200 ft (61 m) which would require monopiles of such large size that their construction, transport, and installation would not be technologically feasible. Floating foundations have not been developed for deep water applications and foundation technology adapting oil and gas type floating platform substructures to wind energy applications is not likely to be proven by the date anticipated for project development;

- Open ocean exposure to the east results in ESWs of approximately 75 ft (23 m) which can cause structural failure or excessive turbine fatigue; and
- Seabed geology in this location appears to include a number of relatively large boulder ridges that would interfere with WTG foundation installation and embedment of submarine cables (NOAA Chart No. 13287).

In addition to these physical criteria, the majority of this potential alternative site is within the Stellwagen Bank National Marine Sanctuary, which makes this alternative less favorable due to potential for impacts to marine mammals in the area and conflicts with designated uses of the Sanctuary.

#### *3.3.3.4 Nauset, Massachusetts (East of Nauset Beach)*

The center of the Offshore Nauset Alternative is located 19.3 miles (31.1 km) east of Nauset, Massachusetts. The alternative site would be located somewhere within a 202.3 square mile (524 $km^2$) area shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The mean wind resource in this area ranges from 20.1 to 21.3 mph (9.0 to 9.5 m/s) (Figure 3.3.3-2).

The area offshore of Nauset, Massachusetts (East of Nauset Beach) (Figure 3.3.3-6) was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to water depth and wave height. Specifically:

- Water depths are estimated to average 650 ft (198 m) which would prevent the use of foundations resting on or inserted in the seafloor. Floating foundations have not been developed for deep water applications and foundation technology adapting oil and gas type floating platform substructures to wind energy applications is not likely to be proven by the date anticipated for project development; and
- Open ocean exposure to the east results in ESWs of approximately 55 ft (17 m) which can cause structural failure or excessive turbine fatigue.

In addition to these physical criteria evaluated, another issue is that the site is in close proximity to Northern Right Whale Critical Habitat precautionary area (National Marine Sanctuary Program, 2007).

#### *3.3.3.5 Nantucket Shoals, Southeast of Nantucket Island, Massachusetts*

The center of the Nantucket Shoals Alternative is located 4.8 miles (7.7 km) southeast of Nantucket Island, Massachusetts. The alternative site would be located somewhere within a 210.7 square mile (545.7 $km^2$) area as shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The Nantucket Shoals area southeast of Nantucket Island, Massachusetts (Figure 3.3.3-7) was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to wave height and transmission line distance. Specifically:

- Open ocean exposure to the east results in ESWs of approximately 65 ft (20 m) which can cause structural failure or excessive turbine fatigue; and
- The interconnection distance to shore (assuming landfall in Hyannis) is approximately 41 miles (66 km). This distance exceeds the normal use of AC transmission cables (should be less than approximately 31 miles [50 km]) and would require the use of HVDC transmission cable. HVDC transmission lines have not yet been proven to be a commercially available technology for offshore wind farms. DC transmission may be possible though likely more costly due to requirements to install AC to DC converters. It would not be possible to connect to the existing two

Nantucket Cables that cross from Nantucket to the Cape Cod because of their limited transmission capacity.

#### 3.3.3.6 Phelps Bank (Southeast of Nantucket Island, Massachusetts)

The center of the Phelps Bank Alternative is located 44.4 miles (71.5 km) southeast of Nantucket Island, Massachusetts. The alternative site would be located somewhere within a 210.5 square mile (545.2 $km^2$) area as shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The area around the Phelps Bank (southeast of Nantucket Island, Massachusetts, Figure 3.3.3-8) was evaluated using the Site Screening Criteria described above and not selected for further environmental analysis due to wave height and transmission line distance. Specifically:

- Open ocean exposure to the east results in ESWs of approximately 65 ft (20 m) which can cause structural failure or excessive turbine fatigue; and
- The interconnection distance to shore (assuming landfall in Hyannis) is approximately 67 miles (108 km). This distance exceeds the normal use of AC transmission cables and would require the use of HVDC transmission cable. HVDC transmission lines have not yet been proven to be a commercially available technology for offshore wind farms. DC transmission may be possible though likely more costly due to requirements to install AC to DC converters.

#### 3.3.3.7 East of Block Island, Rhode Island

The center of the East of Block Island Alternative is located 6.4 miles (10.3 km) east of Block Island, Rhode Island. The alternative site would be located somewhere within a 209.5 square mile (54.6 $km^2$) area as shown on Figure 3.3.3-1. Coordinates that bound the alternative location are shown in Table 3.3.3-1. The area east of Block Island, Rhode Island (Figure 3.3.3-9) was evaluated using Site Screening Criteria described above and not selected for further environmental analysis due to wave height and seabed substrate. Specifically:

- Extreme storm waves in the area are estimated to be approximately 50 ft (15.2 m) which can cause structural failure or excessive turbine fatigue; and
- Seabed geology in this location is likely to consist of an abundance of boulders and rock outcroppings that would interfere with WTG foundation installation and embedment of submarine cables (NOAA Chart No. 13288).

### 3.3.4 Other Alternatives Considered But Not Subject to Detailed Analysis

The following additional alternatives were considered in the preparation of this EIS, but were not subject to detailed analysis, for the reasons identified and briefly described below.

#### 3.3.4.1 Onshore Sites

Onshore wind energy projects, as well as other onshore renewable energy technologies, were not subject to detailed analysis in this EIS due to the fact that they do not satisfy the stated purpose and need, as described in Section 1.1. In addition, with respect to wind energy, there are limited contiguous sites in Massachusetts that are capable of accommodating commercial wind energy facilities. As compared to the approximately 14,000 MWs of wind energy capacity currently installed onshore in the United States, Massachusetts has approximately 5 MWs of existing installed wind energy capacity, with an additional 3 MWs capacity under construction (AWEA, 2007). According to DOE wind resource potential maps, Massachusetts onshore wind resources are rated in general by region, where eastern Massachusetts is rated "marginal", central Massachusetts is rated "fair" and some areas of western Massachusetts are rated as "good" (DOE EIA, 2003).

#### 3.3.4.2 Near Shore Waters

The geographic areas defined on Figure 3.3.3.1 included near shore waters on some of the alternatives considered (e.g., Portland, Cape Ann, Block Island). These alternative sites were selected based upon their potential to meet the basic purpose and need as described in Section 1.1. Siting a facility near shore within the geographic confines of each alternative described in Figure 3.3.3.1 was not selected for detailed analysis due to the potential increase in impacts and decrease in wind resources. The application of the physical criteria (Section 3.2.1.3.) to the offshore portion of each area resulted in the elimination of seven of the sites from further consideration. Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### 3.3.4.3 Dispersed Sites

The applicant has proposed a commercial scale alternative energy facility located within a specific contiguous area of the OCS. Distributing the power potential of this proposed project to multiple sites on the OCS (e.g., four locations on the OCS, each with approximately 100 MW of installed capacity) was considered but eliminated from detailed analysis due to the fact that such dispersal of construction and operational impacts throughout the offshore region increases the geographic scope of direct, indirect and cumulative impacts. Additionally, it is believed that such dispersal of generating sites would decrease the efficiency and reliability of the energy production, and the associated costs (i.e., additional cabling and electric service platform installations) would render any such project uneconomic. Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### 3.3.4.4 Tidal In-Stream Energy Conversion (TISEC) Device

TISEC devices are an exciting new renewable energy technology for the marine environment. However, commercial demonstration of such technologies is still relatively unproven, and available tidal resources in New England are considered marginal as compared to other sites nationally. TISEC development would not be consistent with the purpose and need of the proposed action, as described in Section 1.1.

TISEC devices are a similar technology to wind turbines except that they are installed in the water column and are moved by underwater tidal currents. Though the speed of tidal currents is very slow compared to that of wind, the density of water is more than 1,000 times that of air. Therefore, even slow tidal current speeds can generate considerable energy. Since tidal current speeds are predictable, the TISEC technology can be a more consistently reliable source of electric power generation. Because TISEC devices are underwater generation facilities, they avoid aesthetic impacts on the ocean surface or landscape. In addition to the turbines, which must be able to move toward the direction of changing currents or allow for multidirectional flow, the TISEC devices require an anchoring system and an electrical interconnection line to a land-based transmission system.

TISEC device projects must be sited at or near known areas with a strong tidal current regime and tidal current speeds that range from 2 to 4.7 knots (1.02 to 2.4 m/s). In addition, they generally need to be close to onshore transmission lines, either immediately adjacent to or within 0.25 to 0.5 mile (0.4 to 0.8 km) (TRC, 2006).

In general, research shows that New England has marginal resources in terms of tidal power generation relative to other locations across the country (TRC, 2006). For instance, there are many other potential TISEC locations in the United States and/or Canada that have tidal energy levels that exceed the tidal resources in New England. Construction and a full build out of a tidal energy facility would not be expected to take place for several years, and the size of the first pilot projects likely would be small and not able to provide a substantial contribution to the New England and regional RPS. Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### *3.3.4.5 Wave Energy*

Wave energy project development is not consistent with the purpose and need of the proposed action described in Section 1.1. Wave energy conversion takes energy from ocean waves and converts it to mechanical energy that is then converted to usable electric energy. The initial conversion is done using various devices that capture the energy. Research in this area shows that the average power density of waves on the New England coast is approximately half that of California, and therefore the offshore areas of Massachusetts are less likely for development of this technology, especially given the infancy of this new field (TRC, 2006). Construction and a full build out of a wave energy project in New England would still be many years from now, and construction of the first pilot projects likely would be small and not able to provide a substantial contribution to the Massachusetts and regional RPS. Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### *3.3.4.6 Solar (Photovoltaic and Thermal Electric)*

Development of a solar power system (photovoltaic or thermal electric) is not consistent with the purpose and need of the proposed action described in Section 1.1. Photovoltaic (PV) systems used to generate electricity include: (1) flat plate technology, which uses an arrangement of PV cells mounted on a rigid flat surface and exposed freely to incoming sunlight; and (2) concentrator technology, which uses an arrangement of PV cells and lenses to concentrate sunlight on a small area of cells.

Based on the PV systems currently in operation, flat plate technology ranges in size from 50 - 200 kilowatts (kW), while concentrator technology ranges between 2 kW and 200 kW. At these lower power generation levels, PV applications are most feasible and economical for off-grid and consumer applications.

Despite their prevalence in consumer applications, PV systems have the highest energy costs among alternative energy sources (greater than $0.20/kWhr in 2002 as compared to $0.12/kWhr for the Cape Wind project), which may be attributed to the costs of producing the materials used in PV cells and modules (i.e., crystalline technologies). Because of the high capital costs associated with PV systems, coupled with low efficiencies, the technology does not represent a commercially competitive alternative to the proposed action within the timeframe of the proposed action.[8] Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### *3.3.4.7 Ocean Thermal*

Development of an Ocean Thermal Energy Conversion (OTEC) project is not consistent with the purpose and need of the proposed action described in Section 1.1. OTEC is a technology that converts solar radiation to electric power. Since the ocean is composed of layers of water that have different temperatures, it creates a natural thermal gradient. The OTEC systems use this gradient to drive a power-producing cycle, which can produce a significant amount of energy as long as the temperature differential

[8] Some installations have been constructed as a result of public funding, but costs remain high. For instance, a 425- kW PV solar energy system was recently constructed in Brockton, Massachusetts at a cost of $7 per watt. Costs were addressed via a $1.6 million city of Brockton bond, $789,000 grant from the U.S. DOE, and more than $1 million from the Massachusetts Technology Collaborative (MTC) Renewable Energy Trust. The Project would generate 535 MW hours per year and is expected to provide power to 71 homes and result in no emissions (MTC, 2007).

is about 36 °F (20 °C) between the warmer surface water and colder deep water. The oceans cover more than 70 percent of the earth's surface making them the largest solar energy collector and energy storage system. The potential for OTEC as an alternative resource is great; however, the economics of energy production have delayed the financing of a permanent, continuously operating OTEC plant (TRC, 2006).

The natural thermal gradient necessary for OTEC operation is generally found in the tropical zone between the latitudes of 20 degrees North (N) and 20 degrees South (S). As a result, the siting criteria for such facilities are not compatible with the existing conditions found along the coast of New England and the technology as it exists today does not appear suitable for the New England area. Therefore, in accordance with CEQ §1502.14, further detail analysis was not conducted.

#### *3.3.4.8 Floating Wind Turbines*

This technology utilizes a floating structure that provides enough buoyancy to support the weight of a wind turbine. It must also be able to restrain pitch, roll, and heave motions within acceptable limits in order to operate efficiently and safely. A variety of platform, mooring, and anchoring technologies have been proposed for floating wind turbine systems. This technology remains in its infancy and is not expected to be commercially viable for at least 10 to 15 years. As such, development of a marine wind energy project employing this foundation technology is not consistent with the purpose and need of the proposed action as described in Section 1.1.

### 3.3.5 Geographic Alternatives Considered and Subject to Detailed Analysis Including the Proposed Action

In accordance with CEQ regulations for implementing NEPA, alternatives considered that meet the screening criteria are subject to further detailed environmental analysis in the "environmental consequences" section of the EIS which discusses the specific environmental impacts or effects of each of the alternatives including the proposed action and no action. In order to avoid duplication between the alternatives section and the sections of the EIS dedicated to detailed analysis, this section is dedicated to describing and comparing the alternatives to the proposed action with a brief summary of impacts.

The geographic alternatives considered and subject to detailed analysis include the proposed action, South of Tuckernuck Island, and Monomoy Shoals. Alternatives subject to detailed analysis, but not involving a change of location from the proposed action (Smaller Alternative, Phased Development Alternative, Condensed Array Alternative, and No Action Alternative) are examined in Section 3.3.6. Figure 3.3.5-1 shows all of the alternatives that met screening criteria.

#### *3.3.5.1 Horseshoe Shoal - Proposed Action*

##### 3.3.5.1.1 Description

The proposed action entails the construction of an electric generating facility consisting of 130 wind turbine generators arranged in a grid pattern in the Horseshoe Shoal region of Nantucket Sound, Massachusetts. The northernmost WTGs would be approximately 3.8 miles (6.1 km) from the dry rock feature (offshore near Bishop and Clerks) and approximately 5.2 miles (8.4 km) from Point Gammon on the mainland; the southernmost part of the area of the proposed action would be approximately 11 miles (17.7 km) from Nantucket Island (Great Point), and the westernmost WTG would be approximately 5.5 miles (8.9 km) from the island of Martha's Vineyard (Cape Poge) (see Figure 2.1.1-2). The area occupied by the WTGs and ESP is 25 square mile (64.7 $km^2$).

Each of the 130 wind turbine generators would generate electricity independently of each other. For this area of Nantucket Sound, the wind power density analysis determined that orientation of the array in a northwest to southeast alignment provides optimal wind energy potential for the wind turbine generators. The optimal WTG spacing within the array is 0.39 mile (629 m) by 0.62 mile (1,000 m) between each WTG based on wind direction analysis, which corresponds to a 6 x 9 rotor diameter configuration.

Hydrographic surveys indicate water depths are as shallow as 0.5 ft (0.15 m) (MLLW), with depths of up to 60 ft (18.3 m) (MLLW) occurring between the northern and southern legs of the shoal. However, water depth within the portion of the site where WTGs would be sited ranges from 12 to 50 ft (3.7 to 15.2 m) (MLLW). WTG foundations installed in water depths of 10 to 40 ft (3 to 12.2 m) would utilize a 16.75 ft (5.1 m) diameter monopile and in water depths of 40 to 50 ft (12.2 to 15.2 m) would utilize an 18.0 ft (5.5 m) diameter monopile. The extreme wave height in the area is 17.4 ft (5.3 m).

An ESP would be required to be installed and maintained within the approximate center of the WTG array. It would serve as the common interconnection point for all of the WTGs within the area of the proposed action. The ESP would be a fixed template type platform consisting of a jacket frame with six 42-inch diameter (1.1 m) driven piles to anchor the platform to the ocean floor. The 200 ft by 100 ft (61 m by 30.5 m) platform would rest atop a steel superstructure. The platform would be placed approximately 40 ft (12.2 m) above the MLLW datum plane in 28 ft (8.5 m) of water. Each WTG would interconnect with the ESP via a 33 kV submarine cable system. The ESP would provide electrical protection and inner-array cable sectionalizing capability in the form of circuit breakers. It would also include voltage step-up transformers to step the 33 kV inner-array transmission voltage up to the 115 kV voltage level of the submarine cable connection to the land-based system.

Solid dielectric submarine cables from each wind turbine generator would interconnect within the grid and terminate at their spread junctions on an electrical service platform. The electric service platform would serve as the common interconnection point for all of the wind turbine generators. The proposed submarine cable system is approximately 12.5 mile (20.1 km) in total length (7.6 miles [12.2 km] within the Massachusetts 3.5 mile [5.6 km] territorial line and 4.9 miles [7.9 km] on the OCS) from the electric service platform to the landfall location in Yarmouth. The submarine transmission cable system consists of two parallel cables that would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue. The proposed onshore transmission cable route to its intersection with the NSTAR electric transmission ROW would be located entirely along existing paved ROWs where other underground utilities already exist. The remaining portion of the onshore transmission cable route would be located underground within an existing maintained NSTAR electric transmission ROW, terminating at an existing substation.

The cables would be installed between the WTGs and ESP, as well as the transmission line between the ESP and shore, using a jet plow technology that simultaneously loosens sediments to create a space for the cable to be laid in and allows for natural in-filling. The shoreline crossing of the transmission cable would be installed using horizontal directional drilling technology and onshore cable construction would employ standard cable trenching, conduit placement, and cable pulling methods and equipment.

#### 3.3.5.1.2 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

Construction, decommissioning and operation of the proposed action would result in varying levels of impacts to the physical environment, biological resources, socioeconomics and land use, and navigation and transportation. A summary of the impacts within these four major categories is provided below (see Table E-1 in the Executive Summary for additional summary information describing the impacts of the proposed action).

**Physical Resources**

The proposed action would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. The maximum calculated pile driving sound level at any location would be 41 dBA whereas the lowest ambient level measured would be 35 dBA. During operation, the sound levels of the proposed action would range from 19.2 to 25.9 dBA, well below the ambient conditions of 54 to 71 dBA.

In addition to noise impacts, the proposed action would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the proposed action. The quantities of these pollutants would be small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. A summary of total emissions from the proposed action is provided in Table 5.3.1-7. With respect to water quality, impacts would be temporary and localized and result from installation of monopiles and undersea cables. With respect to EMFs, the proposed action would generate a small EMF in the immediate vicinity of the undersea cables and onshore cables. This small EMF is not expected to adversely affect marine or human life (see Section 5.3.1.7 for information on predicted EMF levels for the proposed action at different locations).

Operation of the proposed action is not anticipated to impact hydrodynamics or water quality. The proposed action would require the storage of 40,000 gallons (151,400 liters) of mineral oil on the ESP. Based on analyses conducted, probabilities of a large spill are extremely small.

**Biological Resources**

The proposed action would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no seagrass has been identified close to the footprint of the proposed action, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone.

With respect to avifauna, the proposed action is in Nantucket Sound which is in the general vicinity of Monomoy National Wildlife Refuge and other locations where there are important staging areas and habitat for roseate terns, and least terns (Perkins, et al., 2003) (Details on potential avian species affected are provided in Section 5.3.2.4). With respect to avian T&E species, information on the piping plover suggest that collision mortality associated with the proposed action would result in minor to moderate adverse impacts but would not jeopardize the Atlantic coast population. With respect to the roseate tern, information shows that a low level of WTG collisions can be expected but would only have a minor to moderate affect on the roseate tern population. Detailed analysis of the piping plover and roseate tern are provided in Appendix G.

Subtidal offshore resources would be affected by the monopiles and scour protection associated with WTGs in the area of the proposed action, which results in a hard bottom structure for colonization by benthos. The added structure is expected to attract a variety of finfish to the site, which could improve recreational fishing resources. Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact for the proposed action due to the WTG and ESP piles is 0.67 acres (2,711 $m^2$). The proposed scour protection scenario includes 106 turbines protected by scour mats covering 1.96 acres (7,936 $m^2$) and 24 turbines protected by rock armor covering 8.75 acres (35,417 $m^2$).Additionally, during construction, the total area of temporary impact for the cable that connects the WTGs to the ESP is 580 acres (2.3 $km^2$) and the temporary impact of the area disturbed from installation of the cable from the ESP to the shore is 220 acres (86 acres [0.3 $km^2$] outside the three mile limit, plus 134 acres [0.5 $km^2$] inside the three mile limit) (refer to Table 5.3.2-3).

Marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the proposed action include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. Due to possible proximity to these marine mammals under the proposed action, there is potential for impact to these species during construction and decommissioning as a result of collisions with large construction vessels.

**Socioeconomic Resources and Land Use**

The proposed action would cause an increase in the number of workers to fill the construction requirements of the alternative. The increase would result in approximately 391 full-time jobs during the 27-month period, with fewer workers required for decommissioning. Limited impacts to urban and suburban infrastructure would be anticipated as a result of the proposed action due to the relatively small number of workers relative to the population of the region, the relatively short duration of the work, and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the proposed action.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the Commonwealth, and thus the area of impact is not within an environmental justice population (refer to Section 4.3.3.3).

The proposed action would result in visual impacts to areas along the south coast of Cape Cod as well as areas along the shorelines of Nantucket and Martha's Vineyard that are oriented toward the proposed action (refer to visual simulations of the proposed action at Figure 5.3.3-5). With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the area of the proposed action. The proposed action would be visible from historic properties and from Tribal areas of cultural and religious importance, and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

The area of the proposed action is used for fishing and boating (power and/or sail), and the shoreline areas are used for bird watching, and beach-going and other general recreational activities. The proposed action is not expected to affect overland transportation arteries or airport facilities. The proposed action received FAA approval indicating WTGs in the area would not affect air navigation or associated communication systems (refer to Appendix B). With regard to navigation, the individual turbines would be located either directly on Horseshoe Shoal or in close proximity it, where vessels are less likely to navigate (refer to detailed discussion of navigation in Section 5.3.4). In addition, the turbines would be spaced in a grid of approximately 6 x 9 rotor diameters (629 x 1000 m) which would allow ample room for vessels, including trawlers, to navigate through the area. However, as discussed in Section 5.3.4.4.2, impacts to radar for vessels operating within the WTG array lead to a moderate impact to navigation safety, under certain conditions. The applicant and the USCG have developed mitigation measures (see Section 9.3.4) to reduce the impacts to an acceptable level.

### *3.3.5.2 South of Tuckernuck Island*

#### 3.3.5.2.1 Description

The South of Tuckernuck Island Alternative is approximately 3.79 miles (5.31 km) southwest of Tuckernuck Island in Federal waters (see Figure 3.3.5-1). Water depth within the site ranges between 15 ft and 100 ft (4.6 m and 30.5 m) below MLLW, with an estimated average depth of approximately 57 ft (17.5 m). The extreme wave height estimate in the area is 52.5 ft (16.0 m). The South of Tuckernuck Island Alternative would have the same generation capacity as the proposed action (130 WTG's, 3.6 MW machines plus an ESP), but would require an area of approximately 36 square miles (93.2 $km^2$). The proposed turbine spacing for the South of Tuckernuck Island Alternative is a grid arrangement approximately 9.0 rotor diameters (0.62 mile [1.0 km]) by 6 rotor diameters (0.34 mile [0.629 km]). Configuration of the South of Tuckernuck Island alternative was developed based on avoidance of turbine placement in the Cape and Islands Ocean Sanctuary (M.G.L c.132A, Section 13) while avoiding infeasible water depths.

This site would require foundations to be placed in various water depths ranging from approximately 15 to 100 ft (4.6 to 30.5 m), but still benefits from some sheltering effects from open ocean waves due to Nantucket Island to the east. The South of Tuckernuck Island Alternative would likely require three different sized monopiles and a quad-caisson foundation depending on water depth. Foundations in water depths between 0 and 30 ft (0 and 9.1 m) would utilize a 16.75 ft (5.1 m) monopile, while foundations in water depths between 30 and 45 ft (9.1 and 13.7 m) would utilize an 18.0 ft (5.5 m) monopile, and foundations in water depths between 45 and 65 ft (13.7 and 19.8 m) would utilize a 19.0 ft (5.8 m) diameter monopile. The quad-caisson foundation, a fabricated steel structure, would be utilized for all WTGs installed at a water depth greater than 65 ft (20 m). This structure would consist of four tower foundations that support the tower interface (see Figure 3.3.5-2). This structure would require more fabrication and installation due to its large size and the more challenging sea conditions off the southern coast of Nantucket Island.

The construction sequencing for this alternative would be similar to that described for the Nantucket Sound alternatives. However, rather than the mechanical driving of the structure into the seabed as described for the monopiles, the caissons of the quad-caisson foundation would be set on the seabed and then suctioned into place to the appropriate depth.

The 115 kV transmission cable system for the South of Tuckernuck Island Alternative would consist of the same equipment as described in Section 2.3 of this document. The total length of the interconnect cable route, from the alternative site of the ESP to the Barnstable Substation, would be 33.4 miles (53.8 km). The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-3.

#### 3.3.5.2.2 Comparison of Alternative with Proposed Action

Environmental impacts associated with the South of Tuckernuck Island Alternative would be greater than the proposed action with respect to avifauna, subtidal resources, non-ESA mammals, fish and fisheries, and essential fish habitat, and less than the proposed action with respect to impacts on visual resources. In the remaining resource impact categories, the South of Tuckernuck Island Alternative would have comparable impacts to the proposed action (see Table 3.3.5-1 for a full comparative listing of impacts relative to the proposed action).

With respect to avifauna, the South of Tuckernuck Island Alternative would have a greater potential for impacts to terrestrial, coastal, and marine birds than the proposed action, primarily because of the increased area in which the turbines would be located (the South of Tuckernuck Island Alternative would require an area of approximately 36 square miles (93.2 $km^2$) versus the area of the proposed action, which is 25 square miles (64.7 $km^2$).

With respect to subtidal resources, the additional pilings, cross-braces, and scour protection required at the South of Tuckernuck Island Alternative because of the greater depth at the site, substantially increase (by more than 10 times) the vertical habitat structure available for colonization by benthos for the life of the Project. However, anchoring impacts associated with construction at the South of Tuckernuck Island Alternative would be twice that of the proposed action and would result in greater overall impact to benthos including shellfish. The South of Tuckernuck Island Alternative also would have greater impacts on benthic resources as a result of the much longer interconnection line requirement compared to that of the site of the proposed action. The greater impacts on benthos also result in greater impacts on fish and fisheries and essential fish habitat, which utilize the benthic resources and would be affected due to greater duration of construction and turbidity impacts. The greater size of the foundations at the South of Tuckernuck Island Alternative would also attract greater numbers of fish at the site due to the larger increase in hard bottom structure than the proposed action.

With respect to non-ESA mammals, the South of Tuckernuck Island Alternative is in closer proximity to seal haul-out and breeding sites than the proposed action, and therefore, development at this site has a greater potential to impact seals both during construction and operation. In addition, there is greater potential to impact whales at the South of Tuckernuck Island Alternative than the site of the proposed action since the site is proximate to historical sightings of these mammals.

With respect to visual impacts, generally fewer viewers would see the project at the South of Tuckernuck Island Alternative site compared to the proposed action, because it would be beyond or close to beyond visible range from Cape Cod, which has the major population density in the area (see Figure 3.3.5-4). As a result, there would be less visual impact associated with the South of Tuckernuck Island Alternative than the proposed action.

#### 3.3.5.2.3 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

Construction, decommissioning and operation of the South of Tuckernuck Island Alternative would result in varying levels of impacts to the physical environment, biological resources, socioeconomics and land use, navigation and transportation. A summary of the impacts within these four major categories is provided below. Table 3.3.5-1 summarizes the impacts of the proposed action with the alternatives analyzed.

**Physical Resources**

The South of Tuckernuck Island Alternative would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. The maximum predicted sound levels would occur during construction of the South of Tuckernuck Island Alternative and would be approximately 30 dBA (at the modeled receptor for the South of Tuckernuck Island Alternative at Madaket Beach on Nantucket Island). In addition to noise impacts, the South of Tuckernuck Island Alternative would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the work. The quantities of these pollutants would be small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. With respect to water quality, impacts would be temporary and localized and result from installation and removal of monopiles and undersea cables. These activities would be expected to meet the state water quality designation in the area, since there are no known major sources of pollutant input or other degrading factors. With respect to EMFs, the South of Tuckernuck Island Alternative would generate a small EMF in immediate proximity to the undersea cables and onshore cables, which is not expected to adversely affect marine or human life.

Operation of the South of Tuckernuck Island Alternative is not anticipated to impact hydrodynamics or water quality. The South of Tuckernuck Island Alternative would require the storage of 40,000 gallons (151,400 liters) of naphthenic mineral oil for insulation and cooling of the four 115 kV transformers on the ESP. Based on analyses conducted for the proposed action (Report No. 3.3.5-1), probabilities of occurrence of a large spill at the ESP are extremely small and given the similarity in likely design and activities, this would apply to the ESP for this alternative.

**Biological Resources**

The USFWS (2008), in their publication "Northeast Coastal Areas Study – Significant Coastal Habitats", identifies the area around Tuckernuck Island as being of high conservation significance. The southern half of Tuckernuck Island consists of outwash plains characterized by coastal heathland, a globally restricted and endangered plant community. This community occurs only from Long Island, NY, to Cape Cod, MA. The shallow waters and shoals of Muskeget Channel and the areas surrounding Tuckernuck and Muskeget Islands are highly productive for marine fish, shellfish, and eelgrass (*Zostera marina*), providing rich feeding grounds for terns and gulls in summer and sea ducks in winter. The largest concentration of oldsquaws (*Clangula hyemalis*) in the western Atlantic occurs here (counts of over 150,000 have been recorded), along with thousands of common eiders (*Somateria mollissima*) and three species of scoter (*Melanitta* spp.). In late summer a thousand or more roseate terns (*Sterna dougallii*), a U.S. Endangered species, feed here in preparation for their southward migration.

Extensive sand spits on Tuckernuck, Muskeget, and Skiff Islands (west side of Muskeget Channel off Martha's Vineyard) support rare plants and are favored haul out points for large numbers of harbor and gray seals (*Phoca vitulina* and *Halichoerus grypus*, respectively). One of only two U.S. breeding locations for gray seal is on Muskeget and the island also supports major herring gull (*Larus argentatus*) and great black-backed gull (*Larus atricilla*) colonies. These islands support many State and Federally-listed rare species including: Nantucket shadbush (*Amelanchier nantucketensis*), a candidate species for listing under the Act, several pairs of short-eared owl (*Asio flammeus*), piping plover (*Charadrius melodus*), a U.S. Threatened species, least tern (*Sterna antillarum*), northern harrier (*Circus cyaneus*) and common tern (*Sterna hirundo*).

The South of Tuckernuck Island Alternative would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no seagrass has been identified close to the footprint of the South of Tuckernuck Island Alternative, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone. With respect to avifauna, the South of Tuckernuck Island Alternative is located in close proximity to the South of Tuckernuck Island area, and construction and operation of the South of Tuckernuck Island Alternative would affect the avian resources in this area including impacts to eiders, scoters, long-tailed ducks, and pelagic species, such as shearwaters, storm-petrels, and jaegers.

Subtidal resources would be affected by the monopiles and additional pilings/cross-braces and scour protection associated with WTGs at the South of Tuckernuck Island Alternative, which would have to be designed using a quad-caisson foundation in some areas due to the greater water depths. This foundation design results in a substantial vertical habitat structure for colonization by benthos for the life of the South of Tuckernuck Island Alternative. The added structure is expected to attract a variety of finfish to the site. Anchoring impacts associated with construction and decommissioning would affect a large area of the seafloor causing temporary disturbance of the substrate, and to shellfish. The work would temporarily cause an increase in turbidity, which would result in finfish temporarily avoiding the area and a short term and limited impact to EFH.

With respect to Non-ESA marine mammals, the South of Tuckernuck Island Alternative is in close proximity to seal haul-out and breeding sites and therefore, development at this site has the potential to impact seals both during construction and operation. In addition, there is potential to impact whales at the South of Tuckernuck Island alternative during construction since the site is proximate to historical sightings of these mammals. With respect to T&E species, the South of Tuckernuck Island Alternative could result in temporary disturbance to listed species during construction and decommissioning, including: the federally-endangered roseate tern (*Sterna dougallii*), the federally-threatened piping plover (*Charadrius melodus*) and three federally protected sea turtle species: loggerhead, leatherback, and Kemp's Ridley sea turtles. During operations, impacts would most likely be limited, since these species occurrence in the area is also limited, and operational activities that could impact T&E species are limited.

**Socioeconomic Resources and Land Use**

The South of Tuckernuck Island Alternative would cause an increase in the number of workers to fill the construction requirements of the alternative. The increase would result in approximately 391 full-time jobs during the 27-month period, with fewer workers required for decommissioning. Limited impacts to urban and suburban infrastructure would be anticipated due to the relatively small number of workers relative to the population of the region, the relatively short duration of the work, and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the South of Tuckernuck Island Alternative.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the Commonwealth and thus the area of impact is not within an environmental justice population (refer to Section 4.3.3.3).

With respect to visual resources, the seascape from Tuckernuck Island southwest towards the South of Tuckernuck Island Alternative consists of panoramic open ocean views of the Atlantic Ocean. The South of Tuckernuck Island Alternative would be located close to Nantucket and the east end of Martha's Vineyard and would have visual impact from those locations. However, it would be far away from Cape Cod and would be rarely visible from that area (see Figure 3.3.5-4).

With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the South of Tuckernuck Island Alternative area, and there are no shipwrecks charted in the vicinity of the alternative site. The South of Tuckernuck Island Alternative would be visible from historic properties and from Tribal areas of cultural and religious importance, and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

The South of Tuckernuck Island Alternative is located close to land (Nantucket Island) and the popular boating and recreational area around Nantucket Island. The South of Tuckernuck Island Alternative is not expected to affect overland transportation arteries or airport facilities (the South of Tuckernuck Island Alternative received FAA approval [see Appendix B]). With respect to navigation, the array would be located away from navigational channels and the turbines would be spaced in a grid of approximately 6 x 9 rotor diameters, which would allow ample room for vessels including trawlers to navigate through the area. However, given the radar impacts discussed in Section 3.3.5.2 above, and similar spacing criteria of WTG's between the proposed action and this alternative, navigation safety would be moderately impacted under certain conditions.

### 3.3.5.3 Monomoy Shoals

#### 3.3.5.3.1 Description

The Monomoy Shoals Alternative site is 3.5 miles (5.6 km) southeast of Monomoy Island, within the eastern approach to Nantucket Sound (Figure 3.3.5-1). Water depth within the Monomoy Shoals Alternative site ranges between 13 ft and 34 ft (3.9 and 10.4 m) below MLLW, with an estimated average depth of approximately 24 ft (7.3 m) (Navigational Chart No. 13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001). This alternative would have the same generation capacity as the proposed action (130 WTG's, 3.6 MW machines plus and ESP), but would require a slightly larger area (25.9 square miles [67.1 $km^2$]). The proposed turbine spacing for the Monomoy Shoals Alternative is a grid arrangement approximately 9.0 rotor diameters (0.62 mile [1,000 m]) by 6 rotor diameters (0.39 mile [629 m]). Configuration of the Monomoy Shoals Alternative was developed based on avoidance of turbine placement in the Cape and Islands Ocean Sanctuary (M.G.L c.132A, Section 13) while avoiding infeasible water depths.

The construction and decommissioning methods for the Monomoy Shoals Alternative would be similar to those presented in Section 2.3 of this document for the proposed action. Although driven monopile foundations and jet plow cable embedment are anticipated to be the proposed method of construction, it is possible that bed rock outcroppings and shallow surface bedrock at the Monomoy Shoals Alternative site may necessitate surface laying of the cable or other alternative installation methods. In addition, it is anticipated that the construction and decommissioning time tables for this alternative would be significantly longer than the proposed action, due to more limited accessibility (primarily due to wave conditions).

The 115 kV transmission cable system for the Monomoy Shoals Alternative would consist of the same equipment as described in Section 2.1 of this document. As shown in Table 3.3.5-2, the total length of the interconnect cable route, from the alternative site ESP to the Barnstable Substation, would be 29.8 miles (48 km). Of this amount, approximately 2.9 miles (4.7 km) of cable would be in Federal waters, 21.0 miles (33.8 km) would be in State waters, and 5.9 miles (9.5 km) of cable would be located in an upland transmission ROW. The interconnect cable would be routed from the ESP in a north-northwesterly direction for about 20.6 miles (33.2 km) and then turn north-northeast for about 3.3 miles (5.3 km) before making landfall. The transmission cable would be located approximately 3.0 miles (4.8 km) south of Monomoy Island. The total inner array length of 33 kV cable would be approximately 74 miles (119.1 km). The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-5.

#### 3.3.5.3.2 Comparison of Alternative with Proposed Action

Environmental impacts associated with the Monomoy Shoals Alternative would be greater than the proposed action with respect to avifauna, subtidal resources, non-ESA mammals, fish and fisheries, essential fish habitat, and T&E species, and have less impact than the proposed action with respect to impacts on visual resources and impacts to cultural resources as they relate to visual impacts on historic structures.[9] In the remaining resource impact categories, the Monomoy Shoals Alternative would have

[9] Under the Monomoy Shoals Alternative, the impact categories: subtidal offshore resources, fish and fisheries, and essential fish habitat, have impacts that would be greater than the proposed action but only with respect to construction and decommissioning. Operational impacts would be expected to be the same for these impact categories as for the proposed action.

comparable impacts to the proposed action (see Table 3.3.5-1 for a full comparative listing of impacts relative to the proposed action).

With respect to non-T&E avifauna, Monomoy Island (including the Monomoy National Wildlife Refuge) provides important resting, nesting and feeding habitat for migratory birds, and due to the proximity to Monomoy Island, the Monomoy Shoals Alternative would have greater potential impacts than the proposed action to terrestrial, coastal, and marine birds.

With respect to subtidal resources, construction and decommissioning impacts on benthic habitat would be more for the Monomoy Shoals Alternative than for the proposed action because of the additional interconnection line length, and the greater wave heights, which would prolong the construction time frame. The greater impacts on benthos also would result in greater impacts to fish and fisheries (including shellfish) and essential fish habitat, which utilize the benthic resources and would be affected due to greater duration of construction and turbidity impacts.

With respect to non-ESA marine mammals, the Monomoy Shoals Alternative site is located adjacent to the northwestern extent of a designated Northern Right Whale Critical Habitat whereas the site of the proposed action is located away from this area (NOAA Chart No. 13200, 2005). Due to the location of this Critical Habitat, there is a greater likelihood of construction, decommissioning, and operational impacts to right whales in this area, than in the area of the proposed action. With respect to acoustical harassment, vessel harassment, water quality, and EMF the operational impacts to whales would be expected to negligible to minor. While improbable, an oil spill would have moderate to major impacts on cetaceans within Nantucket Sound. Of the whale species in the area, the right whale population should be considered at greatest risk to being negatively impacted by an oil spill because of the small population size and slow recovery of their numbers from earlier depletion events.

With respect to T&E species, six federally and/or state protected species have nested at the Monomoy National Wildlife Refuge (pied-billed grebe, northern harrier, piping plover, roseate tern, and arctic tern [USFWS, 2001]). As the Monomoy Shoals Alternative is located close to the avian T&E habitat associated with the Monomoy National Wildlife Refuge, avian T&E impacts would be greater than for the location of the proposed action.

With respect to impacts on visual resources, and visual impacts on historic structures, the Monomoy Shoals Alternative is located further from the populated and historic areas of Cape Cod and is thus expected to be beyond view of the most populated area and historic structures than the proposed action.

#### 3.3.5.3.3 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

Construction, decommissioning and operation of the Monomoy Shoals Alternative would result in varying levels of impacts to the physical environment, biological resources, socio-economics and land use, and navigation and transportation. A summary of the impacts within these four major categories is provided below. Table 3.3.5-1 summarizes the impacts of the proposed action with the alternatives analyzed.

**Physical Resources**

The Monomoy Shoals alternative would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. In addition to noise impacts, the Monomoy Shoals Alternative would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the Monomoy Shoals Alternative. The quantities of these pollutants would be small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. With respect to water quality, impacts would be temporary and localized and result from installation of monopiles and undersea cables. With respect to EMFs, the Monomoy Shoals Alternative would generate a small EMF in immediate proximity to the undersea cables and onshore cables, which would not negatively affect marine or human life.

Operation of the Monomoy Shoals Alternative is not anticipated to impact hydrodynamics or water quality. The Monomoy Shoals Alternative would require the storage of 40,000 gallons (151,400 liters) of naphthenic mineral oil for insulation and cooling of the four 115 kV transformers on the ESP. Based on analyses conducted for the proposed action (Report No. 3.3.5-1), probabilities of the occurrence of a large spill at the ESP are extremely small and given the similarity in likely design and activities, this would apply to the ESP for this alternative. However, as mentioned below, however improbable, the consequences of an oil spill at this alternative location has the potential for greater biological impacts to sensitive marine and coastal birds and marine mammals compared to the proposed action.

**Biological Resources**

The Monomoy Shoals Alternative would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no seagrass has been identified close to the footprint of the Monomoy Shoals Alternative, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone.

With respect to avifauna, the Monomoy National Wildlife Refuge is located close to the Monomoy Shoals Alternative, which provides important resting, nesting and feeding habitat for migratory birds. Specifically, Monomoy Island is an important staging area for roseate terns, provides habitat for roseate, common and least tern nesting colonies, harbors roseate and common tern restoration sites, and is a known piping plover nesting area (Perkins, et al., 2003). Due to the proximity to Monomoy Island, the Monomoy Shoals Alternative has the potential to negatively affect both non-T&E and T&E avian species as a result of disturbance during construction and as a result of the potential for collision into existing structures during operation. The Monomoy Shoals Alternative is also located in the vicinity of historic sitings of three federally and/or state protected sea turtle species (loggerhead, leatherback, and Kemp's Ridley sea turtles) and as such, has the potential to impact these T&E species. Further, this alternative is closer than the proposed action, to areas of whale concentration, particularly the designated Critical Habitat for the endangered Right whale.

Subtidal offshore resources would be affected by the monopiles and scour protection associated with WTGs at the Monomoy Shoal, which results in a hard bottom structure for colonization by benthos for the life of the Monomoy Shoals Alternative. The added structure is expected to attract a variety of finfish to the site, which could improve recreational fishing resources. Anchoring impacts associated with construction and decommissioning would affect a large area of the seafloor causing temporary disturbance of the substrate, and to shellfish. The work would temporarily cause an increase in turbidity, which would result in finfish temporarily avoiding the area and a short term and limited impact to EFH.

With respect to non-ESA Marine Mammals, the Monomoy Shoals Alternative site is due east and southeast of gray seal pupping grounds on Monomoy Island. This pupping ground is known to be used year round with the greatest use occurring during the winter and spring (Natural Heritage and Endangered Species Program [NHESP], 2002). Due to proximity to these areas, there is potential for impact to these species during construction and decommissioning as a result of collisions with vessels or harassment due to vessel activities. The Monomoy Shoals Alternative is outside of Nantucket Sound and in a region of greater occurrence of whale species and therefore has the potential to affect both ESA listed whales and well as others protected under the MMPA.

**Socioeconomic Resources and Land Use**

The Monomoy Shoals Alternative would cause an increase in the number of workers to fill the construction requirements of the alternative. The increase would result in approximately 391 full-time jobs during the 27-month period, with fewer workers required for decommissioning. Limited impacts to urban and suburban infrastructure would be anticipated as a result of the Monomoy Shoals Alternative due to the relatively small number of workers relative to the population of the region, the relatively short duration of the work, and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the Monomoy Shoals Alternative.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the state, and thus the area of impact is not within an environmental justice population (refer to Section 4.3.3.3).

With respect to visual resources, the seascape from Monomoy Island east-southeast towards the Monomoy Shoals Alternative site consists of panoramic open views of the Atlantic Ocean. The site is located further from the more populated area of Cape Cod, and thus viewing of the alternative from Cape Cod would be limited. (See Figure 3.3.5-6 for photo simulations of the Monomoy Shoals Alternative). However, the project is located relatively nearby to the Cape Cod National Seashore, and as such, could result in visual impacts to the heavy seasonal and tourism population that visits this area.

With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the Monomoy Shoals Alternative area. The Monomoy Shoals Alternative would be visible from historic structures and from Tribal areas of cultural and religious importance, and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

Fishing and boating (power and/or sail), seal-tours, bird watching, and beach-going are common activities among visitors to and off the waters off of Monomoy Island. The Monomoy Shoals Alternative is not expected to affect overland transportation arteries or airport facilities. With regard to navigation, the turbine array would be located on a shoal away from navigational channels where vessels are less likely to navigate. In addition, the turbines would be spaced in a grid of approximately 6 x 9 rotor diameters which would allow ample room for vessels including trawlers to navigate through the area. However, given the radar impacts discussed in Section 3.3.5.2 above, and similar spacing criteria of WTG's between the proposed action and this alternative, navigation safety would be moderately impacted under certain conditions.

### 3.3.6 Non-Geographic Alternatives Considered and Subject to Detailed Analysis Including No Action

This section evaluates the non-geographic alternatives including: Smaller Project Alternative and the Condensed Array Alternative.

### *3.3.6.1 Smaller Project*

#### 3.3.6.1.1 Description

The Smaller Project Alternative is located in the same area as the proposed action but contains only half the number of WTGs, and thus has half the generation capacity of the proposed action. Each monopile included in the Smaller Project Alternative is located within a footprint of a monopile of the proposed action. For the Smaller Project Alternative, the monopile locations along the north and south sides of the turbine array have been removed, making it further from Cape Cod and from Nantucket than the proposed action (see Figure 3.3.5-1, which shows the Smaller Project Alternative superimposed over the proposed action). Further detail on the location of the Smaller Project Alternative is shown in Figure 3.3.6-1. The transmission cable would be 29.7 miles (47.8 km) long, 23.8 miles (38.3 km) of which would be located under the sea.

#### 3.3.6.1.2 Comparison of Alternative with Proposed Action

The Smaller Project Alternative has less impact than the proposed action in 13 impact categories: noise, air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, cultural resources (as they relate to visual impacts on historic structures) competing uses of waters and sea bed, and port facilities. In the remaining resource impact categories, the Smaller Project Alternative would have comparable impacts to the proposed action (see Table 3.3.5-1 for a full comparative listing of impacts relative to the proposed action).

With respect to noise, construction related noise impacts to humans would be reduced under the Smaller Project Alternative as the alternative would be located further from both Cape Cod and from Nantucket than the proposed action, and because there would be half as many wind turbines to construct and decommission, and hence a shorter construction time than the proposed action. Operational noise would also be reduced due to the smaller number of turbines and their further distance from land.

Air quality impacts would be reduced under the Smaller Project Alternative as overall emissions from the construction and decommissioning vessels would be smaller than those under the proposed action. However, given the limited timeframe of the construction period, the impacts of air emissions from the construction and decommissioning of either alternative would be considered minor on a local and regional scale.

With respect to water quality, the temporary impacts to sediments related to the WTGs are reduced roughly proportional to the number of WTGs, though impacts related to the installation of the 115 kV cable would increase by one mile (1.6 km) as the ESP of the Smaller Project Alternative is further from shore. Because the number of vessels required to transit to and from the Project area during construction would decrease with the Smaller Project Alternative, the probability of marine vessels spilling fuel, lubricating oils or other substances would also decrease over that of the proposed action. In addition, the decrease in size of the ESP under the Smaller Project Alternative would result in a decrease in the total number of gallons of electrical insulating oil utilized on the ESP, and thus the potential size of an oil spill from the ESP would be reduced.

With respect to electric and magnetic field impacts, the Smaller Project Alternative would result in half the generation capacity of the proposed action and thus involve a smaller amount of electrical current in its interconnection cable and smaller EMFs than the proposed action. However, EMF impacts are negligible under the proposed action, and thus reductions in the levels result in no advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

With respect to avifauna, the number of WTGs and the aerial extent of the proposed action would decrease and thus the number of construction/decommissioning events that could potentially displace the birds would similarly decrease over that of the proposed action.

With respect to benthic impacts, the Smaller Project Alternative results in the number of WTGs being reduced to 65. As a result, the temporary impacts to benthic habitat and resources related to the WTGs are reduced roughly proportional to the number of WTGs. Impacts related to the installation of the 115 kV cable limit would increase in proportion to the additional one mile (1.6 km) of cable. During operation, the smaller number of WTGs would reduce the number of structures that would provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and finfish to the monopiles. Overall, the benthic impacts of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and impact area. The reduced impacts on benthos from the Smaller Project Alternative would also result in less impact to fish and fisheries (including shellfish) and essential fish habitat, which utilize the benthic resources.

With respect to non-ESA marine mammals, there would be some potential for reduction of impacts to marine mammals with the Smaller Project Alternative as there would be half as many WTGs and thus half as many vessel trips and chances for vessel strikes during construction.

With respect to T&E species, the Smaller Project Alternative would have a smaller affected area and would therefore reduce impacts to T&E species by limiting disturbance during construction compared to the proposed action. Disturbance associated with construction/decommissioning activities such as increased vessel traffic, presence of equipment, human presence, and noise would be reduced as a result of the smaller project scope and shorter duration of pile driving activities. The Smaller Project Alternative would also result in less interconnection disturbance between the individual WTGs and hence reduce the sediment plumes which could cause fish to avoid the construction site and displace some avian T&E species. The Smaller Project Alternative would reduce the number of wind turbines by half and thus could be expected to reduce the amount of avian T&E collisions predicted for the proposed action by half.

With respect to socio-economic conditions, the Smaller Project Alternative would offer less in terms of socio-economic benefits including number of construction jobs, electricity generated and revenues from taxes, than from the larger proposed action.

With respect to impacts to visual resources and impacts to historic structures, the views of the Smaller Project Alternative result in a somewhat reduced breadth of visual impacts when looking out at the horizon from Cape Cod or Nantucket. In addition, the Smaller Project Alternative is also somewhat further away from Nantucket and Cape Cod (see Figure 3.3.6-2 which shows visual simulations of the Smaller Project Alternative). Construction related visual impacts would also be reduced due to the shorter period of construction, and less time when large construction vessels would be visible.

With respect to competing uses, the Smaller Project Alternative is smaller than the proposed action and hence would have even less of a potential to impact competing uses in the area.

#### 3.3.6.1.3 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

The following discussion is presented under the four categories of physical resources, biological resources, socioeconomic resources and land use, and navigation and transportation.

**Physical Resources**

The Smaller Project Alternative would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. In addition to noise impacts, the Smaller Project Alternative would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the Smaller Project Alternative. The quantities of these pollutants would be very small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. With respect to water quality, impacts would be temporary and localized and result from installation of monopiles and undersea cables. With respect to EMFs, the Smaller Project Alternative would generate a small EMF in the immediate vicinity of the undersea cables and onshore cables, which would not negatively affect marine or human life. Noise impacts from the Smaller Project Alternative would be limited to noise resulting from pile driving and vessel use. Noise during operation would result from the WTGs themselves.

Operation of the 65 WTG layout is not anticipated to impact hydrodynamics or water quality. The Smaller Project Alternative would require the storage of 20,000 gallons (75,700 liters) of oil on the ESP. Based on analyses conducted, probabilities of a large spill are extremely small. Based on analyses conducted for the proposed action (Report No. 3.3.5-1), probabilities of the occurrence of a large spill at the ESP are extremely small and given the similarity in likely design and activities, this would apply to the ESP for this alternative.

**Biological Resources**

The Smaller Project Alternative would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts to terrestrial vegetation and terrestrial fauna other than birds would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no sea grass has been identified close to the footprint of the Smaller Project Alternative, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone.

With respect to avifauna, the Smaller Project Alternative is in the Nantucket Sound which is in the general vicinity of Monomoy National Wildlife Refuge and other locations where there are important staging areas and habitat for roseate terns, and least tern (Perkins, et al., 2003). The types of avian resources affected for the Smaller Project Alternative are the same as those for the proposed action (refer to Section 5.3.2.4) though potential impacts would be less due to the smaller number of turbines.

Subtidal offshore resources would be affected by the monopiles and scour protection associated with WTGs at the Smaller Project Alternative, which results in a hard bottom structure for colonization by benthos for the life of the Smaller Project Alternative. The added structure is expected to attract a variety of finfish to the site which could improve recreational fishing resources. Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles is 0.33 acres (1,335 $m^2$) for the Smaller Project Alternative. In addition, the installation of the 33 kV cable needed to connect the WTGs to the ESP would require 29.7 miles (47.8 km) of cable and 258 acres of benthic impacts (1.04 $km^2$). The temporary impacts to benthos would also result in temporary avoidance of the area by finfish and temporary impacts to EFH and shellfish.

Marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the vicinity include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. Due to possible proximity to these marine mammals under the Smaller Project Alternative, there is potential for impact to these species during construction and decommissioning as a result of collisions with vessels.

**Socioeconomic Resources and Land Use**

The Smaller Project Alternative would cause a decrease, as compared to the proposed action, in the number of workers to fill the construction requirements of the alternative. The Smaller Project Alternative would result in numerous jobs during the 27-month construction period, with fewer workers required for decommissioning. Limited impacts to urban and suburban infrastructure would be anticipated as a result of the Smaller Project Alternative due to the relatively small number of workers relative to the population of the region, the relatively short duration of the work, and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the Smaller Project Alternative.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the Commonwealth, and thus the area of impact is not within an environmental justice population (refer to Section 4.3.3.3).

The alternative would result in visual impacts to areas along the south coast of Cape Cod as well as areas along the shorelines of Nantucket and Martha's Vineyard that are oriented toward the WTG array (refer to visual simulations at Figure 3.3.6-2). With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the area of the Smaller Project Alternative. The Smaller Project Alternative would be visible from historic structures and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

The area of the Smaller Project Alternative is used for fishing and boating (power and/or sail), and the shoreline areas are used for bird watching, and beach-going and other general recreational activities. The Smaller Project Alternative is not expected to affect overland transportation arteries or airport facilities. The proposed action received FAA approval indicating WTGs in the area, which include WTGs under the Smaller Project Alternative, would not affect air navigation or associated communication systems (refer to Appendix B). With regard to navigation, the turbine array would be located on a shoal away from navigational channels where vessels are less likely to navigate. In addition, the turbines would be spaced in a grid of approximately 6 x 9 rotor diameters which would allow ample room for vessels including trawlers to navigate through the area. However, given the radar impacts discussed in Section 3.3.5.2 above, and similar spacing criteria of WTG's between the proposed action and this alternative, navigation safety would be moderately impacted under certain conditions.

### *3.3.6.2 Phased Development*

#### 3.3.6.2.1 Description

The Phased Development Alternative would utilize the same site as the proposed action and would employ the same transmission cable system layout (see Figure 3.3.5-1), but it would be constructed in two phases with time in between to allow monitoring of operations. The Phased Development Alternative could provide the potential to reduce impacts in the second phase based on evaluation of construction and operational impacts associated with the first phase and making changes to construction and or operational procedures or design. However, at this time any such reductions in impacts based on analysis of the first phase are uncertain and can not be anticipated in this alternatives analysis. In order to facilitate the study of a phased approach to constructing 130 WTGs, it was determined that for illustrative purposes, a 50/50 split would be most effective. A split in the proposed action of 130 WTGs into two phases was accomplished by dividing the project into an eastern half and a western half; each containing 65 WTGs (see Figure 3.3.6-3). The initial 65 WTG phase would be designed to allow expansion to 130 WTGs with as little re-construction as possible. The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system cables) used in this Phased Development Alternative are the same as presented in the proposed action.

**Phase I**

The western half of this alternative would be constructed during the first phase primarily because the 65 westernmost turbine sites would be located in the shallower waters of Horseshoe Shoal and would be in closer proximity to each other allowing for the least amount of inner array 33 kV cable for interconnection to the ESP. This would be the least costly construction of the two phases, thereby reducing interest costs of financing during construction on the overall two phase project. Assuming that assurances were in place for the completion of both phases, the ESP and the complete 115 kV transmission system (both circuits for the offshore and upland components) would be completed during Phase I allowing for power from the first 65 WTGs to be transformed and transmitted into the regional power grid. Both the ESP structure and the complete 115 kV cable system (both circuits) would be the same as those for the proposed action; however some portion of the electrical equipment on the ESP would be delayed until the second phase. The construction of the ESP and the installation of the 115 kV transmission cable along the eastern edge of the first phase eliminates (to the greatest degree possible) the need to conduct Phase II installation activities (eastern half) within the area of the operating first phase of the project. Phase I would include 65 turbines connected in 7 full strings (each made up of 8 to 10 WTGs) and one partial string (3 WTGs), requiring approximately 32.7 miles of 33 kV inner array cable (see Figure 3.3.6-3).

**Phase II**

The eastern half of this alternative would be constructed during the second phase. In general, a project developer would seek to minimize the time between the construction of the first and second phases in order to minimize the lag time and costs associated with:

- Procurement of equipment
- Staging area acquisition and build out
- Mobilization of construction and installation equipment and labor
- At sea construction

For analysis purposes, Phase II would be scheduled within a reasonable time frame of five to ten years to coincide with the state's continued desire for renewable energy sources should renewable energy still be mandated. Construction of Phase II within five years would not be considered a phased approach due to the short length of time between construction cycles. Construction of Phase II beyond ten years is not considered reasonable due to anticipated change to the underlying purpose and need for this project.

The balance of the ESP electrical equipment required for the additional 65 WTGs would be installed during Phase II. For the purposes of this analysis it is assumed that both circuits of the complete 115 kV cable system would be installed during the first phase. Phase II would include 65 turbines connected in 6 full strings (each made up of 9 or 10 WTGs) and the addition of 7 WTGs to one partial string of 3 WTGs that would have been installed in Phase I. Phase II would require approximately 34.0 miles (54.7 km) of 33 kV inner array cable (see Figure 3.3.6-3).

**Decommissioning**

Because it is assumed that all of the WTGs would have the same effective useful life (approximately 20 years), the decommissioning of the Phased Development Alternative would also be conducted in phases to correspond to the phased construction and duration of lag time. Phase I of the decommissioning would remove the WTGs, scour protection and inner array cables that were installed 20 years prior during Phase I (western half of the Project). Following a period of time equal to the lag between construction phases, Phase II of the decommissioning would take place 20 years after the completion of the Phase II construction and would remove the eastern half WTGs, scour protection and inner array cables, along with the ESP and the interconnecting 115 kV transmission system. Similar to the construction phases, the decommissioning of the Phased Development Alternative would require multiple mobilizations/demobilizations and staging and is expected to have similar impacts as the phased construction.

### 3.3.6.2.2 Comparison of Alternative with Proposed Action

The Phased Development Alternative would have greater impact during construction and decommissioning than the proposed action for 10 of 28 impact categories (air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, and recreation and tourism). The impacts on these categories during operation would be similar to the impacts of the proposed action during operation. There would be no change in impacts for the other 18 impact categories for the Phased Development Alternative compared with the proposed action during construction, operation, or decommissioning (see Table 3.3.5-1 for a full comparative listing of impacts relative to the proposed action).

With respect to air quality, construction and decommissioning under the Phased Development Alternative would have more impacts due to the multiple mobilizations, demobilizations and staging operations. In addition, the multiple phases would result in increased air emissions from the construction vessels and equipment due to the increased total number of vessel trips and/or the duration of deployment required to complete the project as compared to the proposed action. With respect to the operation of the Phased Development Alternative, the impacts to air quality would be similar to the proposed action.

With respect to water quality, construction and decommissioning under the Phased Development Alternative would have more impacts due to the multiple mobilizations, demobilizations and staging operations. The longer duration of deployment, increased number of vessel trips required to complete the project, and phased build-out of the ESP would result in a greater probability of a marine vessel spilling fuel, lubricating oils or other substances.

With respect to non-T&E avifauna, construction and decommissioning impacts would be greater for the Phased Development alternative than for the proposed action because of the longer timeframes of the additional mobilizations and demobilizations of major construction vessels for pile driving and WTG installation/decommissioning related to each distinct phase. The total number of vessels required to complete the construction and decommissioning would also be greater than required for the proposed action, increasing potential impacts. With respect to the operation of the Phased Development Alternative, the impacts to non-T&E avifauna would be similar to the proposed action.

With respect to subtidal offshore resources, construction and decommissioning impacts on benthic habitat would be more for the Phased Development Alternative than for the proposed action because of the multiple mobilization and demobilizations that would be required and the multiple anchoring activities associated with the cable-laying and decommissioning activities. The greater impacts on benthos also would result in greater impacts to fish and fisheries (including shellfish) and essential fish habitat, which utilize the benthic resources and would be also affected by the multiple phases of construction and decommissioning. With respect to the operation of the Phased Development Alternative, the impacts to benthic habitat and resources, fish and fisheries would be similar to the proposed action.

With respect to non-ESA marine mammals, construction and decommissioning under the Phased Development Alternative would have more potential impacts due to the multiple mobilizations and demobilizations. The number of vessels required for each phase would increase, creating a greater potential for vessel strikes and underwater noise associated with the operation of the construction vessels. With respect to the operation of the Phased Development Alternative, the impacts to non-ESA marine mammals would be similar to the proposed action.

With respect to T&E species, impacts would be increased under the Phased Development Alternative due to the longer construction and decommissioning timeframes resulting from multiple mobilizations, demobilizations and staging operations. With respect to the operation of the Phased Development Alternative, the impacts to T&E avifauna and marine species would be similar to the proposed action.

With respect to visual resources and recreation and tourism, construction and decommissioning under the Phased Development Alternative would have more impacts due to the extended construction/decommissioning timeframe, multiple mobilizations, demobilizations and staging operations and increased construction vessel traffic. With respect to the operation of the Phased Development Alternative, the impacts to visual resources and recreation and tourism would be similar to the proposed action (see Figure 5.3.3-1).

#### 3.3.6.2.3 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

Construction, decommissioning and operation of the Phased Development Alternative would result in varying levels of impacts to the physical environment, biological resources, socio-economics and land use, and navigation and transportation. A summary of the impacts within these four major categories is provided below.

**Physical Resources**

The Phased Development Alternative would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. In addition to noise impacts, the Phased Development Alternative would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the Phased Development Alternative. The multiple mobilizations and demobilizations would result in an increase in air emissions from the construction vessels and equipment required for the Phased Development Alternative but would still be small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. With respect to water quality, impacts would be temporary and localized and result from installation of monopiles and undersea cables. The potential for oil spills during construction is slightly greater due to the overall construction duration being more extended due to two mobilizations/demobilizations, and a slightly greater number of vessel trips to and from the site. In addition, the Phased Development Alternative would delay the installation of some portion of the electrical equipment on the ESP until the second phase, presenting a second potential of oil spill during installation and transfer. With respect to EMFs, the Phased Development Alternative would generate a small EMF in immediate proximity to the undersea cables and onshore cables, which would not negatively affect marine or human life.

**Biological Resources**

The Phased Development Alternative would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no seagrass has been identified close to the footprint of the proposed action, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone.

With respect to avifauna, the Phased Development Alternative is in Nantucket Sound which is in the general vicinity of Monomoy National Wildlife Refuge and other locations where there are important staging areas and habitat for roseate terns, and least tern (Perkins, et al., 2003). With respect to avian T&E species, information on the piping plover suggest that collision mortality associated with the Phased Development Alternative would result in minor adverse impacts but would not jeopardize the Atlantic coast population. With respect to the roseate tern, information shows that a low level of WTG collisions can be expected but would only have a minor affect on the roseate tern population.

Subtidal resources would be affected by the impacts to soft-bottom benthic communities that would occur during the cabling activities of the construction and decommissioning periods. Temporary impacts to benthic resources would be caused by anchoring activities associated with the cable-laying activities (anchors, anchor line sweep, jet plow pontoons), the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of the scour control structures that would occur over both phases of the Phased Development Alternative. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings and scour protection for the WTGs and ESP, which would result in a hard bottom structure for colonization by benthos. The added structure is expected to attract a variety of finfish to the site, which could improve recreational fishing resources. The total area of permanent benthic impact for the Phased Development Alternative once fully constructed is the same as the proposed action. The WTG and ESP piles would result in 0.67 acres (2,711 $m^2$) of impact and the total area of temporary impact for the cable that connects the WTGs to the ESP would be 580 acres (2.3 $km^2$). The temporary impact of the area disturbed from installation of the transmission cable system from the ESP to the shore would be 220 acres(0.89 $km^2$) (86 acres [0.34 $km^2$] outside the three mile limit and 134 acres [0.54 $km^2$] inside the limit).

Marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the Phased Development Alternative include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. Due to possible proximity to these marine mammals under the Phased Development Alternative, there is potential for impact to these species during construction and decommissioning as a result of collisions with vessels which is further augmented by the multiple mobilizations, demobilizations and staging operations required for the Phased Development Alternative.

**Socioeconomic Resources and Land Use**

The Phased Development Alternative would cause an increase in the number of workers to fill the construction requirements. Limited impacts to Urban and Suburban Infrastructure would be anticipated as a result of the Phased Development Alternative due to the relatively small number of workers relative to the population of the region and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the Phased Development Alternative.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the Commonwealth, and thus the area of impact is not within an environmental justice population.

The Phased Development Alternative would result in visual impacts to areas along the south coast of Cape Cod as well as areas along the shorelines of Nantucket and Martha's Vineyard that are oriented toward the Phased Development Alternative. Visual impacts would be the same once the Phased Development Alternative was operational. With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the area of the Phased Development Alternative. The Phased Development Alternative would be visible from historic properties and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

The area of the Phased Development Alternative is used for fishing and boating (power and/or sail), and the shoreline areas are used for bird watching, and beach-going and other general recreational activities. The Phased Development Alternative is not expected to affect overland transportation arteries or airport facilities. The Phased Development Alternative received FAA approval indicating WTGs in the area, which include WTGs under the Phased Development Alternative, would not affect air navigation or associated communication systems. With regard to navigation, the turbine array would be located on a shoal away from navigational channels, where vessels are less likely to navigate. The multiple mobilizations, demobilizations and staging operations required for the Phased Development Alternative would result in a greater number of vessels for an extended period of time impacting the local navigation; however these impacts would still be minor. In addition, the turbines would be spaced in a grid of approximately 6 x 9 rotor diameters which would allow ample room for vessels, including trawlers, to navigate through the area. However, given the radar impacts discussed in Section 3.3.5.2 above, and similar spacing criteria of WTG's between the proposed action and this alternative, navigation safety would be moderately impacted under certain conditions.

### *3.3.6.3 Condensed Array*

#### 3.3.6.3.1 Description

In designing an offshore wind energy project, turbine spacing is considered which effectively balances the capture of the wind resource (and ultimately the power production), with a number of site specific physical and economic constraints such as water depth and watersheet use. Wind turbines need to be spaced far enough apart to reduce adjacent row wind wake effects (in order to optimize wind park efficiency) and to reduce structural fatigue from turbulence created by the wake effect. As a general rule, manufacturers of the WTGs recommend a minimum spacing of greater than 5 rotor diameters in order to avoid catastrophic structural fatigue and guarantee efficiencies (Seifert and Kronig, 2003).

In order to facilitate the study of a Condensed Array Alternative with 130 WTGs, a 6 x 6 rotor diameter spacing was chosen as a reasonable example that falls within the range of some existing offshore wind energy projects (see Table 3.3.6-1). The Condensed Array Alternative would maintain the same ESP location as the proposed action, and therefore the interconnecting 115 kV transmission cable system would remain the same in all aspects of design, length, installation and routing as the proposed action (see Figure 3.3.5-1). Both the ESP structure and the complete 115 kV transmission cable system (both circuits) would be the same as those proposed for the proposed action. The WTG locations in the proposed action currently are spaced approximately 6 rotor diameters apart in the north-south "columns" of the array. The 130 WTGs of the Condensed Array Alternative have been arranged with the same central column of WTGs as the proposed action's "F" column (WTGs F1 through F14) (see WTG array in proposed action at Figure 2.1.2-1), all maintaining the same location with 6 rotor diameters separation. The WTGs of the proposed action are separated by 9 rotor diameters within the east-west "rows." To reduce the spacing within these rows to 6 rotor diameters for the Condensed Array Alternative, the WTGs to the west of the ESP and the "F" column have been shifted to the east, and WTGs to the east of the ESP and the "F" column have been shifted to the west, providing for a 130 WTG array with 6 x 6 rotor diameter spacing condensed around a similar ESP location as the proposed action.

The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system) used in this Condensed Array Alternative are the same as presented in the proposed action. The WTGs in the Condensed Array Alternative have been arranged in similar interconnecting strings (14 strings of 8 to 10 WTGs each) as the proposed action (see Figure 3.3.6-4). The overall inner array 33 kV cable lengths would be reduced slightly to 58 miles (93 km) (from 66 miles [106 km] for the proposed action). The reduction (approximately 12 percent) would not be proportionate to the 25-30 percent east – west reduction of the condensed array because the inner array cables of the proposed action have been arranged to minimize overall length by maximizing the use of the shorter north – south transects and minimizing the cabling east to west.

The footprint area of the Condensed Array Alternative is approximately 16 square miles (41.4 $km^2$) (as compared to 25 square miles [64.7 $km^2$] for the proposed action). The distances to shore are presented in Table 3.3.6-2. If the Project's spacing were reduced to a 6 x 6 grid, modeling shows that the power production for the proposed 130 WTGs would be measurably reduced. The reduction in power is especially important in the summer months because of the typically high spot prices of electricity that occur in the summer compared to the rest of the year.[10] As a result, even a small loss of power from a denser configuration in the summer months compared to other months of the year would produce a disproportionally greater reduction in revenue for the applicant even though on an annual production basis the reduction in MWs produced might be considered minor. The assessment can be quantified as follows:

$$X = (((P1 - P2) \times ((L1 \times R2) + ((1-L1) \times R1))) / (((P1 \times (1-L2) \times R1) + (P1 \times L2 \times R2)) \times Y)) \times 100\%$$

Where:

P1 = production from a 6 X 9 array [configuration of the proposed action]
P2 = production from a 6 X 6 array [denser configuration]
L1 = percent of (P1 – P2) during peak power pricing hours
L2 = percent of year yielding peak power pricing (assumed to be large enough to consume all losses created by L1)
R1 = average rate/megawatt hour (MWHr) – during non-peak power pricing periods
R2 = average rate/MWHr – during peak power pricing periods
Y = percentage of net revenue to gross revenue
X = percentage loss in net revenue due to denser (6 X 6) configuration

#### 3.3.6.3.2 Comparison of Alternative with Proposed Action

The Condensed Array Alternative would have greater impact than the proposed action for the competing uses impact category during construction, operation, and decommissioning. Additionally, the Denser Configuration Alternative would have less impact during construction for eight impact categories: noise, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species. Of these impact categories noise and water quality would be expected to have similar impact as the proposed action during decommissioning while the other 6 would have a lesser impact. There would be greater expected impact compared to the

[10] The spot market for electricity is calculated on an hourly basis and can vary widely just within the span of a single hot summer day. While it is known that power costs are highest in the summer, it is not possible to predict future summer electricity prices.

proposed action during operation for the avifauna and threatened and endangered species impact categories. The remaining 19 impact categories would have the same level of impact as the proposed action during construction, operation, and decommissioning (see Table 3.3.5-1 for a full comparative listing of impacts relative to the proposed action).

With respect to construction noise, impacts to humans would be slightly less under the Condensed Array Alternative because of the increased distance to shore from the perimeter WTG pile driving. Impacts from operational noise, both above and below water, from the Condensed Array Alternative are expected to be the same as those of the proposed action.

The distance the construction and maintenance vessels must travel from the proposed staging area in Quonset RI to reach the furthest WTGs on the eastern edge of the Condensed Array Alternative is slightly less than the proposed action. This minor reduction is offset by the increased travel distances to reach the nearest WTGs on the western edge of the Condensed Array Alternative from Quonset. As a result, there would be no significant change in air emissions between the two alternatives during construction.

With respect to water quality, water quality impacts related to construction of the Condensed Array Alternative would be less than the proposed action due to the 8 mile (12.9 km) reduction in the amount of 33 kV cabling required.

With respect to avifauna, the 8 mile (12.9 km) reduction in inner-array cable installation would slightly reduce impacts during construction and decommissioning. With respect to operations, the denser spacing is expected to have a greater “barrier” effect due to the higher concentration of structures, thereby increasing the potential for avoidance, collision or other impacts during operation.

With respect to subtidal offshore resources, the Condensed Array Alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts during construction and decommissioning to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 $km^2$). The decrease in length of the 33 kV cable would also decrease temporary impacts to fish and fisheries, and EFH as a result of decreased area of turbidity and disturbed sea bottom. Impacts to T&E species would also be slightly less than for the proposed action as the shorter construction timeframe for the 33 kV cable would result in less disturbance to T&E avian species that could be in the vicinity.

With respect to marine mammals, there is a slightly reduced chance for vessel strike due to the shorter inner-array cabling activities involved with the Condensed Array Alternative compared to the proposed action. With respect to visual resources, visual impacts during construction and decommissioning activities would not be expected to be significantly different than construction related visual impacts of the proposed action. With respect to visual impacts during operations, the overall breadth of impact of the Condensed Array Alternative would have less of a visual impact than the proposed action. However, the concentration of structures would be increased for the Condensed Array Alternative, and thus the visual intrusion of the portion of the Condensed Array Alternative that is visible, would create more of an impact than the proposed action.

With respect to competing uses, vessels involved in commercial fishing within the area of the proposed action would experience increased competing use impacts due to the tighter spacing between the WTGs, which would make navigation more difficult.

#### 3.3.6.3.3 Summary of Impacts on Physical, Biological, Socioeconomic Resources and Land Use, and Navigation and Transportation

Construction, decommissioning and operation of the Condensed Array Alternative would result in varying levels of impacts to the physical environment, biological resources, socio-economics and land use, and navigation and transportation. A summary of the impacts within these four major categories is provided below.

**Physical Resources**

The Condensed Array Alternative would result in impacts to above water and underwater ambient sound levels as a result of construction and decommissioning activities and to above water sound levels as a result of operation. In addition to noise impacts, the Condensed Array Alternative would result in air quality impacts from vessels and equipment involved in the pre-construction G&G investigations, and construction, decommissioning, and maintenance phases of the Condensed Array Alternative. The mobilization and demobilization phases would result in a temporary increase in air emissions from the construction vessels and equipment required for the Condensed Array Alternative but would still be small in relation to other air pollution sources in the general region and would not have a noticeable effect on air quality. With respect to water quality, impacts would be temporary and localized and result from installation of monopiles and undersea cables. With respect to EMFs, the Condensed Array Alternative would generate a small EMF in the immediate proximity to the undersea cables and onshore cables, which would not negatively affect marine or human life.

**Biological Resources**

The Condensed Array Alternative would affect terrestrial vegetation and terrestrial fauna via its upland portion of the interconnection line. The upland portion of the interconnection line would be located within an existing previously disturbed and maintained utility ROW, and thus impacts would be limited. Impacts to coastal and intertidal vegetation, would also be limited since no seagrass has been identified close to the footprint of the proposed action, and HDD technology would be used at landfall to avoid impacts to vegetation along the intertidal zone.

With respect to avifauna, the Condensed Array Alternative is in Nantucket Sound which is in the general vicinity of Monomoy National Wildlife Refuge and other locations where there are important staging areas and habitat for roseate terns, and least tern (Perkins et al., 2003). The denser array associated with the alternative may result in impacts to avian populations as a result of disturbance or collisions with the WTGs.

Subtidal resources would be affected by the impacts to soft-bottom benthic communities that would occur during the cabling activities of the construction and decommissioning periods. Temporary impacts to benthic resources would be caused by anchoring activities associated with the cable-laying activities (anchors, anchor line sweep, jet plow pontoons), the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of the scour control structures that would occur over both phases of the Condensed Array Alternative. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings and scour protection for the WTGs and ESP, which would result in a hard bottom structure for colonization by benthos. The added structure is expected to attract a variety of finfish to the site which could improve recreational fishing resources. The total area of permanent benthic impact for the Condensed Array Alternative due to the WTG and ESP piles is 0.67 acres (2,711 $m^2$). The length of the 33 kV cable under the Condense Alternative that would connect the WTGs to the ESP would be 58.0 miles (93.3 km), which would result in temporary impacts to 504 acres (2.0 $km^2$) of benthic habitat. The temporary impact of the area disturbed from installation of the transmission cable system from the ESP to the shore is 86 acres (0.34 $km^2$).

Marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the Condensed Array Alternative include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. Due to possible proximity to these marine mammals under the Condensed Array Alternative, there is potential for impact to these species during construction and decommissioning as a result of collisions with vessels which is further augmented by the multiple mobilizations, demobilizations and staging operations required for the Condensed Array Alternative.

**Socioeconomic Resources and Land Use**

The Condensed Array Alternative would cause an increase in the number of workers to fill the construction requirements. Limited impacts to urban and suburban infrastructure would be anticipated as a result of the Condensed Array Alternative due to the relatively small number of workers relative to the population of the region and capacity of existing infrastructure including housing, emergency services and transportation to address the needs of the Condensed Array Alternative.

With respect to environmental justice, a socioeconomic analysis was conducted and showed that the counties within the area of impact had a lower percent minorities than the rest of the Commonwealth, and a lower percentage of people living under the poverty level than the rest of the Commonwealth, and thus the area of impact is not within an environmental justice population.

The Condensed Array Alternative would result in visual impacts to areas along the south coast of Cape Cod as well as areas along the shorelines of Nantucket and Martha's Vineyard that are oriented toward the Condensed Array Alternative. With respect to cultural resources, no submerged historic properties or archaeological sites are recorded in the area of the Condensed Array Alternative. The Condensed Array Alternative would be visible from historic properties and thus would affect cultural resources as a result of such visual impacts.

**Navigation and Transportation**

The area of the Condensed Array Alternative is used for fishing and boating (power and/or sail), and the shoreline areas are used for bird watching, and beach-going and other general recreational activities. The Condensed Array Alternative is not expected to affect overland transportation arteries or airport facilities. The Condensed Array Alternative in the same general vicinity as the proposed action which received FAA approval indicating there would not be an effect on air navigation or associated communication systems. Thus the Condensed Array Alternative would also be expected to not affect air navigation or associated communication systems. With regard to navigation, the turbine array would be located on a shoal away from navigational channels, where vessels are less likely to navigate, though the 6 x 6 rotor diameter grid spacing would require mariners to navigate more carefully in the area to avoid collisions with the WTGs. Given the radar impacts discussed in Section 3.3.5.2 above, and the smaller spacing criteria of WTG's with this alternative, navigation safety would be at least moderately impacted under certain conditions.

### *3.3.6.4 No Action*

#### 3.3.6.4.1 Description and Comparison with Proposed Action

Under the No Action Alternative, the resulting environmental effects from taking no action are compared with the environmental effects of authorizing the proposed action or selected alternative. The opportunity for development of a wind power generating facility would not occur or be postponed. The potential environmental impacts resulting from the proposed action would not occur or would be postponed. All impacts, positive and negative, associated with the proposed action would be eliminated. The incremental contribution of any of the proposed action to cumulative effects would also not occur. Strategies that could provide replacement resources for the loss of potential energy production and their associated impacts are discussed in detail in Section 5.4.6.

#### 3.3.6.4.2 Summary of Impacts Under the No Action Alternative

Under the No Action Alternative, the proposed action would not be constructed and the associated impacts detailed in Section 5 would not occur. The No Action Alternative evaluated other strategies for addressing the demand for electricity in New England if the proposed action were not constructed and the viability of those strategies and impacts associated with those other strategies. In general, other than wind energy, only fossil fueled generating technologies would be able to address the electric generation output level of the proposed action within the same timeframe of the proposed action. As a result, impacts associated with the No Action Alternative would come from the burning of fossil fuels for energy production. Specific impacts would depend on the type of fossil fuel used (natural gas, oil, coal) the technology and pollution control systems chosen, and site specific issues associated with individual electric generation facilities.

For a gas fired facility, the principal pollutant of concern is $NO_x$. Emissions of $NO_x$ result from the combustion of nitrogen contained in fuel and the air supplied for combustion. $NO_x$ contribute to the formation of ground level ozone and acid rain. Natural gas facilities also emit VOC and carbon monoxide (CO) as a result of incomplete fuel combustion, which occurs to some degree even in state-of-the-art combined cycle combustion turbines (CCCT) systems being installed today. Although efficient combustion techniques employed in today's combustion turbines combined with the use of relatively clean burning natural gas reduce VOC and CO emissions below any other fossil fuel fired combustion technology, large quantities of these pollutants would still be emitted. In addition to the emissions of criteria pollutants, a gas-fired facility would also emit non-criteria pollutants and $CO_2$. Non-criteria pollutants include Hazardous Air Pollutants (HAPs), which the EPA considers of special concern and for which the EPA has developed national emission standards for specific source categories such as combustion turbines. Some of the HAPs emitted by a natural gas fired combustion turbine include formaldehyde, xylene, toluene, and benzene.

Oil and Coal facilities would also emit the previously referenced pollutants, and in addition would emit substantial quantities of $SO_2$, which contributes to acid rain, sulfate deposition and can react with other compounds in the atmosphere to form particulates. Particulate Matter also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash). Elevated particulate levels have been attributed to a variety of health effects such as respiratory ailments, especially in the young and the elderly. Finally, all fossil fuel facilities would emit $CO_2$, a greenhouse gas.

In addition to air pollution, fossil fuel fired electric generation can use large quantities of water for cooling and may result in water quality impacts or other localized impacts depending on siting such as impacts to wetlands, rare and endangered species, visual impacts, etcetera. A more detailed cost benefit analysis describing impacts under the No Action Alternative is provided in Section 5.4.6.

## 3.4 TRANSMISSION CABLE SYSTEM SITING ALTERNATIVES

On September 17, 2002, the applicant and NSTAR jointly filed a petition with the EFSB and a petition with the DPU to construct, operate and maintain two new 115 kV electric transmission cables to interconnect the proposed action with the regional electric grid in New England.

As part of its review process, the EFSB was required to evaluate whether there is a need for additional transmission resources and evaluate the proposed action in terms of its consistency with providing a reliable energy supply to the Commonwealth with a minimum impact on the environment at the lowest possible cost. A project proponent must present to the EFSB alternatives to its planned action which may include: (a) other methods of generating, manufacturing, or storing electricity or natural gas; (b) other sources of electrical power or natural gas; and (c) no additional electric power or natural gas.

The applicant identified and presented four alternatives to the EFSB that would potentially meet its project need, each of which could provide reliable service for the applicant's proposed action. These approaches included connecting the proposed action: (1) to NSTAR's 115 kV Barnstable Switching Station; (2) to NSTAR's 115 kV Harwich Substation; (3) to NSTAR's 115 kV Pine Street Substation in New Bedford; and (4) to a new 115 kV substation on Martha's Vineyard, then proceeding on to the mainland.

Upon its review, the EFSB concluded that the Martha's Vineyard Alternative did not warrant further consideration because of the magnitude of increased cost over the Barnstable Interconnect without any offsetting benefits. Although the Harwich and New Bedford Alternatives would be somewhat less costly than the Martha's Vineyard Alternative, each would cost approximately $50 million more than the Barnstable Interconnect. Because the Barnstable Switching Station is the major bulk substation on Cape Cod, with six 115 kV transmission lines available to carry energy to various parts of Cape Cod, interconnection at this location would provide high reliability in that energy from the proposed action could be reliably delivered to the grid even if one of the lines emanating from the Barnstable Switching Station is out of service. Therefore, the EFSB determined that, all other considerations being equal, a direct connection at the Barnstable Switching Station provides greater reliability than an indirect connection through another, smaller substation at a greater distance from the Barnstable Switching Station.

The EFSB found that the Barnstable Interconnect was preferable to both the Harwich and New Bedford Alternatives with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost. In addition, the EFSB found that, with the implementation of the proposed mitigation and conditions, the environmental impacts of the proposed facilities along the primary route would be minimized with respect to marine construction impacts, land construction impacts and permanent impacts. Therefore, the EFSB approved the applicant and NSTAR's proposal to construct two approximately 18 miles (29 km), 115 kV underground electric transmission cables along the primary route identified by the applicant.

The applicant has conducted a comprehensive analysis to identify the best route to provide the needed transmission interconnection from the facility to the mainland electrical grid system. A detailed assessment of alternative routes was conducted that concluded that the route proposed would be preferable to alternative routes with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost (EFSB, 2004).

# 4.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

## 4.1 PHYSICAL RESOURCES

For purposes of describing the physical resource characteristics of the proposed action area, this material is presented in the following seven subsections: geology, noise, physical oceanography, climate and meteorology, air quality, water quality, and electrical and magnetic fields.

### 4.1.1 Regional Geologic Setting

The site of the proposed action is located in the Atlantic Coastal Plain physiographic province. The geomorphologic setting can best be described as glacially produced. The surficial expression of Cape Cod and Nantucket Sound were formed during the advance and retreat of the last continental ice sheet in the northeastern United States, part of the Laurentide glaciation, and the subsequent erosion and reworking of the glacial deposits during the Holocene (10,000 years ago to the present) sea-level rise. Figure 4.1.1-1 (see Appendix A for all Figures) presents an interpretation of the glacial processes that formed Cape Cod and Nantucket Sound.

In the area of the proposed action, the maximum advance of the last continental glaciation is marked by the advance of the Cape Cod ice lobe, and the formation of terminal moraines on Martha's Vineyard and Nantucket, estimated at approximately 20,000 years ago. During this advance, it is thought that subglacial tunnel valleys carrying meltwater and sediment, extended south from Cape Cod to the ice margin near Martha's Vineyard and Nantucket, and eroded into the underlying fine grain sediments (Uchupi, E. and Mulligan, A.E., 2006).

As the continental ice sheet retreated, a proglacial lake formed in Nantucket Sound, resulting in the deposition of clays and fine sand. During this retreat, the ice sheet stalled along the southern shore of Cape Cod, depositing unstratified, poorly-sorted, ice-contact deposits of silt, clay, sand, gravel, and boulders (see area "III" in Figure 4.1.1-1). As ice-sheet retreat continued, this unstratified glacial deposit formed a dam and a second glacial lake formed to the north (see area "IV" in Figure 4.1.1-1). Fine-grained sediments were deposited into this second glacial lake. As the ice-sheet continued to retreat, this second dam, located along the southern shore of present day Cape Cod, failed, and the glacial lake on Cape Cod joined glacial Lake Nantucket. This event was followed by failure of the dam that formed Lake Nantucket, resulting in extreme erosion of the glacial lake and basement sediments. As the ice-sheet continued to retreat, fluvial deposition resulted in the formation of outwash plains on Cape Cod and Nantucket Sound (U.S. Geological Survey [USGS], 2006a; Uchupi, E. and Mulligan, A.E., 2006).

As the ice-sheet continued to retreat, another glacial lake formed to the north, in Cape Cod Bay, north of the present day Cape Cod outwash plains and the moraine that formed in central Cape Cod. The water level in this glacial lake was higher than today's sea-level, and groundwater seeps formed on the outwash plain. The unique combination of sand and gravel outwash plains and plenty of source water emanating from the seeps resulted in the formation of straight fluvial valleys that flowed south across the present day Cape Cod outwash plains and Nantucket Sound (Mulligan, A.E. and Uchupi, E. 2004; USGS, 2006a).

During this glacial event, world-wide sea-level was hundreds of feet lower than current levels, and the Earth's crust was depressed by continental glacial loading. As the Laurentide ice sheet continued to melt, sea-level continued to rise, ultimately transgressing over the present day offshore sediments in the project area, drowning the lower reaches of the straight fluvial valleys that had formed, eroding and reworking the glacial deposits along the southern Cape Cod coastline and in Nantucket Sound, a processes that continues today (USGS, 2006a).

Figure 4.1.1-2 presents the present day regional onshore surficial geology of Cape Cod, Martha's Vineyard, and Nantucket. Figure 4.1.1-3 presents the present day regional surficial geology of Nantucket Sound. Figure 4.1.1-4 presents surface sediment types in the proposed action area of Nantucket Sound.

To further understand the regional sedimentary features, two regional geologic cross sections were constructed. Figure 4.1.1-5 presents the locations of two cross sections, identified as A-A′ and B-B′. Figure 4.1.1-6 presents the geologic cross section A-A′, which begins onshore in southwestern Cape Cod, extends through the site of the proposed action in Nantucket Sound, and continues to Nantucket Island. Figure 4.1.1-7 presents geologic cross section B-B′, which begins on Martha's Vineyard, extends through the site of the proposed action, and continues onshore in the mid-Cape Cod region.

### 4.1.1.1 Site-Specific Studies Analysis

Field studies were completed to further refine the understanding of the geology at the site of the proposed action as it relates to the seafloor, sub-seafloor, and onshore cable route. Studies were targeted to detail water depths, surface and sub-surface sediment types, seafloor morphology, sub-seafloor stratigraphy, and natural or man-made obstructions as they relate to installation, operation, and decommissioning of the proposed facilities. Benthic and archaeological samples were incorporated into the geotechnical field programs, where applicable (Report No. 4.1.1-1). Integrated marine geophysical/hydrographic surveys and geotechnical/sediment sampling programs were conducted in 2001, 2002, 2003, 2004, and 2005 on Horseshoe Shoal and along the proposed transmission cable route from the ESP to the proposed landfall location in Yarmouth.

Numerical modeling and engineering analysis of site specific data related to oceanographic processes was performed to assess, simulate, and predict potential impacts to geologic resources for installation and operation of the proposed action. The studies included: Report No. 4.1.1-2 *Simulation of Sediment Transport and Deposition from Cable Burial Operations in Nantucket Sound for the proposed energy Project;* Report No. 4.1.1-3, *Estimates of Seabed Scar Recovery from Jet Plow Cable Burial Operations and Possible Cable Exposure on Horseshoe Shoal from Sand Wave Migration*; Report No. 4.1.1-4, *Analysis of Effects of Wind Turbine Generator Pile Array of the Project in Nantucket Sound*; Report No. 4.1.1-5, *Revised Scour Report;* Report No. 4.1.1-6, *Conceptual Rock Armor Scour Protection Design,*; Report No. 4.1.1-7, *Hydrodynamic Analysis of Scour Effects Around Wind Turbine Generator Piles, Use of Rock Armor and Scour Mats, and Coastal Deposition and Erosion*; and, in Report No. 4.1.1-8, *Seabed Scour Control Systems Scientific Design Station Report*. A detailed summary of these studies is presented in Section 5.3.1.1.

As detailed in Section 5.3.1.1, if the proposed action is authorized, the applicant would conduct additional geophysical/hydrographic surveys, geotechnical/sediment sampling vibracore sampling, and cone penetration test samples along the proposed 115 kV cable routes and along the inner-array 33 kV cable routes to finalize design parameters. All future survey and sampling methods will be site specific and coordinated with MMS.

#### 4.1.1.1.1 Marine Geophysical/Hydrographic Surveys

The marine geophysical/hydrographic surveys were designed to collect remote sensing data to evaluate wind tower installation feasibility, gather data to support the foundation design process, and to support the analysis of the surface and subsurface sediments on Horseshoe Shoal and the proposed submarine transmission and inner-array cable routes. Surveys included:

- Hydrographic measurements with a fathometer to determine water depths;

- Side-scan sonar to evaluate surface sediments, seafloor morphology and potential surface obstructions;
- Seismic profiling with high frequency (HF) (high resolution; limited penetration below the seafloor) and low frequency (low resolutions; deeper penetration beneath the seafloor) acoustic sources; and
- Magnetometer surveys to identify ferrous objects at the surface or shallow subsurface areas; combined with a differential Global Positioning System (GPS) to document the precise location of anomalies.

Figure 4.1.1-8 illustrates the locations of the 2001, 2003, and 2005 marine geophysical and hydrographic vessel tracklines, as they relate to the proposed action facilities.

Following completion of the field survey, the digital data files were processed at the surveyor's mainland facility, then reviewed and interpreted by staff and a marine archaeologist (for potential cultural resources). Digital hydrographic files were corrected for tidal fluctuations to report water depths at MLLW. Side scan sonar and magnetic intensity data were interpreted to delineate acoustic targets and magnetic anomalies.

#### 4.1.1.1.2 Geotechnical Investigations

Two marine sediment sampling methods, vibracoring and sediment boring were used to advance sediment sampling devices below the seafloor surface to collect, sample, and analyze representative sediments from the site of the proposed action. The information gathered during these studies was used to correlate the geophysical data collected to actual sediment characteristics where WTG foundations are proposed in deep sediment (85 ft [26 m] below the seafloor) and along shallow electrical inner-array cable routes in shallow sediment depths (targeted for 6 ft [1.8 m] below the seafloor).

In addition, soil borings and test pits were completed along the onshore transmission cable route to confirm the surficial materials expected to be encountered during transmission cable installation.

Figures 4.1.1-8 and 4.1.1-9 illustrate the offshore locations of the marine vibracores, the geotechnical/sediment sampling, and the wind turbine locations.

Figure 4.1.1-10 illustrates the geotechnical boring and test pit locations along the onshore cable route.

#### 4.1.1.1.3 Marine Vibracore Sampling

A total of 87 vibracores were advanced to confirm geophysical survey interpretations, to visually characterize the sediment, and to collect representative samples for physical property and chemical constituent analysis. Three of the vibracores collected were used to support the marine archaeological investigation.

Vibracores were advanced and collected from a ship. The cores were labeled and capped on the ship and transported to shore for analysis. Cores were advanced up to 30 ft (9.1 m) below the seafloor in the wind turbine field grid and typically to 10 ft (3 m) below the seafloor along the transmission cable route. Onshore, cores were opened, photographed, and were described in accordance with the Unified Soil Classification System.

#### 4.1.1.1.4 Deep Sediment Marine Borings

A total of 22 deep sediment marine borings were advanced, to a maximum depth below the seafloor of 150 ft (45.7 m), to collect geotechnical information as it relates to the below seafloor depths of the proposed wind turbine foundations.

Deep sediment borings were advanced from a ship. Sampling devices, split spoons, were driven ahead of drilling tools to collect representative sediment samples. Standard penetration test blow counts were recorded. Sediment recovered in the split spoons was characterized, and at various applicable locations, field tests included pocket penetrometer and torvane tests to estimate the un-drained shear strength of the cohesive soils encountered. Grain size and Atterberg Limits analyses were performed on sediment samples and pressuremeter tests were performed at select locations to measure the in situ strength and deformation characteristics of the sediment. The pressuremeter tests can be used to assess the bearing capacity and settlement of foundations.

#### 4.1.1.1.5 Upland Geotechnical Boring and Test Pitting

Four soil borings and three tests pits were completed along the pre-existing roadway ROWs and the NSTAR ROW to confirm the existing upland soil conditions.

### *4.1.1.2 Offshore Geology*

The offshore portion of the area of the proposed action is located primarily in the central region of Nantucket Sound with the two transmission cables extending northward into Lewis Bay and the southern shoreline of Cape Cod.

#### 4.1.1.2.1 Seafloor Geomorphology

The area of the proposed action is located in Nantucket Sound, a broad passage of water that separates the south shore of the Cape Cod mainland and the islands of Nantucket and Martha's Vineyard, and Lewis Bay, a coastal embayment along the south coastline of Cape Cod. The foundations for the WTGs and the ESP are proposed for installation on Horseshoe Shoal, located within Nantucket Sound.

In general, the bathymetry in Nantucket Sound is irregular, with a large number of shoals present in various locations throughout this basin. A combination of NOAA nautical charts and project-specific hydrographic surveys were used to assess existing bathymetric conditions.

On Horseshoe Shoal where the WTGs and the ESP are proposed, hydrographic surveys indicate water depths are as shallow as 0.5 ft (0.15 m) (MLLW), with depths of up to 60 ft (18.3 m) (MLLW) occurring between the northern and southern legs of the shoal. The WTGs and ESP would be located in water with depths between 12 and 50 ft (3.7 and 15.2 m) (MLLW).

Water depths between Horseshoe Shoal and the Cape Cod shoreline have an average depth of approximately 15 to 20 ft (4.6 to 6.1 m) (MLLW). Along the proposed transmission cable system route, water depths range from 16 to 40 ft (4.9 to 12.2 m) (MLLW), with an average depth of approximately 30 ft (9.1 m) (MLLW).

In Lewis Bay, water depths range from 8 to 16 ft (2.4 to 4.9 m) (MLLW) in the center of the bay to less than 5 ft (1.5 m) (MLLW) along the perimeter. Water depths along the proposed transmission route in Lewis Bay range from 2 to 16 ft (0.61 to 2.4 m) (MLLW).

Marine geophysical surveys present a seafloor that ranges from flat and barren to rolling with areas of varying height sand waves. Localized areas of glacial erratics (pebble to boulder size rock fragments carried by glacial ice), and a concentrated outcrop of possible till (an unstratified glacial deposit that can include clay, silt, sand, cobbles, and boulders) were observed. This possible till deposit has been avoided during the selection of the final proposed transmission cable alignments. In addition, the side scan geophysical imagery was indicative of coarse glacial material (gravel, cobbles, and boulders) and intermingled with man-made debris (generally from 1 to 5 ft [0.3 to 1.5 m] in size) on the seafloor in the west central part of the proposed action area.

**Sand Waves and Sediment Transport**

The sand waves observed during the geophysical surveys are wave-like seabed features, with elongated, more or less parallel crests. Typically, sand waves are not static, rather they are migrating bedforms and evidence of active sediment transport along the seabed. Sand waves in this shoal environment are morphologically dynamic, with sand waves moving, appearing, disappearing, and changing shape over time as a result of tidal and storm influences. This sand wave process is not unique to Nantucket Sound, but rather occurs in coastal settings wherever the appropriate hydrodynamic conditions exist along with a predominance of sandy, non-cohesive sediments.

Sand waves of varying heights characterize the areas of active sediment transport, generally in the center of the Horseshoe Shoal. However, a large field of sand waves extends across the southern half of the shoal, and several smaller fields are located to the north within the area of the proposed action. Figure 4.1.1-11 presents the location and maximum observed heights of sand waves identified during geophysical surveys completed in 2003 and 2005, and includes the locations of the proposed WTGs and the electrical transmission cable routes.

The sand wave crests are oriented generally in a north-south direction, with long period wavelengths ranging from 100 to 600 ft (30.5 to 182.9 m). Short period sand waves are located between the larger crests. The average sand wave height observed was 4 to 5 ft (1.2 to 1.5 m), but waves as high as 12 ft (3.7 m) were present. Smaller wave heights from 1 to 2 ft (0.3 to 0.61 m) were often observed between the larger wave crests.

Tidal currents flow east and west across the Nantucket Sound, with the eastward-flowing flood tide more dominant than the westward-flowing ebb tide. The symmetry of the sand waves indicates migration to the east or west, depending on where they formed on the Horseshoe Shoal. Sand waves forming on the west flank of the shoal tend to migrate easterly. Sand waves forming on the east flanks of the shoal tend to migrate to the west. Sand waves across the crest of the shoal have a symmetrical profile, suggesting an equal force in both the ebb and flood tidal phases. Not all bed forms exhibit a clear migration direction, indicative of multiple processes impacting sediment transport in Nantucket Sound, include storm events.

Analytical sediment transport modeling was completed to determine the extent to which existing wave and current conditions are likely to lift and move sand at the site of the proposed action. A two-dimensional sediment transport model was developed to simulate 26 current and wave conditions across the site of the proposed action. The model inputs included a grid of wave heights and ambient currents for the site of the proposed action. The model then calculates near bottom velocities and shear stresses associated with waves and ambient currents. The model results represent whether and where sediment transport is likely to occur and potential rates of bed load and suspended load sediment transport (Report No. 4.1.1-9).

Ten tidal and wind driven current scenarios were run for Horseshoe Shoal. The conditions were selected to represent a range of tidal currents, locally-generated wind waves within Nantucket Sound, ocean waves, and wind-generated currents in the sound. Extreme conditions, such as storms, were not modeled. The results of the model runs are useful in understanding the dynamics of sediment transport in

Nantucket Sound under different conditions. However, qualitative sediment transport rates and net sediment flux within Horseshoe Shoal are not possible without field measurements for model verification (Report No. 4.1.1-9).

The results of the modeling indicate that active sediment transport occurs at Horseshoe Shoal under typical wave and tidal current conditions. The highest sediment transport rates are focused locally on the shallowest portions of the shoal, and there is relatively little sediment transport in the deeper regions of the shoal (particularly the east side) under typical conditions. Bed load transport is typically an order of magnitude greater than suspended load transport. The range of sediment transport volume from the energy flux calculation for mean flood tide conditions and commonly occurring waves (height = 1.3 ft [0.4 m], period = 2.3 seconds) is 0 to 32.3 cubic ft/ft-day (0 to 3.0 $m^3$/m-day), though the authors recognize that the model cannot account for erosion and equilibration of the seafloor and likely the rates predicted are overstated (Report No. 4.1.1-9).

Spring tidal currents and typical wind-driven currents (wind speeds ranging from 15 to 20 mph [6.7 - 8.9 m/s]) initiate approximately 20 percent more transport than mean tidal currents. The greatest impact on sediment transport initiation is wave action. Larger locally generated waves within Nantucket Sound can result in a significant increase in sediment transport. Storm generated ocean swells reaching the sound can greatly increase sediment transport rates, as much as one-hundred fold (Report No. 4.1.1-9). Jet-plowing operations would not be scheduled during or prior to any predicted extreme storm events and therefore were not included in the modeling. Additionally, jet-plowing would be suspended during any unanticipated extreme storm events.

#### 4.1.1.2.2 Subseafloor Geology

The sediment below the seafloor was characterized by completing geophysical surveys at all of the WTG locations and along electrical transmission cable runs, and the collection, characterization, and analysis of samples collected from 84 vibracores (not including three archeological cores) and 22 deep borings on Horseshoe Shoal. On Horseshoe Shoal, vibracores were advanced up to 20 ft (6.1 m) below the seafloor. Geotechnical borings were advanced below the proposed depth of the WTG foundations (85 ft [26 m]) though one was extended to 150 ft (47.5 m) below the seafloor. Geophysical surveys characterized shallow and deep sediments, with bottom profiler gathering data to 200 ft (61 m) below the seafloor at some locations. In general, geotechnical surveys indicate that subsurface soil conditions within the WTG array on Horseshoe Shoal consist primarily of sands and glacial deposits to greater than 100 ft (30.5 m) below the seafloor.

Shallow sediment samples collected from vibracores (extended up to 20 ft [6.1 m] below the seafloor) between the WTGs indicates the shallow surficial sediments are primarily medium sand in shallow water and fine sand in deeper water. Characterization via bulk physical analysis was completed on composite samples collected from the upper 4 to 5 ft (1.2 to 1.5 m) of sediment collected from the vibracores. The samples collected from shallow water indicated the presence of well sorted sands with less than 5 percent fines. In the deeper waters, well sorted sand to silty sand was present. Detailed cross sections across Horseshoe Shoal A”-A’” and B”-B’” are presented as Figures 4.1.1-12 and 4.1.1-13, respectively; the plan view for cross section locations are presented in Figure 4.1.1-5.

Along the proposed transmission cable route in Nantucket Sound, sediment characterization samples were collected and analyzed and were found to be very similar to those in the WTG array area. Within Lewis Bay, a higher percentage of silt and clay were identified with the sands. In addition, thin layers of organic material, including thin (0.5 ft [0.15 m] thick) layers of peat, were observed. The geophysical sub-bottom profiles approaching Lewis Bay contain inconsistent (continuous, discontinuous) acoustic subsurface reflectors, which may be evidence of the fluvial erosion (during sea-level fall) and then wave erosion (during sea-level rise) that has occurred on the Cape Cod southern coastline (OSI, 2002 and 2003).

These shallow sediments are representative of the material to be disturbed (suspended during jet plow embedment) during the WTG inner-array cable installation, which is targeted for a depth of 6 ft (1.8 m).

Figure 4.1.1-9 presents vibracore sample locations and a plan view of a geologic cross section location along the 115 kV Cable Route from the WTG array to landfall. The cross section is presented in Figure 4.1.1-14.

Deeper sediments were characterized as re-worked fine to medium sands. Locally, intermittent beds of organics are located within and below this re-worked sediment. This is presented on the cross section presented in Figure 4.1.1-12 with boring SB-01-2002. This intermittent zone of organics may be a soil horizon marking land surface exposed during the sea level low-stand prior to the marine transgression and sea-level rise that continues today. The lack of a broad soil horizon is likely related to the erosion and re-working of the sediment during this marine transgression.

In addition, limited areas of Horseshoe Shoal contained near-surface gaseous sediments derived from organic material which was identified by acoustical penetration restrictions during the geotechnical seismic profiling. This is a common occurrence in shallow near-shore sediments. Signs of high biogenic gas content, such as sea-bed pockmarks, were not identified during the geophysical surveys.

In addition to the organic soil horizon, a thin but distinct sedimentary facies of interbedded clay was locally observed at the same location and others, but at a greater depth. Though not widespread, this may be evidence of a former glacial lake. Analysis of the sub-bottom geophysical results and the deep boring data indicates this intermittent clay horizon has been eroded, a geologic unconformity. This is best illustrated on the cross section presented in Figure 4.1.1-13 comparing the silty-clay horizon of SB-03 and the fine sand and clay horizon of SB-02-2002, with the sandy sediment in SB-01.

A correlation between the geophysical and geotechnical soil boring results indicates the subsurface sediment is dominated by fine to coarse-grained sand interbedded with deposits of clay, silt, gravel and/or cobbles. An example of this geologic setting is illustrated on the geophysical trackline profile G-13, correlated to marine boring GZA-SB-02 in Figure 4.1.1-15.

Evidence of diapirism, a fairly common type of soft sediment deformation in continental shelf sediments, was assessed for the area of the proposed action. Diapirs can be composed of salt or mud depending on the source sediments. Sediments undergo compaction as younger sediments are deposited over them, leading to increasing pressure on fluids within the sediments. The pressurized fluids can start to flow, mobilizing the sediments to zones of lower pressure at or near the seafloor. This process may also be associated with methane-producing organic content in the sediments (Kennett and Fackler-Adams, 2000).

In the process of flowing upward, the diapirs deform the overlying sediments in a doming or piercing fashion. Diapirs are discrete features that can be identified on geophysical subbottom profiler data and can be avoided. They can be active or inactive, exhibit a range of sizes, and may or may not intersect the seafloor.

Researchers reviewing geophysical data collected on outer continental shelf-upper continental slope margins around the world, including along the U.S. Mid Atlantic outer continental margin, have observed a number of features that may be caused by the release to the seafloor of pressurized subsurface fluids, possibly coupled with pore gas in the sediments (Hill et al., 2004). Water/gas expulsion from sediments can cause pockmarked depressions in the seafloor, and slumping and landslides of fine-grained marine sediments in areas of steep unstable slopes (such as on continental slopes in deep water). Potential large-scale mass wasting of marine sediments on continental slopes has been speculated to trigger tsunamis, though few have been reported throughout the world (Driscoll et al., 2000).

A review of geologic literature did not result in evidence of salt or methane hydrate diapirism in Nantucket Sound.

Some small nearshore features have been interpreted as sediment diapirs in western Nantucket Sound (Swift, 2006) and a possible diapir is also exposed along the eroding cliffs along the Outer Cape (Oldale et al., 1993).

In addition, limited evidence of mud diapirism deforming sediment in Nantucket Sound, outside of the area of the proposed action in Waquoit Bay, is available in geologic literature. The processes that control the nature and extent of these geologic features are not well understood. Researchers further speculate that mud diapirism may be widespread beneath land and the seafloor of Nantucket Sound. In the Waquoit Bay area, at least one diapir appears to be actively deforming the seafloor upward in a region of active tidal sediment transport. The study suggests that the presence of such features in Nantucket Sound may present a hazard to permanent offshore structures emplaced in the area (Swift, S. A. and Mulligan, A., 2003).

No evidence of diapirism has been identified to date in the Nantucket Sound areas surveyed for the proposed action, based upon the review of the shallow and deep subbottom profiler records completed for the proposed action (TRC, 2007).

The area of the proposed action is on the shallow inner continental shelf, approximately 125 miles (200 km) landward of the deep-water outermost continental shelf and upper slope margin, where the mass sediment slumps and the possible water/gas expulsion features have been observed along the eastern United States coast. Although the proposed action is located on the low-relief topographic high that is Horseshoe Shoal, slopes are gradual and the potential for mass wasting of sediments along the shoal's edges is low. Nonetheless, the presence/absence of diapirs and shallow gaseous sediments, as well as slope stability, would be evaluated within the proposed action's Area of Potential Effects (APEs) during the shallow hazards survey and the supplemental post-lease geotechnical program.

Bedrock was not encountered during the geophysical investigation. The depth to bedrock beneath the seafloor is estimated at greater than 300 to 900 ft (91.5 to 274.4 m) below the seafloor across the area of the proposed action, sloping to the southeast. The estimated depth to bedrock is below the deepest foundation proposed (USGS, 1983; USGS, 1990; USGS, 2006d).

#### 4.1.1.2.3 Onshore Geology

The two 115 kV AC submarine transmission cables are proposed for landfall at the end of New Hampshire Avenue in the Town of Yarmouth. From this landfall, an onshore 115 kV transmission cable system would be installed in an underground conduit system within existing roadways for approximately 4.0 miles (6.4 km) until it intersects the existing NSTAR Electric transmission line ROW at Willow Street in Yarmouth. From that point, the onshore transmission cable system would proceed west, and then south in an underground conduit system approximately 1.9 miles (3.1 km) along the existing NSTAR Electric ROW to the Barnstable Switching Station. See Figure 4.1.1-16 which illustrates the onshore cable route and anthropogenic features.

The overland run, from landfall to just before Willow Street, is located beneath an existing roadway over thick Harwich Outwash Plain deposits, see Figure 4.1.1-16. The Harwich Outwash Plain consists of unconsolidated sand and gravel, with localized silt and clay (USGS, 2006a). From that point to the Barnstable Switching Station, the transmission corridor traverses the Sandwich Moraine along existing roadway, then an existing utility ROW. The Sandwich Moraine contains thick unconsolidated, poorly-sorted, sand, silt, and clay, and includes cobbles and boulders (USGS, 2006a).

To further evaluate the subsurface conditions along the onshore cable route, four borings and three test pits were completed. Below the shallow fill material, where present, unconsolidated glacial sediments were penetrated along the entire onshore cable route including the fluvial outwash sediments on the Harwich Outwash Plain, and the unstratified glacial sediments on the Sandwich Moraine. Bedrock was not encountered.

To illustrate the materials encountered and relative increase in topography from landfall, through the Harwich Outwash Plain, and along the Sandwich Moraine, two cross sections were completed. Cross section D-D′, completed from four soil borings advance in existing roadways from landfall to the mid-Cape Highway is presented on Figure 4.1.1-17 (plan view of the cross section locations are presented on Figure 4.1.1-16). Cross section D′-D″, completed from three test pits advanced within the existing utility ROW, runs from the mid-Cape Highway to the Barnstable Switching Station is presented on Figure 4.1.1-18.

#### 4.1.1.3 Seismic Setting

In general, Cape Cod and Nantucket Sound are considered a relatively stable tectonic setting, distantly located from a tectonic plate boundary, where frequent high energy earthquakes are typically more common. This intraplate setting is not a seismic-free location. The seismic activity here is less frequent than at plate boundaries, but low intensity earthquakes are common in New England, with an average of 30 to 40 occurring each year, but with most never felt by residents. In Massachusetts, 316 earthquakes were recorded between 1627 and 1989. In Rhode Island, only 32 earthquakes were recorded between 1766 and 1989 (NESEC, 2006).

Compared to the mainland of New England, it is recognized that Nantucket Sound is relatively less seismically active. However, on October 24, 1965, the residents of Nantucket Island felt a moderate earthquake. Very slight damage was recorded, mostly to ornaments and doors. Windows and dishes rattled, and house timbers creaked (USGS, 2006b). This recent example indicates that the area of the proposed action is not earthquake free but that seismic activity is low energy.

Occasionally, higher energy earthquakes could occur in Massachusetts, such as the largest earthquake recorded in Massachusetts, the Cape Ann earthquake of 1755. With an intensity value of VIII on the Modified Mercalli scale (magnitude 6+ on the Richter Scale), very strong shaking and moderate structural damage were recorded in Boston and the North Shore (USGS, 2006b).

Seismic waves travel out from an earthquake epicenter through the surrounding rock. Ground motion is higher closer to the location of the event. In general, ground motion decreases away from the epicenter, though the amount of ground motion at the surface is related to more than just distance from the epicenter. Some natural materials can amplify ground motion, for instance ground motion is generally less on solid bedrock and greater on thick deposits of clay, sand, or artificial fill.

Seismic hazards defined in building codes are typically based on peak ground acceleration. During an earthquake, a particle attached to the earth would move back and forth irregularly. The horizontal force a structure must withstand during an earthquake is related to ground acceleration. Peak ground acceleration is the maximum acceleration experienced by a particle during an earthquake.

The USGS produces probabilistic Seismic Hazard Maps for the United States with peak ground acceleration values represented as a factor of "g." One g is equal to the force on an object at the surface of the earth due to gravity. Engineers utilize these probabilistic ground motion values, representing hard rock beneath site soils, when designing earthquake resistant structures.

The USGS Seismic Hazard Maps were reviewed for the area of the proposed action. The maps show a 10 percent probability of a 2-3 percent g exceedence in 50 years (see Figure 4.1.1-19). In addition, there is a 2 percent probability of a 6 to 10 percent g exceedence in 50 years (see Figure 4.1.1-20) (USGS, 2002a).

#### 4.1.1.3.1 Liquefaction

Liquefaction is a process whereby the strength and stiffness of a soil and/or sediment is reduced by earthquake shaking or other rapid loading. The result is a transformation of soil and/or sediment to a liquid state. Typically, three general factors are necessary for liquefaction to occur. They are (USGS, 2006c):

- Young (Pleistocene) sands and silts with very low or no clay, naturally deposited (beach, river deposits, windblown deposits) or man-made land (hydraulic fill, backfill).
- Soils and sediments must be saturated. The space between individual particles is completely filled with water. This water exerts a pressure on the soil and sediment particles that influences how tightly the particles themselves are pressed together. This is most commonly observed at or near bodies of water such as rivers, lakes, bays, and oceans, and associated wetlands.
- Severe shaking. This is most commonly caused by a large earthquake. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. This factor is limited by the distance from the large earthquake epicenter. That is, liquefaction potential decreases as distance increases from the epicenter of a large earthquake.

Based on the USGS Seismic Hazard Maps for the area of the proposed action, the risk of a large earthquake resulting in severe shaking of the young, saturated sand deposits of Horseshoe Shoal is low. Site specific assessments would be completed following completion of the permitting process.

#### 4.1.1.3.2 Faults

A fault is a fracture surface within the Earth's lithosphere along which displacement has occurred. No active (younger than about 10,000 years) shallow or deep faults have been identified within the area of the proposed action based upon geologic literature review. Older in-active faults, including those likely associated with what is believed to be a nearby failed Triassic-Jurassic rift basin, are likely present in the area (see possible evidence of the failed rift via the basalt found at approximately 1,400 ft [426.8 m] below ground surface in boring USGS, 6001 on Figure 4.1.1-6).

### 4.1.2 Noise

Noise could affect the local environment during the construction, operation and decommissioning of the proposed action. The ambient sound level of a region is defined by the total noise generated within the specific environment, and is usually comprised of sound emanating from natural and artificial sources. At any location, both the magnitude and frequency of environmental noise may vary considerably over the course of the day and throughout the week. A noise assessment was performed based on the collection of background sound levels and comparing them to the various noises that would be produced during project construction, operation, and decommissioning.

#### *4.1.2.1 General Information on Noise*

##### 4.1.2.1.1 Above Water Noise

Sound results from vibrations in the air. The range of pressures that cause the vibrations that create sound is large. Sound is therefore measured on a logarithmic scale, expressed in decibels (dB). The frequency of a sound is the "pitch" (high or low). The unit for frequency is hertz (Hz). Most sounds are composed of a composite of frequencies. The normal human ear can usually distinguish frequencies from 20 Hz (low frequency) to about 20,000 Hz (high frequency), although people are most sensitive to frequencies between 500 and 4000 Hz. The individual frequency bands can be combined into one overall dB level.

When sound energy is concentrated at a single frequency, the peak in the spectrum may be audible as a "pure tone." Generally this condition occurs when a particular 1/3-octave band has a sound level higher than the average level of the two adjacent bands by 5 to 15 dB (with the 15 dB threshold used for low frequencies below 125 Hz). This is the definition of a pure tone condition that was used in this analysis.

Sound is typically measured on the A-weighted scale (dBA). The dBA has been shown to provide a good correlation with the human response to sound and is the most widely used descriptor for community noise assessments (Harris, 1991). The lowest sound that is usually found in rural environments is about 30 dBA, while an uncomfortably loud sound is about 120 dBA. In order to provide a frame of reference, some common sound levels are provided in Table 4.1.2-1 (all Tables are in Appendix A).

Common terms used in this noise analysis are defined as follows:

**$L_{eq}$** – The equivalent noise level over a given period. It is a single value of sound that includes all of the varying sound energy in a given duration.

**$L_{90}$** – The dBA sound level exceeded 90 percent of the time, and is always less than the $L_{eq}$. The $L_{90}$ is utilized by the MassDEP to characterize the background or residual noise level. This descriptor generally excludes extraneous intrusive sounds such as an aircraft overflight or occasional vehicular traffic.

**$L_{max}$** – The near instantaneous maximum sound level measured during a given period. It is therefore always greater than the $L_{eq}$.

Two measures often used by Federal agencies to relate the time-varying quality of environmental noise to its known effect on people are the 24-hour equivalent sound level ($L_{eq(24)}$) and the day-night sound level ($L_{dn}$). The $L_{eq(24)}$ is the level of steady sound with the same total (equivalent) energy as the time-varying sound of interest, averaged over a 24-hour period. The $L_{dn}$ takes into account the duration and time the noise is encountered. The $L_{dn}$ is the $L_{eq(24)}$ with 10 dB on the dBA added to nighttime sound levels between the hours of 10 p.m. and 7 a.m., to account for people's greater sensitivity to sound during nighttime hours.

#### 4.1.2.1.2 Below Water Noise

Similar to above water noise, in the underwater environment, acoustic energy moves through the water as sound waves, which are minute variations in water pressure. The main difference is the medium in which the sound vibrations pass through (water instead of air). The underwater sound pressure level is defined on a dB scale, similar to the familiar above water decibel scale, but the reference pressure is different. As a result, an identical sound pressure wave in air and underwater is recorded differently in the two fluids. For example, a sound pressure of 80 dB in air is equivalent to 106 dB underwater, i.e., the underwater scale is shifted 26 dB higher than the air scale. There are also substantial differences in ambient (background) sound levels in air and in the ocean, and in the frequency weighting that is used in water versus air. Thus, the reader should not try to equate dB levels reported for water with those in air, or vice-versa.

The existing sound in the sea comes from many sources, natural and man-made, including turbulence in ocean currents, tides, surface waves, cavitations (collapse of air bubbles) in near-surface waves, low-level seismic activity, sea animals, and ship traffic. The hearing capabilities of and the frequency responses of marine mammals vary widely. Therefore, underwater sound levels are presented as un-weighted or linear decibels (dBL). As with airborne sound, the frequency component of the underwater sound is important in this analysis.

Underwater sound levels are commonly measured as either the $L_{eq}$ or the $L_{max}$. For underwater sound, the typical measurement range at sea is from 80 dB (still water conditions) to 180 dB. The ambient underwater sound level is highly variable in time and by location. For example, a one-knot current can produce turbulent pressure changes (sound waves) of 116 dB. Typical ambient underwater sound levels in Nantucket Sound are from $L_{eq}$ 95 to 115 dB for surface winds of 5 to 30 mph (2.2 to 13.4 m/s).

### *4.1.2.2 Regulatory Requirements*

In 1974, the USEPA published, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. This publication evaluates the effects of environmental noise with respect to health and safety. The document provides information for state and local governments to use in developing their own ambient noise standards. The USEPA has determined that to protect the public from activity interference and annoyance outdoors in residential areas, noise levels should not exceed an $L_{dn}$ of 55 dBA.

The MassDEP has a noise standard (310 CMR 7.10). Although the proposed action would be located outside of the Massachusetts territorial limit (3.5 miles [5.6 km] from shore), and the standard would not technically be applicable to the proposed action, the Secretary of the EOEA included a requirement in the MEPA Certificate that required that the standard be addressed for informational purposes.

Noise is regulated in the Commonwealth of Massachusetts under regulation 310 CMR 7.10. The regulation limits sound as follows:

(1) No person owning, leasing, or controlling a source of sound shall willfully, negligently, or through failure to provide necessary equipment, service, or maintenance or to take necessary precautions cause, suffer, allow, or permit unnecessary emissions from said source of sound that may cause noise.

This "Noise" definition is described quantitatively in MassDEP Noise Policy 90-001 as follows:

- Increases in broadband sound may not exceed 10 dBA above ambient at the property line and nearest residence.
- A source may not produce a "pure tone" condition. A pure tone is defined as any octave band center frequency sound pressure level that exceeds the two adjacent center frequency sound pressure levels by 3 dB or more.

These criteria are applied both at the property line and at the nearest inhabited residence. Ambient sound is defined as the background dBA sound level exceeded 90 percent of the time ($L_{90}$). This type of measurement essentially excludes short term, intrusive noise sources, such as aircraft overflights or occasional traffic. The MassDEP standard does not apply to construction activities. There are no local or Federal noise standards applicable to the proposed action.

### *4.1.2.3 Existing Conditions*

#### 4.1.2.3.1 Offshore Locations

Ambient noise monitoring programs were conducted at two offshore locations, near navigation buoys where recreational boaters travel: at Buoy G5 in the North Shipping Channel about 1 mile (1.6 km) north of the edge of the Proposed Alternative location of the proposed action, and at Buoy R20 at the edge of the Main Channel about 1/3 mile (0.5 km) south of the Proposed Alternative location (Report No. 4.1.2-1). These data were collected on October 22, 2002 between 10 a.m. and 12 noon. The weather conditions were clear skies, light winds (4 mph [1.8 m/s] average), and light seas (0.5 to 1.5 ft [0.15 to 0.46 m] waves). The boat engine was shut-off during the measurements and the dominant sounds were wave interaction with the boat hull (the boat was allowed to drift), periodic over flying aircraft and distant boat traffic. Figure 4.1.2-1 is a map showing the locations of Buoys G5 and R20, as well as all onshore monitoring locations and modeling receptors.

The background ($L_{90}$) sound levels were 35 and 37 dBA, respectively, at Buoys G5 and R20. The corresponding average ($L_{eq}$) sound levels were 46 and 51 dBA. To estimate existing average sound levels for the design wind speed condition of the proposed action, the measured levels were increased by 14 dBA, the average observed difference between the two wind conditions for long term monitoring done at three shoreline locations (see Section 4.1.2.3.2 of this document). The frequency spectrum for existing condition sound levels at the two buoy locations are given in Figure 4.1.2-2.

#### 4.1.2.3.2 Onshore Locations

Baseline sound monitoring locations were chosen to satisfy the MEPA certificate that required monitoring at "the nearest representative locations along the south coast of Barnstable and Yarmouth and the east coast of the Vineyard." Along the coasts, there is a wide variety of existing land use and population density. If representative locations were targeted at areas with the most people, then logical choices would be Hyannisport, the shore along Lewis Bay in Yarmouth and Edgartown harbor. These areas, however, have high levels of human activity and motor vehicle traffic, and baseline sound levels are higher than those found at uninhabited areas along the coast. To ensure the measured sound levels are a conservative (i.e., low) estimate of baseline conditions along the entire coast, secluded areas along the coast were sought out (Report No. 4.1.2-1). In the same vein, measurements were taken in November and December 2002, a time of year with little or no beach traffic (cars, trucks and boats). Measurements made in the summer would have been higher. The three monitoring sites were located on the coast at Point Gammon in Yarmouth (5.2 miles [8.37 km]) from the closest WTG at the northeast corner of the Proposed Alternative location of the proposed action), at Oregon Beach, Cotuit in Barnstable (5.5 miles

[8.9 km]) from the closest WTG at the northwest corner of the Proposed Alternative location of the proposed action), and at Cape Poge Wildlife Refuge at the tip of Cape Poge on Martha's Vineyard (5.4 miles [8.7 km]) from the closest WTG at the southwest corner of the Proposed Alternative location of the proposed action).

Point Gammon is on a private peninsula (Great Island) in Yarmouth that sticks out into Nantucket Sound. The monitoring location was above a south-facing beach on the south tip of Great Island. The equipment was located 100 ft (30.5 m) from the high water mark where the grade is 20 ft (6.1 m) above the beach. The microphone (with wind screen) was mounted 7 ft (2.1 m) above grade. The principal sounds at this site were the wind and ocean waves, periodic over-flying aircraft, and an occasional passing ferryboat. There was no vehicle or pedestrian access to this location during the measurement program that lasted seven days (November 15 - 22, 2002).

Oregon Beach is a public beach located off Main Street and Oregon Way, south of Cotuit Center in Barnstable. The coast generally faces southeast at this point on the Cape. The equipment was located 80 ft (24.4 m) from the high water mark where the grade is a few feet above the beach. The microphone (with wind screen) was mounted 7 ft (2.1 m) above grade. The principal sounds at this site were the wind and ocean waves, sea birds, periodic over-flying aircraft, and occasional motor vehicles and pedestrians accessing the beach area. Monitoring lasted more than four days (November 14 - 18, 2002).

Cape Poge Wildlife Refuge on Chappaquiddick Island, Martha's Vineyard is a wildlife refuge and recreational area with facilities for swimming and shore fishing. It is a very isolated location, travel to which requires a four-wheel drive vehicle. The coast faces east towards the ocean at the monitoring location that was setup near the lighthouse above the beach. The equipment was located 40 ft (12.2 m) from the high water mark on a sand dune where the grade is 20 ft (6.1 m) above the ocean. The microphone (with wind screen) was mounted 8 ft (2.4 m) above grade. The principal sounds at this site were the wind and ocean waves, and sea birds. Measurements were taken for seven days (November 25 - December 2, 2002).

The baseline measurements of existing sound conditions were examined in detail for the two wind conditions for which the proposed action's acoustic effects were quantified in Section 5.3.1.2 of this document: the cut-in wind speed of the WTGs (a steady wind speed of 8 mph at hub height, equivalent to 5 mph at 9.8 ft [3 m] above the ground) and the design wind speed of the WTGs (a steady wind speed of 30 mph [13.4 m/s] at hub height, equivalent to 16 [7.2 m/s] mph at 9.8 ft [3 m] above the ground). The WTGs would not operate under hub height wind speeds below 8 mph (3.6 m/s).

Background ($L_{90}$) and average ($L_{eq}$) sound level measurements are summarized for three separate meteorological conditions in Table 4.1.2-2: (1) the cut-in wind speed for the turbines; (2) the design wind speed for the turbines (on-shore flow); and (3) the design wind speed for the turbines (off-shore flow). The distinction between on-and off-shore winds at the design wind speed condition is important for two reasons: (1) baseline sound levels are lower for off-shore winds as discussed below; and (2) sound from the proposed action would be reduced by 27 dBA under off-shore winds due to the wind shadow effect. The frequency spectrums for these measurements are given in Figures 4.1.2-3 through 4.1.2-11.

The baseline measurements of existing sound conditions covered a full range of meteorological conditions from calm to high winds, with wind directions blowing both onshore and offshore and average wind speeds of 0 to 28 mph (0 to 12.5 m/s). The monitoring equipment was located on elevated land above and back from the high water mark to minimize the influence of surf sound yet still provide a quiet environment removed from highway and street noise. Surf sound is not an important factor except under high wind conditions, when surf sound can be heard anywhere along the coast. The baseline measurements, summarized in Table 4.1.2-2, reveal background ($L_{90}$) sound levels as low as 27 dBA (at

Point Gammon) and in the 30s at the other two sites, which are representative of very quiet rural areas. Since the measurements also covered periods of time when steady winds were up to 28 mph (12.5 m/s) (wind gusts were higher), higher baseline sound levels are expected, and these higher levels would be measured at any location, whether it was along the shore where there might be surf sound in the background or inland where noise from wind flow around buildings and trees occurs.

At Point Gammon (November 15 - 22), measured background ($L_{90}$) levels ranged from 27 to 66 dBA, and average ($L_{eq}$) levels were 35 to 71 dBA. At Oregon Beach (November 14 - 18), measured background ($L_{90}$) levels ranged from 34 to 57 dBA, and average ($L_{eq}$) levels were 41 to 61 dBA. At Cape Poge (November 25 - December 2), measured background ($L_{90}$) levels ranged from 37 to 70 dBA, and average ($L_{eq}$) levels were from 40 to 73 dBA. At all three sites, existing sound levels are directly correlated to surface wind speed, and on-shore winds produce slightly higher sound levels than offshore winds, which is expected because offshore winds both suppress wave action at the shoreline and shield the coast from the sound of ocean waves by the wind shadow effect.

The long term monitoring conducted demonstrated also that ambient sound levels increase with increases in wind speed. On average, ambient sound levels during the design wind speed were 14 dBA greater than during the cut-in speed.

#### 4.1.2.3.3 Underwater Noise Levels

Short-term noise level measurements were collected of underwater noise at Buoy G5 in the North Shipping Channel and at Buoy R20 at the edge of the Main Channel. Measurements were conducted on October 22, 2002 between the hours of 10 a.m. and 12 noon. Meteorological conditions included clear skies, light winds averaging 4 mph (1.8 m/s) and light seas (0.5 to 1.5 ft [0.15 to 0.46 m] waves), which are conservative conditions (e.g., lower underwater noise levels would be expected under these types of meteorological conditions). The boat engine was shut off during the measurements. The dominant noise sources were the wave interaction with the boat hull, aircraft, and distant boat traffic.

Measured $L_{eq}$ underwater sound levels were found to be 90 dB and 93 dB at Buoys G5 and R20, respectively. The sound level at Buoy R20 is slightly higher due to the shallower water and greater current. The depth at this location is also more representative of the water depth on Horseshoe Shoal, and accordingly, the Buoy R20 data were used as a baseline for the proposed action.

Underwater sound levels with higher wind speeds (as would occur with proposed action operation) would be higher. Studies conducted in other coastal water areas indicate that the sound level increases 7.2 dB per doubling of wind speed. Accordingly, the estimated underwater $L_{eq}$ sound level for the design wind speed of the proposed action would be 107.2 dB. The frequency spectrum for the existing condition is provided in Figure 4.1.2-12.

The applicant further reviewed baseline underwater sound level measurements conducted over a 9-month period at the North Hoyle, United Kingdom wind farm site. Shoal depths at this location are similar to those at the site of the proposed action. This long term monitoring program revealed that underwater sound levels are nearly constant regardless of the time of day, with the exception of some peaks during midday hours caused by passing boat traffic. Measured baseline levels at the North Hoyle site were in the range of 100 to 150 dB. The 90 to 93 dB sound levels measured at the site of the proposed action are therefore relatively low compared to the measured North Hoyle site, even when scaled up to 107.2 dBA to account for the design wind speed condition. The short term measurements conducted at the site of the proposed action are considered to be adequate to characterize the existing underwater noise environment at the site of the proposed action.

### 4.1.3 Physical Oceanography

This section provides a characterization of existing conditions for currents, waves, salinity, temperature, sediment transport, and water depth/bathymetry in Nantucket Sound. These same parameters are also discussed for Lewis Bay.

#### *4.1.3.1 Existing Conditions*

The proposed action is located within Nantucket Sound, with electric transmission cable installation continuing into the waters of Lewis Bay on the south shore of Cape Cod. Nantucket Sound is a broad passage of water that separates the south shore of the Cape Cod mainland and the islands of Nantucket and Martha's Vineyard. It is approximately 23 miles (37 km) long (east-west direction), and between 6 and 22 miles (9.7 and 35.4 km) wide. The Sound has depths up to 70 ft (21.3 m) below MLLW. The depths relative to MLLW shallow up to 2 ft (0.6 m) on Horseshoe Shoal. WTGs that have a diameter of 16.75 ft (5.1 m) would be set in water depths ranging from 12 to 39 ft (3.6 to 12 m), while WTGs with a diameter of 18 ft (5.5 m) would be set in water depths ranging from 40 to 50 ft (12.2 to 15.2 m). The spacing between the WTGs is proposed to be 0.39 mile (0.63 km) in a northwest/southeast direction and 0.62 mile (1 km) in an east/west direction. The Horseshoe Shoal area is a dynamic system with strong tidal currents (1.6 to 3.1 ft/s [0.5 to 1.0 m/s]) and shifting bed forms consisting mainly of sand. The Sound's tide range is approximately 3 ft (0.9 m). Lewis Bay is a coastal embayment along the south coastline of Cape Cod. It is northeast of Hyannis Harbor, and is separated from Nantucket Sound by Point Gammon and Great Island. Oceanographic conditions for each area are discussed in the sections that follow.

##### 4.1.3.1.1 Currents and Tides

An empirical analysis based on current Acoustic Doppler Current Profiler (ADCP) data and historical data was used to determine tidal current speeds and direction for the site of the proposed action; and modeling by Woods Hole Group (Trowbridge, 2002 as referenced in Report No. 4.1.1-9) was used to determine wind-driven currents on Horseshoe Shoal.

Currents in Nantucket Sound are driven by strong, reversing, semidiurnal tidal flows. Wind-driven currents are only moderate because of the sheltering effect of Nantucket and Martha's Vineyard, however, the southwesterly winds during the summer produce eastward flow through Nantucket Sound (Wilkin, 2006). The tidal range and diurnal timing are variable because of the semi-enclosed nature of the Sound and the regional variations in bathymetry. Typical tidal heights are in the range of 1 to 4 ft (0.3 to 1.2 m), with tidal surges of up to approximately 10 ft (3 m) having been recorded during hurricanes (Bumpus et al., 1973; Gordon and Spaulding, 1979). Times of high and low tides vary across the Sound by up to two hours.

Tidal flow and circulation within the Sound generate complex currents, the directions of which form an ellipse during the two tidal cycles each day. The complex bathymetry of Nantucket Sound forces the tidal ellipses to take different shapes in different regions of the Sound. Just off the coast of the south shore of Cape Cod, there is a strong rectilinear, semi-diurnal tidal flow approximately parallel to the coast (Goud and Aubrey, 1985). Tides around the Nantucket Shoals produce a strong anticyclonic circulation (Wilkin, 2006). The tidal current flows to the east during the flood tide (incoming) and to the west during the ebb tide (outgoing). Higher speeds occur between islands with a relatively uniform speed (1 knot [0.5 m/s]) in the Sound, although speeds and directions vary as bathymetry changes. Speeds on Horseshoe Shoal range higher, up to 2 knots (1 m/s). Nearing shore, the speeds reduce and directions are oriented by local bathymetry or shorelines (Report No. 4.1.1-2). The intensity of tidal flow, in general, decreases from west to east. There is a slow net drift of the water mass toward the east in the Sound. The net drift is about 2,153 square ft (200 $m^2$) per tidal cycle, or roughly five percent of the total easterly and westerly tidal flows (Bumpus et al., 1971).

To characterize site-specific tidal and wind-driven currents at the site of the proposed action in Nantucket Sound, analytical models were applied by the applicant, with the results summarized as follows.

- Flood currents on the shoals are generally directed easterly, with ebb currents generally directed westerly. The average direction of the ebb current was 230 degrees with average speeds between 0.6 and 1.9 knots (0.31 and 0.98 m/s), and the average direction of the flood current was 50 degrees with average speeds between 0.6 and 1.2 knots (0.31 and 0.62 m/s).
- Local changes in tidal current direction occur on Horseshoe Shoal due to its bathymetric features, with currents diverted slightly around the shallowest portion of the shoal.
- Flood currents are generally stronger than ebb currents, and spring tidal currents are approximately 15 to 20 percent stronger than mean tidal currents.
- Tidal current velocities were calculated to be approximately 1.2 knots (0.61 m/s) at Horseshoe Shoal.
- Wind-driven current velocities modeled at Horseshoe Shoal were found to be much lower than tidal velocities, and were found to be concentrated over the crest of the shoal.
- Current speed and direction were found to vary more with location than water depth.

The tide range in Lewis Bay is 3 ft (0.9 m) with no variation in range. The tidal currents are highly variable in Lewis Bay although typically weak. At the cable landfall location the currents are very weak, less than 0.05 knots (0.03 m/s) during both maximum flood and ebb. At the location west of Egg Island the maximum speed is between 0.30 and 0.35 knots (0.15 and 0.18 m/s) during ebb.

#### 4.1.3.1.2 Waves

There is no extensive source of wave data within Nantucket Sound, so available wind data and wave data taken from ADCP devices deployed between May 2003 and September 2004 were used to characterize wind-generated waves at the site of the proposed action (Report No. 4.1.3-1). The major factors affecting the magnitude and period of wind-generated waves in this area are: the fetch length (the distance over which wind acts on the water surface), average water depth, and wind speed. The wave model applied used these factors to estimate wave height and period under different conditions. Fundamentally, larger waves are generated as wind speed, water depth, and fetch length increase. Fetch is restricted within Nantucket Sound due to surrounding landforms including Cape Cod, Monomoy Island, Nantucket Island, and Martha’s Vineyard.

Wave model simulations were performed using the USACE’s *Wind Speed Adjustment and Wave Growth* model (USACE, 1992) to estimate significant wave height (i.e., the average height of the highest 1/3 of waves in a sea state); peak period (i.e., the period that characterizes the majority of the waves in the sea state); and peak direction. The results represent wave conditions near the center of the proposed action at Horseshoe Shoal. Generally, the model indicates that Horseshoe Shoal is exposed to the largest waves from the easterly directions. Wind-generated significant wave heights generally range from less than 1 to nearly 4 ft (0.3 to 1.2 m), with relatively short spectral peak wave periods (between 2 and 4 seconds). Individual wave heights can be higher, and substantially higher waves would be present during storms.

Using the model results, a shoaling coefficient and wave breaking criteria were applied to obtain a distribution of the wave heights over the shoals. Generally, wave height changes in the shallow portions of the shoal due to wave shoaling and breaking, while wave period remains constant. Figure 4.1.3-1 shows the significant wave height distribution for the largest calculated significant wave height at the site of the proposed action.

It is also possible that longer period waves enter Nantucket Sound from the Atlantic Ocean. Therefore, a conservative estimate of long period swell conditions was developed for the site of the proposed action. The average wave height of offshore waves approaching from easterly through southeasterly directions east of Monomoy within the Atlantic Ocean was used for this analysis. The average height for these offshore waves is 4.5 ft (1.4 m), and the average wave period is eight seconds. Average ocean waves were selected for this analysis to capture potential effects for longer period waves. Although significantly higher and longer period waves occur in the ocean (e.g., heights greater than 20 ft [6.1 m] with periods exceeding 12 seconds), it was not judged appropriate to assume such large waves occur in Nantucket Sound given the presence of the numerous relatively shallow shoals. A shoaling coefficient was used to modify the ocean swell and provide an estimate of resulting wave heights and distribution at Horseshoe Shoal. Offshore waves are also likely to be modified substantially by the complex and shallow shoal structure separating Nantucket Sound from the Atlantic Ocean, as well as by the relatively narrow gaps between Monomoy Island and Nantucket Island to the east and between Nantucket Island and Martha's Vineyard to the south. These factors were not included in the analysis because these features would typically serve to dissipate ocean swell effects. Therefore, the analysis is relatively conservative, reflecting higher wave levels than would likely occur. The results are shown in Figure 4.1.3-1.

External analysis was performed to estimate wave height and period characteristics for the 2-, 10-, 50- and 100-year return periods. These were estimated for both locally generated and offshore waves using a computer model entitled "Extrm2: Extremes Program." The extreme storm wave for the proposed action is defined as the average height of the highest 1 percent of all waves in the spectrum (for the 50-year return the extreme storm wave at Horseshoe Shoal was estimated to be 17.3 ft (5.3 m).

Data was collected at the SMDS tower between April 2003 and September 2004 using an ADCP. The wave data indicated that the maximum recorded significant wave height reached 6.6 ft (2.0 m) while the maximum wave height reached 8.2 ft (2.5 m). The majority of wave patterns had a significant wave height between 1 ft (0.3 m) and 1.3 ft (0.4 m). The wave period varied depending on whether wind-generated waves (2 to 6 second periods) or swell (6 to 12.8 seconds) determined the shape of an individual wave spectrum. The highest waves had periods of approximately six seconds, slightly longer (about one second longer) than periods predicted by wave modeling.

Waves having periods between 2.6 and 3.4 seconds were the most frequently recorded in the data set. The long-period portion of the histogram reveals a subtle maximum in wave period distribution at periods of about seven seconds. This suggests that many of the swell 'cases' did not represent distinctive swell waves but were rather a result of noise in the data. Swell amplitudes were higher for the periods of time of high water, suggesting that the probability of swell penetration in the Sound increases as the sea level increases.

Typically, winds with speeds of 8.8 knots (15 m/s) generated waves with a significant wave height of 3.9 ± 0.7 ft (1.2 ± 0.2 m). This relationship varied slightly, depending on water depth. Measured waves were approximately ten percent higher during the periods of high water. A comparison with model results indicates that the observed wave height/wind speed relationship fits well with the results of the model. Wind and wave directions correlated well with a tendency for waves to propagate along the east-west axis of Nantucket Sound.

#### 4.1.3.1.3 Salinity

Salinities in Nantucket Sound are near oceanic, and salinity gradients are small due to strong lateral and vertical mixing. River runoff into Nantucket Sound is low, so there is little dilution of ocean waters with fresh water. Surface and bottom water salinities vary seasonally and spatially from about 30 parts per thousand (ppt) to 32.5 ppt (Bumpus et al., 1973). Surface water salinities throughout the Sound are just over 31 ppt during the summer, and are uniformly about 32 ppt in the winter (Limeburner et al., 1980).

#### 4.1.3.1.4 Temperature

The annual cycle of surface and bottom water temperatures in Nantucket Sound encompasses a range of about 45ºF (7.2ºC), from nearly 30ºF (-1ºC) in the winter to as high as 75ºF (24ºC) in the late summer (Bumpus et al., 1973). During ADCP data collection at the SMDS between April 2003 and September 2004, the recorded water temperature varied from 30.2°F (-1ºC) (recorded in February) to 72.5ºF (22.5ºC) (recorded in August). Temperature extremes are greatest in coastal ponds and estuaries, and the seasonal temperature cycle is smallest in the deeper parts of the Sound. However, because the Sound is shallow and well mixed, there is little lateral temperature variation and vertical temperature stratification. There is a tendency in the summer for surface water temperature to increase from east to west in Nantucket Sound. In the winter, a slight gradient develops in the opposite direction (Limeburner et al., 1980). This change is caused by the intrusion of warmer continental shelf water into the Sound from the east during the summer months.

Bottom water temperature varies less and changes more slowly on a seasonal basis than surface water temperature. The highest bottom water temperature in Nantucket Sound during summer is in the range of 61ºF to 66ºF (16 to 19ºC) (Theroux and Wigley, 1998). Warmest bottom water temperatures are near the coast of the south shore of Cape Cod, and temperature decreases with distance offshore. Coolest bottom water temperatures in Nantucket Sound (during winter) are in the range of 32ºF to 35.6ºF (0 to 2ºC), and become warmer with distance from the Cape Cod and Nantucket shorelines.

#### 4.1.3.1.5 Sediment Transport

A comprehensive analytical two-dimensional sediment transport model developed by Woods Hole Group based on a theory by Madsen and Grant 1976 was used to conduct 26 simulations, addressing a range of current and wave conditions for the site of the proposed action. For each condition, the model calculated wave-induced bottom current velocities, near-bottom tidal current velocities, a qualitative representation of where and whether sediment transport would be likely to occur, and quantitative estimates of potential bed load, suspended load, and total sediment transport rates. The analytical sediment transport modeling was performed to determine the extent to which existing wave and current conditions are likely to lift and move sand at the site of the proposed action. Generally, the analysis found that active sediment transport occurs at all areas of Horseshoe Shoal, even under typical wave and tidal current conditions. The highest potential for sediment transport is along the shallow portions on the northwest corner, with little potential for sediment transport along the deeper east side of the shoal. The largest wind-generated waves in the wave distribution within Nantucket Sound can cause a significant increase in sediment transport.

Spring tidal currents initiate approximately 20 percent more transport than mean tidal currents, and wind-driven currents from a sustained 17.2 mph (7.7 m/s) westerly wind have a similar effect. The greatest impact on sediment transport initiation is due to waves. Larger locally generated waves within Nantucket Sound can cause a significant increase in sediment transport. If swell waves from the ocean impact the site at Horseshoe Shoal, sediment transport rates can increase as much as 100 fold, even for typical swell waves propagating from the Atlantic Ocean (e.g., 4 to 5 ft [1.2 to 1.5 m] height with an 8 second period). Since flood currents are stronger than ebb currents, there is a long-term forcing mechanism to cause the net transport of sediment to the east, particularly at Horseshoe Shoal.

Bed load transport (sediment movement along the sea bottom) on Horseshoe Shoal is typically an order of magnitude greater than suspended load transport. This is expected at the Horseshoe Shoal Site, where sediments are relatively coarse (Report No. 4.1.1-2). The level of wave and current energy under typical conditions is not sufficient to lift and suspend large volumes of sediment within the water column. The bed load flux on Horseshoe Shoal is between 0.18 and 25 cubic ft (0.005 and 0.7 $m^3$) per day.

The south central portion of Horseshoe Shoal is an area in which sand waves have been identified. Sand wave crests on Horseshoe Shoal were oriented in the north-south direction in general, with long period wavelengths ranging between 100 and 600 ft (30.5 and 183 m). Short period sand waves were located between the larger crests. Sand wave heights averaged 4 to 5 ft (1.2 to 1.5 m), but waves as tall as 15 ft (4.6 m) were found. The size of the sand waves is attributed to the dynamic shallow water environment on Horseshoe Shoal. The symmetry of the sand waves indicates a migration to the east or the west, depending on where they formed on Horseshoe Shoal. (USACE, 2004 as referenced in Report No. 4.1.1-3). Other areas of Horseshoe Shoal contain few significant topographical features and are dominated by smooth sandy bottoms (OSI, 2002).

The existing sediment transport in Lewis Bay is presented in Report No. 4.1.1-2 and Report No. 4.1.1-3. The bottom sediments are generally finer in Lewis Bay (up to 12 percent clays and silts) than in Nantucket Sound, consistent with the lower energy environment in the Bay. Lewis Bay is thus likely a depositional area which implies that the sediment transport is low since sediment would accumulate if there were sufficient sediment sources supplying material.

#### 4.1.3.1.6 Water Depth/Bathymetry

In general, the bathymetry in Nantucket Sound is irregular, with a large number of shoals present in various locations throughout this glacially formed basin. Charted water depths in the Sound range between 1 and 70 ft (0.3 and 21.3 m) at MLLW. A combination of NOAA nautical charts and project-specific hydrographic surveys were used to assess existing bathymetric conditions.

The site of the proposed action is located on Horseshoe Shoal, a prominent geological feature in the center of the Sound. Depths on Horseshoe Shoal have been mapped over the years as shallow as 0.5 ft (0.15 m) at MLLW, although this depth can vary from year to year. Measured depths of 60 ft (18.3 m) at MLLW occur between the northern and southern legs of the shoal. An east-west trending natural channel feature exists on the southern leg of the shoal, with measured water depths approaching 50 ft (15.2 m) at MLLW.

Water depths between Horseshoe Shoal and the Cape Cod shoreline are variable, with an average depth of approximately 15 to 20 ft (4.6 to 6.1 m) at MLLW. Along the transmission cable system corridor, depths vary from about 16 to 40 ft (4.9 to 12.2 m) at MLLW, with an average depth of approximately 30 ft (9.1 m) at MLLW.

Water depths in Lewis Bay and Hyannis Harbor are variable, ranging from approximately 8 to 14 ft (2.4 to 4.3 m) at MLLW in the center of the bay to less than 5 ft (1.5 m) at MLLW along the perimeter and between Dunbar Point and Great Island. There are three navigation channels in Lewis Bay: the

Federal Navigation Channel providing access to Hyannis Inner Harbor (authorized depth -13 ft [-4.0 m] MLLW); one privately maintained channel into Mill Creek (reported depth of -2 ft [-0.6 m] MLLW in 1983); and one privately maintained channel northeast of Great and Pine Islands (approximately 7 ft [2.1 m] deep at MLLW).

The submarine transmission cable system route would extend outside the eastern edge of the Federal channel into Lewis Bay, and would then turn east north of Egg Island to make landfall between Mill Creek and the privately maintained channel northeast of Great and Pine Islands. Water depths along this route in Lewis Bay range from 5 to 10 ft (1.5 to 4.6 m), with an average of approximately 10 ft (3 m). The shallowest portions of Lewis Bay/Hyannis Harbor along this route exist between Great Island and Dunbar Point and at the landfall, with depths of 1 to 4 ft (0.3 to 1.2 m) at MLLW.

### 4.1.4 Climate and Meteorology

This section describes the existing climate and meteorological conditions for the site. The Massachusetts climate is characterized by frequent and rapid changes in weather, large daily and annual temperature ranges, large variations from year to year, and geographic diversity. The National Climatic Data Center (NCDC), which is part of the NOAA defines distinct climatological divisions to represent areas that are, as nearly as possible, climatically homogeneous. Locations within the same climatic division are considered to share the same overall climatic features and influences. The site of the proposed action is located within the Massachusetts coastal division.

#### *4.1.4.1 Ambient Temperature*

The NCDC provided data that shows for the Massachusetts coastal division the average annual temperature is 49.8ºF (9.9ºC), the average winter (December - February) temperature is 30.9ºF (-0.6ºC), and the average summer (June through August) temperature is 69.0ºF (20.6ºC). The average daily maximum temperature in the coastal division is approximately 57.0ºF (13.9ºC) and the average daily minimum temperature is approximately 42.1ºF (5.6ºC) based on data collected in Hyannis, Massachusetts from 1971 through 2000. Average temperatures at the individual stations in the general area at or near the site are summarized in Table 4.1.4-1, along with the climatological division average where available. Data for some stations reflect different periods of record, but they show the lack of any major temperature differences in the area.

Table 4.1.4-2 provides information on the monthly ambient air temperatures within the Massachusetts coastal division. Data presented in Table 4.1.4-2 was collected at the Buzzard Bay Buoy Tower from 1985 through 2001 and is representative of the monthly temperature variations found in this climatological division.

#### *4.1.4.2 Wind Conditions*

Wind conditions in the Massachusetts coastal division have been summarized in Tables 4.1.4-3 and 4.1.4-4 using data collected at the Buzzard Bay Buoy Tower, which is located northwest of the Nantucket Sound, from 1985 through 2001. Table 4.1.4-3 presents the monthly and annual average wind speeds, monthly average peak wind gusts, and the maximum hourly peak wind gust recorded during this time period at the Buzzard Bay Buoy Tower and Table 4.1.4-4 presents the monthly and annual percent frequency of the wind directions recorded at the tower. The monthly average wind speeds range from a low of 13.7 mph (6.1 m/s) in August to a high of 20.4 mph (9.1 m/s) in December with an annual average of 17.3 mph (7.7 m/s). The average monthly peak wind gust was 22.9 mph (10.2 m/s) and the peak hour wind gust was recorded to be 88.8 mph (39.7 m/s). Wind directions are variable throughout the year as shown in Table 4.1.4-4; however, during the summer months (June through August) the predominant winds are from the southwest, while during the winter months (December through February) the predominant winds are from the northwest.

Mean wind speeds within the Nantucket Sound area, at the height of the proposed wind rotor height of 257 ft (78.3 m), were estimated using AWS Truewind's proprietary algorithm and vary from a low range of 15.7 to 16.8 mph (7 to 7.5 m/s) in the nearshore areas to a high range of 20.1 to 21.3 mph (9 to 9.5 m/s) in the southern and eastern portions of the Sound that lack the sheltering effects from the islands (see Figure 4.1.4-1). An average wind speed of 19.75 mph (8.8 m/s) was recorded at the Nantucket Sound meteorological tower over the three years of data collected.

#### *4.1.4.3 Precipitation and Fog Events*

Data from the NCDC shows the annual average precipitation is 47.16 inches (119.79 cm) in the Massachusetts coastal division. Monthly variations in average precipitation in the division are shown in Table 4.1.4-5 with a high of 4.38 in (11.12 cm) in November and a low of 3.39 in (8.61 cm) in July.

Fog is a fairly common occurrence over the area. Fog is especially frequent and persistent at times in areas south of Cape Cod resulting in significant restricted visibility. On average, the Nantucket area experiences fog on approximately one day out of six as shown in Table 4.1.4-6. Also shown in Table 4.1.4-6 is that almost all of the days with low visibility can be attributed to fog.

Although snowfall can vary significantly over small distances, representative monthly and annual snowfall amounts for the Massachusetts coastal division are presented in Table 4.1.4-7. These data were recorded in Hyannis, Massachusetts from 1971 through 2000 and indicate that the highest average monthly snowfall is 6.9 inches (17.5 cm) in January and the annual average is 18.4 inches (46.7 cm).

General information concerning the frequency of freezing precipitation is available in "A Climatography of Freezing Rain, Freezing Drizzle, and Ice Pellets across North America" (Cortinas et al., 2000). Isopleths presented in this paper indicate that freezing rain occurs from 0 to 10 hours per year.

#### *4.1.4.4 Hurricanes*

There have been 10 hurricanes that have impacted Massachusetts in the last 154 years (NHC, 2005). Five of the hurricanes were Category One hurricanes on the Saffir-Sampson Hurricane Scale, two were Category Two hurricanes, and three were Category Three hurricanes. No Category Four or Five hurricanes have been recorded in Massachusetts in the last 154 years.

A Category One hurricane has winds 74 to 95 mph (33 to 42.5 m/s) and a storm surge 4 to 5 ft (1.2 to 1.5 m) above normal. Damage due to a Category One storm is primarily to unanchored mobile homes, shrubbery, and trees. Some coastal flooding and minor pier damage could also be expected. A Category Two hurricane has winds 96 to 110 mph (43 to 49.1 m/s) and a storm surge generally 6 to 8 ft (1.8 to 2.4 m) above normal. Category Two hurricane damage may include roofing material, doors, and windows of buildings and considerable damage to mobile homes, shrubbery, trees, poorly constructed signs, and piers. Coastal and low-lying flooding is expected before the arrival of the hurricane center. A Category Three hurricane has winds 111 to 130 mph (49.6 to 58.1 m/s) and a storm surge 9 to 12 ft (2.7 to 3.7 m) above normal. Some structural damage to small residences and utility buildings, damage to shrubbery and trees with foliage blown off and trees blown down, mobile homes and poorly constructed buildings are destroyed, and coastal and low-lying flooding are possible damages due to a Category Three hurricane.

#### 4.1.4.5 Mixing Height

Average seasonal mixing height data within the Massachusetts coastal division are presented in Table 4.1.4-8. As shown in the table, the minimum average mixing height in the division is 1,276 ft (389 m), while the maximum average mixing height in the division is 4,662 ft (1,421 m). The minimum average mixing height is much higher than the height of top of the proposed rotors (440 ft [134.1 m]).

### 4.1.5 Air Quality

One measure of air quality within a region is whether background ambient air concentrations are in attainment with National Ambient Air Quality Standards (NAAQS). The NAAQS were developed by the USEPA for criteria pollutants to protect human health and welfare. The attainment status of an area is determined through an evaluation of available air quality data. The MassDEP and Rhode Island Department of Environmental Management collect ambient air quality data from a network of monitors located within their respective states. The network is designed to provide data representative of pollutant concentrations over large areas and also to determine concentrations in areas where they are expected to be the highest.

#### 4.1.5.1 Existing Air Quality

The MassDEP and monitoring data show that Massachusetts and Rhode Island are in attainment with the NAAQS for all criteria pollutants except ozone. Available monitoring data show that the 8-hour NAAQS for ozone has been exceeded at several monitors across each of the states, and all of Massachusetts and Rhode Island have been classified as moderate non-attainment areas with respect to the 8-hour NAAQS for ozone. Figure 4.1.5-1 graphically depicts the non-attainment areas within Massachusetts and Rhode Island. Ground level ozone is created through chemical reactions involving precursor pollutants ($NO_x$ and volatile organic compounds [VOCs]) in the presence of sunlight. Motor vehicles and fossil fuel fired power plants are among the major contributors to ozone precursor emissions.

The USEPA regulations, published as “General Conformity Rule” (58 FR 63214, November 30, 1993) to implement section 176(c) of the CCA for non-attainment areas and maintenance areas, require that Federal actions, unless exempt, conform with the federally-approved state implementation plan (SIP). Air emissions, within nonattainment areas, that are not covered by an air permit and that exceed the minimal levels require a conformity analysis.

#### 4.1.5.2 Regional Air Quality

The entire Commonwealth of Massachusetts and State of Rhode Island have been classified as being in attainment with NAAQS for all criteria pollutants, with the exception of ozone. However, some local variations in air quality may exist due to differences in meteorological conditions and emission sources. Local air quality has been evaluated by examining data obtained from individual monitoring stations. Qualitative assessments of influences on local air quality have also been made based on a consideration of air emissions generating activities and operations conducted in each local area.

Recent ambient air quality data (2004-2006) from the MassDEP and the DEM monitoring stations in the study area have been summarized and presented in Table 4.1.5-1. In accordance with USEPA policy, highest second high monitored concentrations, as opposed to maximum concentrations, are presented in Table 4.1.5-1 for pollutants with short-term standards, since one exceedence of the standard is allowed per year.

These data were recorded at monitoring stations closest to the site of the proposed action and are considered representative of air quality conditions at the onshore portions the site of the proposed action. Where multiple sites were approximately equal in distance to Nantucket Sound, all were evaluated and the highest value was presented in Table 4.1.5-1. Table 4.1.5-2 provides some summary information concerning the nearest monitors and their intended purpose, while Figures 4.1.5-2 through 4.1.5-7 show the locations of the monitoring sites.

As shown in Table 4.1.5-1, there have been exceedences of the 8-hour ozone NAAQS recorded at the Oak Bluffs, Massachusetts, and Narragansett, Rhode Island, monitors over the last three years (2004-2006). At the Oak Bluffs ozone monitor a total of 8 days had an 8-hour ozone NAAQS exceedence during this period with four days during 2005 and four days during 2006. Table 4.1.5-3 presents the dates of these monitored exceedences and the recorded 8-hour ozone concentration. An examination of the wind direction data for these 8 days of exceedences reveals that winds were predominately from the west and southwest indicating probable regional transport of ozone or its precursors from areas west to southwest of New England. Figures 4.1.5-8 through 4.1.5-15 show 8-hour ozone contours for each of the days with a recorded exceedence of the 8-hour ozone standard and the weather conditions during each of the days.

Information in the *Commonwealth of Massachusetts 2005 Air Quality Report* (MassDEP, 2006) and the *2004 Air Quality Summary, State of Rhode Island* (DEM, 2006) were reviewed to obtain information on how air quality, as measured at the air quality monitors, varied within the study area over recent years. In general, the information in these air quality reports indicates that the air quality in the study area has been improving over the durations monitored for each pollutant. Figure 4.1.5-16 presents a graph of the recorded annual $SO_2$ concentrations from 1985 through 2005. As the graph shows, there has been a slight decrease in the annual $SO_2$ concentrations recorded throughout Massachusetts over the last 21 years.

The annual $PM_{10}$ concentrations recorded in Rhode Island between 1994 and 2004 years are presented in Figure 4.1.5-17. The highest $PM_{10}$ levels measured each year through 2001 were at the Allens Avenue site, which was located immediately adjacent to Route I-95 in Providence. That site reflected worst-case levels and was not representative of neighborhood exposures. Monitoring at the Allens Avenue site was discontinued in 2002 due to extensive construction and demolition activity in the area associated with a highway relocation project. Since the discontinuation of the Allens Avenue site, the monitor at the Vernon Street site, which is located near Route I-95 in Pawtucket, consistently records the highest annual mean $PM_{10}$ levels in the State. The annual mean $PM_{10}$ concentrations at the Vernon Street site in 2004, as in the two previous years, were approximately 3 micrograms per cubic meter ($\mu g/m^3$) higher than at the other urban sites and approximately double that of the rural West Greenwich site. However, over the last ten years the monitored $PM_{10}$ concentrations show a slight decrease.

Recorded annual $NO_2$ concentrations from 1985 through 2005 are shown in Figure 4.1.5-18 and indicate that, similar to annual $SO_2$ and $PM_{10}$ concentrations, the annual $NO_2$ concentrations have decreased slightly since 1985 at all the monitors in Massachusetts. Figure 4.1.5-19 shows the 8-hour CO concentrations recorded in Rhode Island from 1992 to 2004. Maximum 8-hour CO concentrations at the Dorrance Street site, the only site that has operated continuously since 1990, decreased during the period. The CO concentrations at the East Providence site remained roughly constant between 1998 and 2002, but decreased in 2003 and 2004. Previously, the CO levels at the Dorrance Street site were significantly higher than those in East Providence, but due to the steady decrease in the monitored concentrations at the Dorrance Street site, the CO concentrations at the two sites have been similar since 2002.

The Oak Bluffs, Massachusetts, ozone monitor has only been in operation since 2004, so no trends of ozone concentrations can be inferred from this monitoring location. However, MassDEP does have a network of other ozone monitors throughout the State with the nearest ones being the Truro, Easton, and Fairhaven monitors. Figure 4.1.5-20 presents a graph of the number of 8-hour ozone NAAQS exceedences recorded per year from 1985 through 2005 at these three ozone monitors. As the graph shows, the number of recorded exceedences is variable from year-to-year, but overall there has been a slight decrease in the number of exceedences recorded.

According to the *Commonwealth of Massachusetts 2005 Air Quality Report* (MassDEP, 2006), the MassDEP $PM_{2.5}$ sampling network has been operating only since January 1999 and an ambitious program of sampler replacement has been accomplished since December 2004 in conjunction with a rigorous preventative maintenance program to improve overall data capture. The report provides no trend information, apparently because there has been too short a record of consistent quality. However, examining the three years of $PM_{2.5}$ concentrations presented in Table 4.1.5-1 shows that the 24-hour $PM_{2.5}$ concentrations have been variable over this time period, while the annual $PM_{2.5}$ concentrations have decreased each year.

**Nantucket Sound**

There are no air quality monitoring stations in Nantucket Sound. Emissions from onshore and upwind are transported and dispersed over the Sound. Additionally, emissions from mobile sources within the area, including recreational and commercial vessels, and low flying aircraft contribute to the air quality impacts offshore.

### 4.1.6 Water Quality

Under Massachusetts Surface Water Quality Standards (314 CMR 4.06(3)), Lewis Bay and the surface waters adjacent to Nantucket Island are categorized as Class SA coastal and marine water bodies. (Other waters of Nantucket Sound in the area of the proposed action are not classified.) According to the MassDEP standards, Class SA waters are designated as "an excellent source of habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation." In approved areas, Class SA waters are suitable for shellfish harvesting without the need for depuration (that is, removal of contaminants) (Open Shellfish Areas).

#### *4.1.6.1 Freshwater Resources*

##### 4.1.6.1.1 Groundwater

No sites associated with releases/spills of petroleum products or hazardous substances that have been reported to the appropriate agencies identified in the Environmental First Search Report (ESS, 2005) appear to be located within the proposed on land cable route. As indicated in the MEPA FEIR, the Environmental First Search Report did describe eleven state-listed oil and/or hazardous material disposal sites including two disposal sites and nine spill sites, within 0.25 miles (0.4 km) of the proposed cable route. None of these sites are crossed by the route, and none appear to pose a risk to soils and/or groundwater quality conditions along the proposed cable route. An additional three underground storage tanks are within 0.25 miles (0.4 km) of the proposed upland cable route, but none are currently listed as a location where a release or spill of materials has occurred. Based on review of the Federal CERCLIS list dated 4/14/2005, and the National Priorities List (NPL) dated 5/17/2005, there are no CERCLIS or NPL sites located within 0.25 mile (0.4 km) of the proposed on land cable route.

The environmental conditions on the known state-listed oil and/or hazardous material release and spill sites identified in close proximity to the proposed on land cable route do not appear to have impacted soil and/or groundwater quality conditions within the proposed cable route.

Onshore construction of the proposed action is located within the EPA-designated Cape Cod Sole Source Aquifer. The Cape Cod aquifer consists of shallow glacial outwash deposits, recharged primarily through precipitation (Olcott, 1995). Groundwater flow is from high areas of Cape Cod, to lower areas, where it is discharged from the aquifer back to the land surface or directly to the ocean (Olcott, 1995).

The proposed action is located within Zone I and Zone II Wellhead Protection Areas for public supply wells, as designated by MassDEP regulations. The MassDEP regulations (310 CMR 22.21(1)(b)(5)) state that current and future land uses within the Zone I shall be limited to land uses directly related to the public water system or to other land uses which the public water system has demonstrated would have no adverse impact on water quality. The regulations also state that no new underground storage tanks for petroleum products shall be located within Zone I. According to the MassDEP regulations, Zone II is defined as: that area of an aquifer that contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at the approved yield, with no recharge from precipitation).

#### 4.1.6.1.2 Freshwater Streams

Under Massachusetts Surface Water Quality Standards (314 CMR 4.06(2) (b)), the water resources located along the onshore route are classified as Class B, High Quality Water by MassDEP. According to the MassDEP standards, Class B waters are designated as "habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation." In approved areas, Class B waters are suitable as a source of public water supply with appropriate treatment.

Thornton Brook is mapped as a perennial stream on the current USGS map, however, the stream channel was observed completely dry during fieldwork conducted in October 2001 and December 2002. In addition, Thornton Brook was observed to be dry over four days of field observation during July 16, August 3, 15, 16, and 17 of 2007, during non-drought conditions, and documented as dry. Pursuant to 310 CMR 10.58 (2) (a) 1.d., the issuing authority shall find that any stream is intermittent based upon a documented field observation that the stream is not flowing. In addition the Yarmouth Conservation Administrator has confirmed that Thornton Brook is not perennial. Thornton Brook is intermittent and does not have an associated Riverfront Area.

#### 4.1.6.1.3 Freshwater Wetlands

In addition to establishing wetland setbacks, the Yarmouth Wetlands Protection Regulations (WPR) govern work within Lake and Pond Recharge Areas. These areas are defined under Section 3.05 as wetland and upland landforms that contribute surface and subsurface water to the lakes and ponds of the towns and are mapped within a "Water Resources Protection Study" prepared for the Town of Yarmouth (Figure 4.1.6-1). Conservation Commission jurisdiction is restricted to mapped areas within 300 ft (91.4 m) of a lake or pond. The proposed onshore transmission cable system route would be located within the mapped recharge areas of Jabinettes Pond (Wetland 2) and Long Pond (Wetland 6). As such, groundwater flow from portions of the transmission cable route has the potential to affect water quality in Jabinettes Pond and Long Pond. The regulations at Section 3.05(3) prohibit land use practices that present serious threats to the quality of lake and pond recharge areas, including: outdated underground storage tanks, landfills, stump dumps, road salt storage, package treatment plants, and automotive and construction equipment repairs. The proposed transmission cable system is not a land use that is specifically prohibited under these regulations.

### *4.1.6.2 Coastal Waters*

#### 4.1.6.2.1 Estuaries and Bays

On December 14, 2004, sampling was conducted within Lewis Bay at the proposed temporary cofferdam location for the potential HDD drill exit points. Sediment samples from vibratory cores (vibracores) were collected and analyzed to determine bulk chemical and physical characteristics of the material to be dredged from Lewis Bay. The sampling protocol and testing analyses were performed in accordance with the MassDEP-DWPC Regulations 314 CMR 9.00.[11]

A total of four vibracores were advanced in the vicinity of the proposed action's landfall. Three of the vibracores (VC04-01, VC04-02, and VC04-03) were advanced within the area of the proposed temporary cofferdam dredging. The fourth vibracore was advanced near the seawall at the end of New Hampshire Avenue. Figure 4.1.6-2 shows the locations of the vibracores.[12]

The sample results of the bulk chemical and physical analyses were compared with the MassDEP-DWPC classification criteria found in 314 CMR 9.07 for dredging and dredged material disposal. Table's 4.1.6-1 and 4.1.6-2 show the classifications of the sediment samples based on chemical constituents and physical characteristics as established in the regulations. Note that results from only the three vibracores located within the proposed dredge footprint are provided since this data set would be what is reviewed by MassDEP as part of the 401 WQC process. Based on MassDEP criteria, the dredge material was classified as Category 1, Type A.

Methods for dredging and disposal activities that the MassDEP-DWPC may approve are dependent upon the chemical and physical classification of the sediment to be removed. Approvable options for various sediment types are summarized in Table 4.1.6-3. Sediment types identified in this sample analysis are approvable for either hydraulic or mechanical dredging methods. Unconfined in-harbor disposal (in the case of this Project; replacement of dredged material) is normally approvable by MassDEP as determined from the sediment constituents.

The sampling protocol was based on the following references:

- Quality Assurance/Quality Control for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods, dated March 1987 (USEPA 430/9-86-004).
- Analytical Methods for USEPA Priority Pollutants and 301(h) Pesticides in Estuarine and Marine Sediments, dated May 1986 and prepared by Tetra Tech (USEPA 68-01-6938), TC-3953-03 Final Report.
- User's Guide to Contract Laboratory Program, dated December 1988 (USEPA/540/8-89/012).
- Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual, dated February 1991 (USEPA 503/8-91/001).

[11] MassDEP Regulations Effective 3/1/95.

[12] Subsequent to the nearshore vibracore field program study, MADEP Regulations 314 CMR 9.00 were revised on December 29, 2006. Per 314 CMR 9.07(2) as part of the sampling and analysis requirements, an applicant shall perform a "due diligence' review to determine the potential for the sediment proposed to be dredged to have concentrations of oil or hazardous materials. Furthermore, 314 CMR 9.07(2)(a), stated that "no chemical testing shall be required if the sediment to be dredged contains less than 10 percent by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve and if the "due diligence" review demonstrates, to the Department's satisfaction, that the area is unlikely to contain anthropogenic concentrations of oil or hazardous material." Furthermore, the sediment results show that the sediment located within the area to be dredged contains less than 10 percent by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve. The sample results of the bulk chemical and physical analyses were compared with the 1995 MADEP-DWPC classification criteria found in 314 CMR 9.07(2) for dredging and dredged material disposal. The December 29, 2006 revised Regulations do not establish chemical and physical classification criteria. Table's 4.1.6-1 and 4.1.6-2 show the classifications of the sediment samples based on chemical constituents and physical characteristics as established in the 1995 regulations.

- 401 WQC For Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the United States Within the Commonwealth, dated March 1, 1995 (314 CMR 9.00).
- Guidance for Performing Tests on Dredged Material in Open Waters, dated May 15, 1989 (USEPA Region 1 and USACE, New England Division).
- Technical Guidance for Screening Contaminated Sediments, dated January 1999 (New York State Department of Environmental Conservation).

The primary surface waterbodies in the area of the proposed action are Nantucket Sound, Hyannis Harbor, and Lewis Bay. As mentioned above, these waterbodies are categorized as Class SA by MassDEP. Lewis Bay and Hyannis Harbor are listed on the Massachusetts Section 303(d) List of Waters as impaired due to the presence of pathogens in water quality samples. However, no specific sources of pathogen pollution were reported by the Commonwealth in its 304(b) report to USEPA (USEPA, 2002).

The Barnstable County Department of Health and Environment and the Towns of Yarmouth and Barnstable collect additional information on the water quality of Lewis Bay and Hyannis Harbor. The waters offshore of Cape Cod's bathing beaches are sampled during the summer for the bacterial indicator organisms E. coli and enterococci. The beaches sampled as part of this program that are closest to the proposed action landfall are Englewood Beach in Yarmouth; and Veterans Beach, Keys Beaches and Kalmus Beach in Barnstable. None of the results of these samples exceeded established local and Massachusetts Surface Water Quality Standards at 314 CMR 4.06(2)(b) (Barnstable County, 2002).

### *4.1.6.3 Offshore Waters*

#### 4.1.6.3.1 Continental Shelf

The area of the proposed action is situated in a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas.

When the approach of average waves (2.6 second period, 1.6 ft [0.49 m] height) is aligned with running tidal currents, near-bottom suspended sediment concentrations in Nantucket Sound are estimated to be approximately 71 milligrams per liter (mg/L). When average waves (2.2 second period, 1.3 ft [0.40 m] height) approach perpendicular to running tidal currents, near-bottom suspended sediment concentrations in Nantucket Sound are estimated to be approximately 45 mg/L (Woods Hole Group, 2003, 2004, 2005).

Analysis from the sediment core samples obtained from the area of the proposed action indicated that sediment contaminant levels were below established thresholds in reference to sediment guidelines (see Tables 4.1.6-4 thru 4.1.6-7). Specifically, all of the chemical constituents detected in the sediment core samples obtained from the WTG array site and along the submarine transmission cable route had concentrations below Effects Range-Low (ER-L) and Effects Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995). To assess the relative environmental quality of the sediments collected from the area of the proposed action, the analytical laboratory results for targeted chemical constituents were compared to established guidelines for marine and estuarine sediments, particularly Long et al., 1995. To aid in the identification of contaminants of potential ecological concern, federal and state agencies (such as NOAA, MADEP) use these site-related sediment data to compare established screening level criteria. These guidelines were not promulgated as regulatory criteria or standards as they were not intended as cleanup or remediation targets, discharge attainment targets or intended as a pass-fail criterion for dredged material disposal decisions or any other regulatory purpose. They were intended as an informal guideline for use in interpreting chemical data from analyses of sediments.

The Long et al. (1995) marine/estuarine ER-L screening values represent a concentration at which adverse benthic impacts are found in approximately 10 percent of studies. A level greater than the ER-M indicates a greater than 50 percent incidence of adverse effects to sensitive species and/or life stages. A concentration between the ER-L and ER-M therefore indicates an expected impact frequency between 10 percent and 50 percent. The ER-L and ER-M values were not derived as toxicity thresholds. That is, there is no assurance that there would be a total lack of toxicity when chemical concentrations are less than the ERL values. Similarly, there is no assurance that samples in which ER-M values are exceeded would be toxic. Toxicity, or a lack thereof, must be confirmed with empirical data from toxicity tests. The ERL values were intended and should be used primarily as estimates of the concentrations below which toxicity is least likely. The ERM values are better indicators of concentrations associated with effects than the ERLs.

### 4.1.7 Electrical and Magnetic Fields (EMF)

#### *4.1.7.1 Introduction*

The information on EMFs contained in this section was obtained from review of existing data available for the area of the proposed action, the EMF monitoring and modeling conducted by the applicant, and review of the scientific literature on EMF. This introduction provides an overview of EMF; discusses potential sources of EMF; and summarizes the current status of research, in order to provide a context for the proposed action discussion. The assessment of EMF impacts anticipated is provided in Section 5.3.1.7.

Electric power transmission and distribution (T&D) lines create EMFs because they carry electric currents at high voltages. The voltages and currents are produced by electric charges. Electric charges (electrons and protons) are present in all matter, and can give rise to electrical effects. Most objects are electrically neutral because positive and negative charges are present in equal numbers. When the balance of electric charges is altered, electrical effects result such as the attraction between a comb and our hair, the drawing of sparks after walking on a synthetic rug in the wintertime, or the presence of EMFs from power lines. The work put into separating electric charges is measured by *voltage*. The units of work-per-unit-charge are *volts* (V) or *kilovolts* (kV; 1 kV = 1000 V). Voltage is the "pressure" of electricity, and is analogous to the pressure of water in a plumbing system.

Electric charges push and pull on other charges and, therefore, each electric charge generates an *electric field* that exerts a force on nearby charges. Opposite charges (i.e., + and –) attract, and like charges (i.e., + and +) repel. Electric fields are equal to the "force per unit charge" and are measured in units of *volts/meter* (V/m) or *kilovolts/meter* (kV/m).

The movement of electric charges is called *electric current* and is measured in *amperes* (amps). Current measures the "flow" of electricity, which is analogous to the flow of water in a plumbing system. The moving charges in an electric current produce a *magnetic field* which exerts force on other moving charges. Wires carrying currents running in parallel attract, while wires carrying currents in opposite directions repel. This is the principle by which electric motors generate force.

The magnitude of a magnetic field, or magnetic flux density, is measured in *gauss* (G) or *tesla* (T) (1 T = 10,000 G). Smaller fields are measured in *milligauss* (1 milligauss (mG) = 0.001 G) or *microtesla* (1 µT = one-millionth of a tesla). Milligauss is the unit most often used to measure the strength of magnetic fields in electric transmission lines. Permanent magnets contain electrical currents at the atomic level that can generate strong magnetic fields, approximately 100 to 500 G (i.e., 100,000 to 500,000 mG). Thus, magnetic fields from permanent magnets can exert forces on electric currents, or on other magnetic objects, as for example, when a compass needle orients toward a magnet.

The strength of power line EMFs diminish with distance from the source similar to the light from a candle grows dimmer as you move away from it. The field strengths are constantly varying and decease as the inverse square of the distance from the source. For an electric transmission line, the EMF levels are highest next to the transmission lines (typically near the center of the ROW) and decrease as the distance from the transmission corridor increases. Electric fields are attenuated by objects, such as trees and walls of structures, and are completely shielded by electrically conducting material such as metal, the earth, or the surface of the body. Magnetic fields, on the other hand, penetrate most materials. Table 4.1.7-1 summarizes some of the characteristics of electric and magnetic fields.

Humans are exposed to a wide variety of natural and man-made electric and magnetic fields. The earth's atmosphere produces slowly-varying electric fields (about 0.1 to 10 kV/m) that occasionally manifest themselves as lightning. The earth's core produces a steady magnetic field, as can easily be demonstrated with a compass needle. The earth's magnetic field ranges in strength from about 470 mG to 590 mG over the United States, and is about 560 mG in the Northeast. Knowing the strength of the earth's fields provides a perspective on the size of the magnetic field measurements from an electric transmission line.

Man-made magnetic fields are common in everyday life. Many childhood toys contain magnets, and many of us use magnets to hold items on the metallic surface of refrigerators. These permanent magnets typically have fields (magnetic flux density) in excess of 100,000 mG. An increasingly common diagnostic procedure, magnetic resonance imaging, uses fields of 20,000,000 mG on humans and is considered safer than X-rays.

Electric transmission line currents are AC, because they change size and direction 60 times per second (60 cycles per second = 60 Hertz or 60 Hz). The AC currents produce AC magnetic fields; however, aside from the variation in time (60 Hz) that characterizes electric transmission line fields, they are identical in nature to steady fields, such as those due to the earth's atmosphere, or geomagnetism. Moreover, as human bodies move, the direction of the earth's magnetic field relative to this movement experiences a time-varying magnetic field, similar to AC magnetic fields.

Electric power transmission lines, distribution lines, and the electric power lines that come into our homes and workplaces are sources of electric and magnetic fields that vary in time at a frequency of 60 Hz (in North America) or 50 Hz (abroad). Magnetic fields are proportional to the current, and electric fields are proportional to the voltage on the wires; both decrease as distance from the electrical wires increases. EMFs from different sources (e.g., adjacent wires) may partially cancel or may add to the EMF level at any location. For residences, typical baseline 60 Hz magnetic fields in the middle of rooms range from 0.5 to 2.0 mG. These fields are, to a large extent, produced by outdoor distribution wiring, indoor wiring, and electric currents in ground return pathways.

In the home, 60 Hz EMFs can also be found in the vicinity of electric appliances, including fans, electric ranges, microwave ovens, refrigerators, clothes washers and dryers, fluorescent lights, televisions, toasters, vacuum cleaners, etc. Appliances produce magnetic flux densities in the range of 40 to 80 mG at distances of 1 ft, but the density quickly diminishes with distance. Personal electric appliances such as shavers, electric toothbrushes, hair dryers, massagers, electric toys, and electric blankets can produce magnetic flux densities measuring 100 mG or more in the vicinity of the appliance.

Table 4.1.7-2 summarizes the magnetic flux density associated with various devices and phenomena and several guidelines established by various organizations for certain occupations, individuals, and the general public. Table 4.1.7-3 further summarizes maximum allowable electric and magnetic field intensities at the edge of transmission line ROWs.

Power frequency EMF are part of a spectrum that encompasses frequencies that range from very high ionizing energy, such as gamma rays with frequencies of billions of cycles per second, to very low non-ionizing energy below that of power frequencies. Visible light is also included in this spectrum at the threshold between ionizing and non-ionizing electromagnetic waves. The greater the frequency of the electromagnetic energy source, the shorter the wavelength and the higher the energy. Lower frequency sources have longer wavelengths and correspondingly lower energy.

Power frequency fields are very low frequency fields (60 Hz in North America) with extremely long wavelengths of around 3,100 miles (5,000 km). Because of the extremely long wavelength, fields associated with power frequency are experienced as separate electric and magnetic fields and are therefore not considered radiation or emissions. They carry very little energy and cannot break chemical bonds or heat living tissue.

#### 4.1.7.1.1 Sources of Electric and Magnetic Fields Exposure

Electric and magnetic fields are common and exist in a wide variety of natural and man-made forms. Natural fields are associated with items used, such as the geomagnetic field of the earth and magnets. These natural fields are static and therefore do not switch back and forth like power frequency fields. Like electric appliances, overhead T&D lines are a common source of exposure to electric and magnetic fields. High voltage transmission lines can generate relatively high electric fields. However, because high voltage transmission lines are constructed along ROWs, and because electric fields drop off quickly with distance and are shielded by cable shields and physical obstacles, electric fields experienced by people within dwellings are typically dominated by the internal wiring and the use of appliances. Magnetic fields from transmission lines, although not able to be shielded by structures, also drop off quickly with distance. Therefore, magnetic fields within dwellings are also typically dominated by nearby distribution system wiring, house wiring, or appliance use. Electric and magnetic fields from different sources (e.g., adjacent wires) may partially cancel or be additive at a given location. Results of studies have shown that electric fields in the home, on average, range from zero to ten volts per meter and magnetic fields range from 0.6 to 3 mG (NIEHS, 2002).

Power frequency electric and magnetic fields can also be found in the vicinity of electric appliances, including fans, electric ranges, microwave ovens, can openers, refrigerators, clothes washers and dryers, fluorescent lights, televisions, toasters, vacuum cleaners, hair dryers, alarm clocks, electric blankets, and computers. Appliances produce magnetic fields that can range from one to 150 mG at distances of 1 ft (0.3 m) (NIEHS, 2002). These fields decrease in strength much more quickly with distance than do power line fields.

### *4.1.7.2 Onshore Environment Pre-Project*

Baseline measurements of power frequency (60 Hz) magnetic flux density were made on June 5 and 6, 2002, along the proposed onshore transmission cable route. Based upon these measurements and physical characteristics of the planned cable system, projections of the magnetic flux density were developed that would be representative of worst-case existing conditions during times of peak electrical loads. The baseline measurements were made along the street section of the route, and at representative locations along the NSTAR Electric 115 kV ROW.

Calculations were performed using the "ENVIRO" computer program, developed by the EPRI, to determine the magnetic flux densities expected along the onshore route as a result of the operation of the proposed transmission cable system, taking into account the effects of existing sources as well as the new transmission facilities. Calculations were performed with the proposed action generating at a maximum delivered output of 454 MW and at the annual average output of 168 MW. All measurements and calculations were performed at 3.3 ft (1 m) above grade.

Electric fields were not measured nor studied in any detail for the following reasons:

- The electric field of the proposed 115 kV cables would be effectively contained within the body of each cable (i.e., shielded) by its grounded metallic shield;
- Electric field strength is a function of power line voltage and the operating voltage of NSTAR Electric's existing overhead T&D lines would not be changed by the proposed facilities (and thus, the resulting electric field strengths would not change);
- The focus of potential health effects of power frequency fields has been primarily with magnetic rather than with electric fields; and
- Calculations performed to determine existing electric field strengths and those expected after any proposed modifications to NSTAR Electric's 115 kV transmission lines show that the existing and predicted electric field levels at the edge of NSTAR Electric's ROW are well below 0.55 kV/ft (1.8 kV/m), which has been used as a guideline by the Commonwealth of Massachusetts EFSB. The maximum electric field strength in and adjacent to the streets along the proposed route of the onshore transmission cable system is on the order of 0.03 kV/ft (0.1 kV/m).

#### 4.1.7.2.1 Landfall to NSTAR Electric ROW

The primary sources of existing power frequency EMF along the street portion of the proposed onshore transmission cable system route are the existing overhead distribution lines. Their nominal operating voltage is 23 kV phase-to-phase/13.2 kV phase-to-ground. They are fed radially from Distribution Line 92, which emanates from Hyannis Junction Substation. Proceeding in a southerly direction down the route (away from the substation and towards the landfall location), the load current on the lines decreases as the trunk circuit extends along the route branching to other distribution circuits. At New Hampshire Avenue, the line changes from 3-phase to single phase. Measured magnetic flux density at the edge of the pavement closest to the overhead line ranged from 1 to 21 mG along the length of the route, generally increasing in a northerly direction consistent with increasing current. Representative measurements directly under the lines did not exceed these values by more than 1 mG. At the time of the measurements, total load on Line 92 was about 14 MW. Line 92 experienced a 27 MW load during the historical system peak on August 9, 2001 (Report No. 4.1.7-1). Extrapolating to these load levels produces maximum magnetic flux density in the range of 2 to 40 mG, although local field strengths may vary depending on conductor geometry and individual loads. The measured field strength directly under the lines in front of the Marguerite E. Small School was 5 mG or 9 mG when extrapolated to peak load.

Calculated existing electric field strengths in and adjacent to the streets along this route range between 0.032 and 0.29 kV/ft (0.01 and 0.09 kV/m).

#### 4.1.7.2.2 Within the NSTAR Electric Right-of-Way

Magnetic flux density was measured under existing 115 kV lines 118 and 119 and existing 23 kV lines in the NSTAR Electric ROW where it crosses Willow Street at the low point in the lines. The highest field strength measurements were found at this location. The location is representative of the field strengths on the existing ROW between Harwich Tap and Barnstable Switching Station. Current flow at the time of the measurements was 296 Amps in line 118 and 143 Amps in Line 119. The magnetic flux density was highest under the 118/119 lines, at 26 mG, falling to 18 mG at the north edge of the ROW, and 6 mG at the south edge of the ROW. Using the same line geometry (which is much better defined and more consistent than for the in-street distribution circuits), the corresponding magnetic flux densities were calculated at NSTAR Electric's forecast peak loading (without the proposed action) of 643 Amps on line 118 and 311 Amps on line 119. This resulted in 127 mG directly under the lines, 56 mG at the north edge of the ROW, and 12 mG at the south edge of the ROW.

Calculated existing electric field strength directly under the 115 kV overhead lines 118 and 119 is 2.0 kV/m. At the north edge of the ROW, this falls to 0.2 kV/m, and is less than 0.1 kV/m at south edge of ROW.

#### *4.1.7.3 Offshore Environment Pre-Project*

##### 4.1.7.3.1 Conditions in Nantucket Sound

There are no known power facilities in the waters of Lewis Bay or Nantucket Sound in the vicinity of Horseshoe Shoal, with the exception of the existing Nantucket cable that runs from Nantucket to Cape Cod, which may also have low levels of EMF associated with its operation. Further to the west of the site of the proposed action are existing electric cables that run between Falmouth and Martha's Vineyard. The only other pre-project magnetic field existing in the location of the proposed 115 kV submarine transmission cable is the natural geo-magnetic field of the earth, which is a static DC field that is oriented toward the North and downward into the earth.

## 4.2 BIOLOGICAL RESOURCES

### 4.2.1 Terrestrial Vegetation

The terrestrial vegetation associated with this proposed action is located along the onshore transmission cable system route starting at the landfall location in Yarmouth, Massachusetts and heading to Barnstable Switching Station. The proposed onshore transmission cable system route runs north from the landfall at New Hampshire Avenue in Yarmouth for approximately 4 miles (6.4 km) along Berry Avenue, Higgins Crowell Road, and Willow Street. The route leaves the roadways for approximately 2 miles (3.2 km) then heads west and then south along the existing NSTAR Electric ROW to the Barnstable Switching Station.

The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data. This section provides characterization of salt marsh, freshwater wetland, and upland vegetation that occurs along the on land transmission cable route, including mapping of wetland boundaries and buffer zones, and an explanation of the significance of each wetland area to the interests enumerated in the WPA.

#### *4.2.1.1 Woodlands*

The upland vegetated communities located adjacent to the roadway portion of the proposed transmission cable system route are primarily pitch pine-oak forests dominated by white oak (*Quercus alba*), pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), lowbush blueberry (*Vaccinium angustifolium*), and sassafras (*Sassafras albidum*). Soils in these areas were observed to be sandy and are mapped as Carver coarse sand and Carver loamy coarse sand (NRCS, December 15, 2006). The woodland vegetation adjacent to the project terrestrial path is typical of Cape Cod consisting of trees of various age classes and distribution.

### *4.2.1.2 Fields and Open Space*

The on-land transmission cable corridor does not intersect any naturally occurring field or open space areas. The managed NSTAR Electric ROW contains upland vegetation that is maintained as scrub/shrub community, with the primary cover consisting of interspersed woody and herbaceous species that vary in density along the ROW. The ROW is managed in compliance with NSTAR's vegetation management plan. Common species observed include black oak (*Quercus velutina*), sassafras, greenbrier (*Smilax glauca*), bearberry (*Arctostaphylos uva-uri*), poison ivy (*Toxicodendron radicans*), and knapweed (*Centaurea jacea*). Soils along the ROW consist of medium to coarse sands, and are mapped as Plymouth-Barnstable complex. (NRCS, December 15, 2006). In addition to the scrub/shrub community of the ROW there are also residential yards adjacent to the roadways that could be considered open spaces with vegetation consisting of mowed grasses and ornamental landscaping.

### *4.2.1.3 Freshwater Wetlands*

Wetlands in the area of the proposed action were characterized based on review of mapped resources, wetland field investigations, and related studies completed as part of the proposed action siting and permitting process. The following sources were reviewed as part of this characterization:

- USGS Topographic Map, Dennis and Hyannis Quadrangles
- USGS Aerial Photos dated March 5, 1995 and April 3, 1995
- MassGIS data on mapped wetland resources, open space mapping, endangered species
- Lake and Pond Recharge Areas Map, prepared for Town of Yarmouth by IEP, Inc. (August 1988)
- MassDEP SAV Mapping Inventory for 1995, and 2001
- SAV Diver Survey, Woods Hole Group, Inc. July 2003
- SAV Investigation Cape Wind Energy Project Nantucket Sound, Massachusetts, August 2006
- Ocean Surveys, Inc. (OSI) Plan Drawing 01ES047.2, Sheet 1 of 7
- Massachusetts NHESP records
- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM), Town of Yarmouth, Barnstable County, Community Panel Numbers 250015 003C (June 17, 1986) and 250015 005D (July 2, 1992)
- FEMA FIRM, Town of Barnstable, Barnstable County, Community Panel Number 250001 0005C (August 19, 1985)
- National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database for Barnstable County, Massachusetts (December 15, 2006)
- NOAA Published Bench Mark Data, Hyannis Harbor, Massachusetts (September 29, 1989)
- Coastal Watersheds Map, prepared for Town of Yarmouth by IEP, Inc. (August 1988)
- Town of Yarmouth GIS database

- Town of Yarmouth Comprehensive Plan, Chapter 7 Coastal Resources (March 20, 1997)

Wetlands have been identified in the vicinity of the area of the proposed action seaward and within the state territorial limit of Nantucket Sound and Lewis Bay, and along the onshore transmission cable route. Portions of the submarine and onshore transmission route fall within the town boundaries of Barnstable and Yarmouth. Wetlands in the area of the proposed action are generally defined and regulated according to the following Federal, State, and local wetland regulations:

- Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403)
- Section 404 of the CWA (33 U.S.C. 1344)
- ESA of 1973 (16 U.S.C. 1531-1543)
- WPA (M.G.L. c. 131, §40), Rivers Protection Act (Ch. 258 of the Acts of 1996), and regulations (310 CMR 10.00)
- Section 401 WQC (33 U.S.C. 1251, et seq.) and regulations (314 CMR 9.00)
- Coastal Wetlands Restriction Act (M.G.L. c. 131, §105)
- Coastal Zone Management Act of 1972 (16 U.S.C. §1451 to 1465), and regulations (301 CMR 20.00-21.00)
- Chapter 91 Waterways License (310 CMR 9.00)
- Massachusetts ESA (M.G.L. c. 131 §40) and regulations (321 CMR 10.00)
- Cape Cod Commission Act (Ch. 716 of the Acts of 1989 and Ch. 2 of the Acts of 1990)
- Cape Cod Atlas of Tidally Restricted Salt Marshes, Cape Cod, Massachusetts (December 2001)
- Yarmouth Wetlands Protection By-law and Regulations (Chapter 143)
- Barnstable Wetlands Protection Ordinance (Article 27)

There are several freshwater wetlands located adjacent to the proposed terrestrial route. These wetlands include Jabinettes Pond, Thornton Brook, red maple swamps, an Atlantic white cedar swamp, and a coastal plain pond. All areas potentially subject to Federal, state, or local jurisdiction within 200 ft (61 m) of the onshore transmission route were field investigated in October 2001, August 2002, and December 2002. Wetlands were delineated in December 2002, in accordance with criteria established by the USACE, MassDEP, and the Yarmouth WPR. It should be noted that there are no wetland resource areas located along or within 100 ft (30.5 m) of the onshore transmission route within Barnstable. Vegetated wetland boundaries were surveyed using GPS.

Six freshwater wetland systems, as shown on Figure 4.2.1-1, were identified within approximately 100 ft (30.5 m) of the proposed onshore transmission cable route in Yarmouth. A locally regulated isolated wetland north of Water Street and east of Berry Avenue was also identified during field investigations. Because this wetland area is slightly more than 100 ft (30.5 m) from the transmission cable route, it is not within the jurisdiction for this proposed action. The following provides a description of those six wetland resource areas, as shown on Figure 4.2.1-1, within 100 ft (30.5 m) of the onshore transmission cable route.

- **Wetland 1 – Bordering Vegetated Wetland (BVW), Bank, Waters of the United States (local, State, and Federal jurisdiction)** is an Atlantic white cedar (*Chamaecyparis thyoides*) swamp located on the east and west sides of Higgins Crowell Road in Yarmouth. The wetland is within approximately 60 ft (18.3 m) of the road, and is located at a well-defined break in slope. A 12-inch (30.5 cm) concrete culvert beneath the road appears to connect the east and west wetland areas, and this wetland is therefore regulated as Bank and Waters of the United States. On the east side of the road, the wetland is relatively undisturbed and consists of a mixed cedar, tupelo (*Nyssa sylvatica*), and red maple (*Acer rubrum*) canopy. There is also a shrub layer with highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), green briar (*Smilax rotundifolia*), fetterbush (*Leucothoe racemosa*), and swamp azalea (*Rhododendron viscosum*). On the west side of the road, the majority of the mature Atlantic white cedars are dead or in decline. Vegetation includes live sapling Atlantic white cedars, red maple, tupelo, inkberry (*Ilex glabra*), sweet pepperbush, green briar, highbush blueberry, water willow (*Decodon verticillatus*), and wool grass (*Scirpus cyperinus*). This wetland is regulated as BVW and Bank, and has a 100 ft (30.5 m) Buffer Zone under the Massachusetts WPA, and a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m) Vegetated Buffer under the Yarmouth WPR. Wetland 1 is regulated as Waters of the United States by the USACE.

- **Wetland 2 – BVW, Bank, Land Under Waterbodies and Waterways (LUWW), Waters of the United States** (local, State, and Federal jurisdiction) consists of Jabinettes Pond, on the east side of Higgins Crowell Road, and Thornton Brook, located on both the east and west side of the road. A vegetated wetland abutting Jabinettes Pond is located within 100 ft (30.5 m) of the proposed onshore transmission cable route. It is dominated by red maple, tupelo, highbush blueberry, sweet pepperbush, spicebush (*Lindera benzoin*), green briar, and sensitive fern (*Onoclea sensibilis*). Jabinettes Pond discharges into Thornton Brook, which appears to flow west and crosses beneath Higgins Crowell Road via a buried culvert. Road runoff is also channeled via paved swales on both sides of Higgins Crowell Road into Thornton's Brook. The stream briefly appears aboveground on the west side flows in a culvert beneath an old vegetated road. An unused concrete flow control structure with a slot for flashboards was observed on the east end of the west side culvert. The stream finally appears aboveground into a defined channel with steep man-altered banks and flows southwest.

  Thornton Brook is mapped as a perennial stream on the current USGS map, and it is presumed to be perennial under 310 CMR 10.58(2) (a) (1) (a). However, Thornton Brook was observed to be dry over four days of field observation during July 16, August 3, 15, 16, and 17 of 2007, during non-drought conditions, and was documented as dry. Pursuant to 310 CMR 10.58 (2)(a)1.d., the issuing authority shall find that any stream is intermittent based upon a documented field observation that the stream is not flowing. In addition the Yarmouth Conservation Administrator has confirmed that Thornton Brook is not perennial. Thornton Brook is therefore intermittent and does not have an associated Riverfront Area.

  Wetland 2 is regulated as BVW, LUWW, and Bank. A 100 ft (30.5 m) Buffer Zone and 200 ft (61 m) Riverfront Area from Bank are jurisdictional under the Massachusetts WPA. The Yarmouth WPR regulate Wetland 2 as Vegetated Wetland, LUWW, and Bank with a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m)

Vegetated Buffer. Wetland 2 is regulated as Waters of the United States by the USACE.

- **Wetland 3 – BVW, Bank, Waters of the United States** (local, state, and Federal jurisdiction) is a forested wetland located approximately 50 ft (15.2 m) west of Higgins Crowell Road in Yarmouth. The wetland is dominated by red maple, sweet pepperbush, highbush blueberry, inkberry, swamp azalea, fetterbush, cinnamon fern (*Osmunda cinnamomea*), and Sphagnum mosses. An intermittent stream channel flows west through the wetland and into Little Sandy Pond, located approximately 700 ft (213.4 m) west of Higgins Crowell Road. The intermittent stream channel was observed dry in areas in the vicinity of the wetland delineation in December 2002. Wetland 3 is regulated as BVW and Bank with a 100 ft (30.5 m) Buffer Zone under the Massachusetts WPA, and a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m) Vegetated Buffer under the Yarmouth WPR. This wetland is regulated as Waters of the United States by the USACE.

- **Wetland 4 – BVW, Waters of the United States** (local, State, and Federal jurisdiction) is a large forested swamp located approximately 30 ft (9.1 m) east of Higgins Crowell Road in Yarmouth. The wetland has an open understory consisting of sweet pepperbush, highbush blueberry and Sphagnum mosses and canopy dominated by red maple. The wetland is defined by an obvious topographic break in slope. A headwall with a partially buried culvert is located on the wetland's edge, adjacent to the roadway, but does not appear to be functioning. Wetland 4 is regulated as BVW and has a 100 ft (30.5 m) Buffer Zone under the Massachusetts WPA, and a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m) Vegetated Buffer under the Yarmouth WPR. This wetland is regulated as Waters of the United States by the USACE.

- **Wetland 5 – BVW, Bank, Waters of the United States** (local, State, and Federal jurisdiction) is located on the west side of Higgins Crowell Road in Yarmouth and is separated from the road by a strip of upland dominated by pitch pine and sheep laurel (*Kalmia angustifolia*). The wetland consists of a roughly circular wet meadow dominated by asters, little bluestem (*Schizachyrium scoparium*), rushes (*Juncus* spp.), umbrella-sedges (*Cyperus* spp.), St. John's wort (*Hypericum* spp.), cranberry (*Vaccinuium oxycoccos*), spike rush (*Eleocharis* spp.), and sundews (*Drosera* spp.). The east side of the wet meadow area abuts a 30 ft (9.1 m) wide shrub swamp, densely vegetated with green briar, inkberry, highbush blueberry, pitch pine, and fetterbush. A manmade intermittent channel on the west side of the wetland flows west into Hawes Run. Both the wetland and intermittent channel were dry at the time of inspection in December 2002. The USGS map shows the wet meadow as an open waterbody meeting the 10,000 square ft (929 $m^2$) size requirements for a Pond under the Massachusetts WPA. However, observations of the area dry during non-drought periods indicates that it does not meet the definition of Pond under the Massachusetts WPA (310 CMR 10.04) or the Yarmouth WPR (Section 1.04). Wetland 5 is regulated as BVW and Bank with a 100 ft (30.5 m) Buffer Zone under the Massachusetts WPA. Under the Yarmouth WPR, a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m) Vegetated Buffer is established from the wetland boundary. Wetland 5 is regulated as Waters of the United States by the USACE.

  Wetland 5 is located within PH 40 and EH 188 a known area to contain the Plymouth Gentian (*Sabatia kennedyana*) a species of special concern according to NHESP.

From Willow Street in Yarmouth, the onshore transmission cable system route leaves the roadway and extends west and south for approximately 2 miles (3.2 km) along the NSTAR Electric ROW to the Barnstable Switching Station. One freshwater vegetated wetland area bordering the south shore of Long Pond in Yarmouth is present along the existing ROW immediately west of Willow Street.

- **Wetland 6 – BVW, Bank, LUWW, Waters of the United States** (local, state, and Federal jurisdiction) consists of Long Pond, which is situated on the northern edge of the ROW just west of Willow Street. The pond contains open water, surrounded by a fringe of emergent marsh and shrub swamp dominated by highbush blueberry, sweet pepperbush, swamp azalea, and leatherleaf (*Chamaedaphne calyculata*). The wetland is located at the base of a steep slope; however, many of the wetland plants, including swamp azalea and sweet pepperbush, are growing significantly upslope. Therefore, the boundary of the wetland was delineated using evidence of hydrology and hydric soils, under criteria established by the MassDEP. Wetland 6 is regulated as BVW, Bank, and LUWW and has a 100 ft (30.5 m) Buffer Zone under the Massachusetts WPA, and a 50 ft (15.2 m) No-Build Zone and 35 ft (10.7 m) Vegetated Buffer under the Yarmouth WPR. This wetland is regulated as Waters of the United States by the USACE.

  Wetland 6 is located within PH 88 and EH 187 a known area to contain the Plymouth Gentian a species of special concern according to NHESP. Wetland 6 is also identified as Coast Plain Pondshore Natural Community according to the NHESP Natural Communities GIS data layer. The MassGIS data layer currently has 92 different Coastal Pain Pondshores mapped. Coast Plain Pondshore vegetation has zonation that is correlated with a flooding regime (Swain and Kersley, 2001). Coastal Plain Pondshores typically have a characteristic zonation pattern from dry to waterline, as follows:

  - Upland oak forest;
  - Shrub border dominated by highbush blueberry (*Vaccinium corymbosum*) associated with sweet pepperbush (*Clethra alnifolia*), and green briar (*Smilax rotundifolia*);
  - Emergent exposed pondshore dominated by coastal plain flat-topped goldenrod (*Euthamia tenuifolia*), pondshore rush (*Juncus pelocarpus*), rose coreopsis (*Coreopsis rosea*) and golden pert (*Gratiola aurea*), with beaksedge (*Rhynchospora* spp.), lance-leaf violet (*Viola lanceolata*), and dwarf St. John's-wort (*Hypericum mutilum*);
  - Semi-permanently flooded zone characterized by one or more of the following: bayonet rush (*Juncus militaris*), spike-sedge (*Eleocharis* spp.), pipewort (*Eriocaulon aquaticum*); and
  - Hydromorphic rooted vegetation in deeper water including yellow water-lily (*Nuphar variegata*), white water-lily (*Nymphaea odorata*), and Robbins' spike-sedge (*Eleocharis robbinsii*).

### 4.2.2 Coastal and Intertidal Vegetation

Coastal wetlands as classified under the Massachusetts Wetland Protection Act were identified along the sections of the proposed submarine transmission cable route inside the state territorial limit in Lewis

Bay to the proposed landfall location at New Hampshire Avenue in Yarmouth, and the coastal portions of the onshore transmission cable system route abutting Lewis Bay. The proposed landfall location is a rectangular embayment beach surrounded by a concrete headwall. Residences with associated yards are located directly adjacent (east and west) to the rectangular embayment, and their ocean frontage is fortified by concrete retaining walls and riprap.

#### 4.2.2.1 Flora

The shoreline at the New Hampshire Avenue landfall is a concrete revetment. The landfall location is devoid of flora. Residences with associated yards are located directly adjacent (east and west) to the rectangular embayment, and their ocean frontage is fortified by concrete retaining walls and riprap. There are no known significant populations of coastal flora present at the proposed landfall location.

#### 4.2.2.2 Barrier Islands, Beaches, and Dunes

The shoreline at the landfall does not serve as a sediment source for coastal beaches or coastal dunes; however, it provides a vertical buffer that is significant to storm damage prevention and flood control. There are two coastal beaches associated with this proposed action. One is Coastal Beach 1 in which the proposed transmission cable system comes ashore. The other is Coastal Beach 2, which is located approximate 60 ft (18.3 m) east of the proposed transmission route and is known as Englewood Public Beach.

- **Coastal Beach 1** (state and local jurisdiction) is defined under the Massachusetts WPA as unconsolidated sediment subject to wave action, tidal and coastal storm action that forms the gently sloping shore of a body of water. Coastal Beach extends from the mean low water line landward to the coastal bankline or seaward edge of existing manmade structures. Coastal Beach 1 is a gently sloping, sandy area that extends from mean low water line to the concrete revetment that comprises Coastal Bank at the proposed landfall location. The Massachusetts WPA and the Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Coastal Beach. In addition, the Yarmouth WPR prohibit structures within 50 ft (15.2 m) of Coastal Beach and establish a 35 ft (10.7 m) Vegetated Buffer.

- **Coastal Beach 2** (state and local jurisdiction) is Englewood Public Beach, located approximately 60 ft (18.3 m) east of New Hampshire Avenue. The beach extends from the mean low water line west to the edge of a paved parking lot adjacent to New Hampshire Avenue. The Massachusetts WPA and the Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Coastal Beach. In addition, the Yarmouth WPR prohibit structures within 50 ft (15.2 m) of Coastal Beach and establish a 35 ft (10.7 m) Vegetated Buffer.

#### 4.2.2.3 Brackish and Saline Wetlands

The transmission cable system corridor intersects coastal wetland resources and their buffer zones, some of which are jurisdictional under the Massachusetts WPA and some through the CWA under the USACE. Jurisdictional and coastal wetland resource areas observed to occur between the 3.5 mile (5.6 km) limit and the proposed landfall location, (see Table 4.2.2-1), include the following:

- **Salt Marsh 1** (state and local jurisdiction) is defined as vegetated wetlands located in the intertidal zone dominated by herbaceous plants adapted to varying levels of salinity. Salt Marsh 1 is located approximately 200 ft (61 m) west of the proposed landfall location, between Lewis Bay and Shore Road in Yarmouth. This salt marsh is vegetated by poison ivy (*Toxicodendron radicans*), salt meadow cordgrass (*Spartina patens*), rushes (*Juncus* spp.), and seaside goldenrod (*Solidago sempervirens)*. This salt marsh is positioned between the residences at 43 and 37 Shore Drive. The Massachusetts WPA and the Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Salt Marsh. In addition, the Yarmouth WPR prohibit structures within 50 ft (15.2 m) of Salt Marsh and establish a 35 ft (10.7 m) Vegetated Buffer.

- **Salt Marsh 2** (state and local jurisdiction) is located approximately 85 to 120 ft (26 to 36.6 m) west of the proposed transmission cable system route on New Hampshire Avenue. It is bordered by residences to the east and west, Shore Road to the south, and Broadway to the north. According to the Cape Cod Atlas of Tidally Restricted Salt Marshes (2001), a 12-inch (30.5 cm) wide culvert connecting this salt marsh to Lewis Bay is consistently clogged, causing regular tidal flooding over Shore Road between Salt Marsh 1 and Salt Marsh 2 (Cape Cod Commission, 2001). Salt Marsh 2 is vegetated by high tide bush (*Iva frutescens*), bayberry (*Morella caroliniensis*), poison ivy, salt meadow cordgrass, rushes, and seaside goldenrod. A defined channel is visible in the center of the salt marsh. The Massachusetts WPA and the Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Salt Marsh. In addition, the Yarmouth WPR prohibit structures within 50 ft (15.2 m) of Salt Marsh and establish a 35 ft (10.7 m) Vegetated Buffer.

- **Navigable Waters of the United States** (Federal jurisdiction) are defined as waters seaward of the high water line of navigable waters under Section 10 of the Rivers and Harbors Act of 1899. Navigable Waters of the U.S. encompass and extend beyond the state-regulated Land Under the Ocean. Since the landward boundary of navigable waters of the U.S. extends to the MHW elevation, this resource area partially overlaps with the Federally-regulated Waters of the United States and State-regulated Land Subject to Tidal Action, Land Containing Shellfish, and Coastal Beach.

- **Waters of the United States** (Federal jurisdiction) are defined as waters seaward of the highest annual tide line in tidal waters. The seaward limit of jurisdiction extends to the Massachusetts 3.5 mile (5.6 km) limit. When adjacent wetlands are present, such as salt marshes, the limit of jurisdiction extends to the boundary of the wetland. Waters of the United States overlap with the Federally-regulated Navigable Waters of the United States and the State-regulated Land Under the Ocean, Land Subject to Tidal Action, Land Containing Shellfish, Coastal Bank and Coastal Beach. This resource area also includes Salt Marsh 1 and 2, described below. It should be noted that although Salt Marsh is identified herein there are no direct impacts to Salt Marsh from the proposed action, as presented above.

- **Land Under the Ocean** (State and local jurisdiction) is defined under the Massachusetts WPA as the land extending from the mean low water line seaward to the boundary of the municipality's jurisdiction, and includes land under estuaries. Land Under the Ocean along the route consists of Lewis Bay and portions of Nantucket Sound within the 3.5 mile (5.6 km) state territorial limit. All work proposed in Land Under the Ocean includes Nearshore Areas, which extend to the municipality's jurisdiction but not beyond the point where the land is 80 ft (24.4 m) below the level of the ocean at mean low water. Most of the proposed work in Land Under the Ocean would be within the Town of Yarmouth; however, a small portion of the work would occur within the Town of Barnstable. The Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Land Under the Ocean. The Barnstable Wetlands Protection Ordinance provides no additional regulations for Land Under the Ocean beyond those in the Massachusetts WPA.

- **Coastal Bank** (State and local jurisdiction) is defined as the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland. The Coastal Bank at the New Hampshire Avenue landfall is a concrete revetment. The Massachusetts WPA and the Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Coastal Bank. In addition, the Yarmouth WPR prohibit structures within 50 ft (15.2 m) of Coastal Bank and establish a 35 ft (10.7 m) Vegetated Buffer.

- **Land Subject to Tidal Action** (State and local jurisdiction) is defined as land subject to the periodic rise and fall of a coastal waterbody, including spring tides. The Yarmouth WPR establish a 100 ft (30.5 m) Buffer Zone to Land Subject to Tidal Action.

- **Land Subject to Coastal Storm Flowage** (State and local jurisdiction) is defined as an area that extends upgradient or landward from the ocean and the ocean's estuaries to a point where the maximum lateral extent of flood water would theoretically terminate based upon the 100-year storm elevation referenced in the latest FIRM. The Land Subject to Coastal Storm Flowage extends approximately 1,100 linear ft (335.3 m) from the shoreline, along the route from the proposed landfall. The 100-year flood elevation varies from 13 ft (4 m) National Geodetic Vertical Datum (NGVD) at the landfall location to 11 ft (3.4 m) NGVD just beyond the intersection of Berry Avenue and Broadway.

  Portions of the area of the proposed action below elevation 13 ft (4 m) NGVD are also within the "V-zone." The V-zone is an area subject to flooding with wave action during a 100-year storm event. In the vicinity of the proposed landfall, the V-zone extends to approximately 300 ft (91.4 m) north of the Coastal Bank.

- **Land Containing Shellfish** (State and local jurisdiction) is located within Land Under the Ocean and Waters of the United States and may be located in Coastal Beach and Salt Marsh. The applicant's research and discussions with the Yarmouth Shellfish Constable (Caia, 2002) indicate that Lewis Bay contains quahogs (*Mercenaria mercenaria*) and soft shell clams (*Mya arenaria*), with some scallops (*Placopectin magellanicus*) and Eastern oysters (*Crassostrea virginica*). Shellfish resources within Lewis Bay are utilized for commercial and recreational shellfishing. The proposed submarine transmission cable route in Lewis Bay crosses a designated recreational shellfish area, but would not cross any privately licensed shellfish areas or grants (Town of Yarmouth Natural Resource Commission's Aquaculture Lease Site Maps and Recreational Shellfish Area Maps dated June 1, 1998 and December 2, 1999). Figure 4.2.2-1 presents MassGIS mapping of shellfish suitability areas that includes the locations of these designated commercial and recreational shellfish areas. Additional information on shellfish resources in Lewis Bay is provided in Section 4.2.5.3 (Benthic and Shellfish Resources).

- **Coastal Watershed Areas** (local jurisdiction) are defined in the Yarmouth WPR as wetland and upland landforms that contribute surface and sub-surface water to the estuaries within the town. These areas are mapped and delineated within a "Water Resources Protection Study" prepared for the Town of Yarmouth (see Figure 4.1.6-1). Conservation Commission jurisdiction is restricted to mapped areas within 300 ft (91.4 m) of a major estuary. Portions of the proposed route are in a mapped Coastal Watershed Area within 300 ft (91.4 m) of Lewis Bay, defined as a major estuary under Section 1.04 of the local regulations.

#### *4.2.2.4 Seagrass Beds*

MassDEP mapping and previous geophysical studies were used to identify areas of potential submerged aquatic vegetation (SAV) within the area of the proposed action. Geophysical studies using side-scan sonar of Horseshoe Shoal were completed in 2002, 2003 and 2005. The 2003 geophysical survey included side-scan sonar of the proposed cable route as indicated in Figure 2.1.2-1. MassDEP mapping and geophysical studies indicate that there are three potential SAV areas occurring within the area of the proposed action. Two are mapped in Federal waters beyond the Massachusetts 3.5 mile (5.6 km) limit and are located on Horseshoe Shoal. The other area occurs within the Massachusetts 3.5 mile (5.6 km) limit, near Egg Island in Lewis Bay. The potential seagrass areas were investigated in order to groundtruth the SAV beds, both in terms of characteristics and extent.

The Horseshoe Shoal investigation conducted on July 25, 2006 was performed to address several areas where previous side-scan sonar observations indicated the potential presence of SAV beds. The major goal of this study was to determine the presence or absence of seagrasses, and to qualitatively assess the composition of SAV in these areas of variable side-scan sonar returns (Report No. 4.2.2-1). The Lewis Bay investigation was performed July 1, 2003 to determine the extent of mapped SAV bed in the vicinity of the proposed submarine transmission cable route and to modify the proposed cable route accordingly to avoid direct impacts to SAV near Egg Island (Report No. 4.2.2-2).

The vegetative composition within the Horseshoe Shoal study area was found to consist primarily of attached red (*Grinnellia americana, Dasya pedicellat,* and *Gracillaria tikvahiae*), and green (*Codium fragile* and *Ulva lactuca*) macro-algae, not seagrasses. Of the 20 observation points, only one location included patches of eelgrass (*Zostera marina*). Of the algal species identified, only *C. fragile* is not native to New England waters; however, since its introduction it has rapidly expanded its range, and its presence at depths ranging from emergent tidal pools to depths of -39 ft (-12 m) below MLW (Villalard-Bohnsack, 2003) (Report No. 4.2.2-1).

Many of the macro-algae observed are considered seasonal, with growth beginning in early to mid-summer and disappearance by late August (Hillson, 1982; Kingsburry and Sze, 1997; Villalard-Bohnsac, 2003). Of the species observed, *G. americana* is potentially the most likely responsible for the variable side-scan sonar readings collected during geophysical studies conducted in 2003 and 2005. *G. americana* is a fast growing red alga, with a two- to four-inch-wide blade capable of growing to 19.7 inches (50 cm) in length within a single summer growth season (Hillson, 1982). For additional details on the methodology and results, see Report No. 4.2.2-1.

Several small patches of eelgrass (*Zostera marina*) were found at location T2B during the July 25, 2006 survey. This is located in the northern end of the western potential SAV bed per the 2003 and 2005 surveys in the Horseshoe Shoal area. The patches ranged in size from 3 to 9 ft (1 to 3 m) in diameter (due to the limited field of view of the camera system, size estimates are approximations) (Report No. 4.2.2-1). No other seagrass was observed during the survey.

The MassDEP Wetlands Conservancy Program has mapped submerged aquatic vegetation (SAV) beds one quarter acre or larger in size along the coast using aerial photography, GPS, and field verification. Mapping was completed in 1995 and 2001. The 2001 data were published in February 2006 and made available on the MassGIS website. The MassGIS mapping is shown on the benthic habitat map (Figure 4.2.2-1). Based upon the MassDEP mapping, one SAV bed has been mapped within Lewis Bay, located to the west of Egg Island in the Town of Barnstable. This SAV bed was also confirmed during the geophysical and geotechnical investigations conducted in 2001 and 2003. Based on a December 2002 telephone conversation with Mr. Charles Costello of the MassDEP Wetlands Conservancy Program, the applicant indicates that the mapped SAV bed had not changed much in size between 1995 and 2001. According to the MassGIS website, MassDEP mapping of the eelgrass data are conducted on a 5-year cycle. The next mapping was scheduled for 2006-2007, but results are not yet available.

The Lewis Bay SAV was identified by free diving and visual observations from a small research vessel. The diver search was conducted using a 100 ft (03.5 m) search line that was marked every 10 ft (3 m) for reference. The area was swept in a 360 degree pattern at 10 ft (3 m) increments out to 100 ft (30 m). It was determined that the SAV was eelgrass (*Zostra marina*). The extent of the mapped eelgrass bed is shown in Report No. 4.2.2-2. As presented in Tables 1 and 2 of Report No. 4.2.2-2, the divers observed that the seagrass tended to occur in small patches ranging in diameter from 3 to 20 ft (1 m to 6.3 m). Based on the field survey results, the submarine transmission cable system would be no closer than 70 ft (21.3 m) to the western edge of the eelgrass bed located near Egg Island.

## 4.2.3 Terrestrial and Coastal Faunas Other than Birds

The project components that occur on land are restricted to the transmission cable to be installed within and adjacent to roadways, along an existing electric transmission ROW, and a minor amount of work at an existing substation. Therefore, terrestrial fauna are those species likely to inhabit the various vegetative communities adjacent to the roadways, particularly in areas located away from development and busy roadway intersections. However, the area of the proposed action within the paved roadways and roadway shoulders is not expected to provide nesting, breeding, feeding, or overwintering habitat for wildlife species. As a result of "edge effect," the maintained NSTAR Electric ROW is likely to provide habitat for a diverse, but not unique, wildlife community.

### *4.2.3.1 Mammals*

Mammals that could use the terrestrial cable corridor would be typical of southeastern Massachusetts. These mammals would include but not be limited to white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), Virginia opossum (*Didelphis virginiana*), woodchuck (*Marmota monax*), striped skunk (*Mephitis mephitis*), common raccoon (*Procyon lotor*) and various rodents. Many of these species would use the NSTAR ROW and the woodland adjacent to some of the roadway portions of the proposed buried line for hunting, browsing, and nesting habitat.

#### 4.2.3.1.1 Bats

Although resident and migrant bat populations have been documented on the Islands, it remains unclear as to how they travel to and from the islands; however, it is possible that they may cross Vineyard Sound and/or Nantucket Sound (DeGraaf and Yamasaki, 2001; Buresch, 1999).

Species of bat that currently or historically occur in Massachusetts include big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), Northern long-eared bat *(Myotis septentrionalis*), Indiana bat (*Myotis sodalist*) (last recorded in 1939; Federally and State Endangered), small-footed bat (*Myotis leibii*) (known to occur only in Hampden County; species of conservation concern), Eastern pipistrelle (*Pipistrellus subflavus*), silver-haired bat (*Lasionycteris noctivagans*) (species of conservation concern), red bat (*Lasiurus borealis*) (species of conservation concern), and hoary bat (*Lasiurus cinereus*) (species of conservation concern). The majority of these species occur statewide in Massachusetts, however, no state or federally-listed threatened or endangered bat species occur in southeastern Massachusetts. A total of twenty three hibernacula are known to support wintering bats in Massachusetts. Eleven are anthropogenic hibernacula (i.e., mines) and twelve are naturally occurring caves (MDFW, 2005). The majority of hibernacula are located in the western portion of the state in Berkshire County. Known hibernacula are located in the Townships of Charlemont, Cheshire, Chester, Egremont, Lanesborough, New Ashford, New Marlborough, North Adams, Pepperell, Rowe, Sturbridge, and West Stockbridge. There are no known winter hibernacula located in Barnstable, Dukes, or Nantucket Counties. The furthest southeastern known hibernaculum in Massachusetts is located in the Township of Sturbridge in Worcester County.

Of the seven species occurring in the region, the silver-haired bat, eastern red bat, and hoary bat (tree-roosting bats) are considered long-distance migrants, whereas the big brown bat, northern myotis, eastern pipistrelle, and little brown myotis do not typically travel long distances between their hibernacula and summer ranges (Whitaker and Hamilton, 1998). Although home ranges have not been described for northern myotis and little brown myotis, eastern pipistrelles and big brown bats are thought to travel no more than 50 miles (80 km) between hibernacula and summer ranges (DeGraaf and Yamasaki, 2001). Bats in southeastern Massachusetts either hibernate or migrate south during the winter, and are generally active between late April and early October, depending upon the temperature and weather conditions. Long-distance migratory bats travel south to their winter ranges (southern United States) between August and early October, and return during April and May. Little is known about the migratory behavior of the tree-roosting bats. However, museum records of migratory bats in North America suggest some tendency to migrate along the Pacific and Atlantic coasts, especially during the fall (Cryan, 2003).

Species such as big brown bats, *myotis* species, and eastern pipistrelle make small scale movements in April and May, and August and September between summer breeding areas and winter hibernacula. Most of these species travel 50 miles (80 km) or less, however, some dispersals are as far as 310 miles (500 km) (England et al., 2001). The long-distance migratory bats over-winter in southern North America. Silver-haired bats winter in mild coastal climates as far north as New York (England et al., 2001). Red-bats winter in Arkansas, Missouri, Kentucky, Tennessee, West Virginia, Virginia, North Carolina, the Gulf States, and northern Mexico (England et al., 2001). Hoary bats winter in coastal areas from South Carolina to central Florida, the Gulf States west to Texas, and south to northern Mexico (England et al., 2001). Their migratory movements are usually associated with the passage of cold fronts. Most migrants arrive at breeding grounds by May or June, and depart for winter habitats in August and September.

Although bats are terrestrial species and are generally not associated with saline habitats, saltwater crossings have been documented for migratory tree bats. Occasional observations of silver-haired, eastern red bats and hoary bats on ships at sea and offshore islands such as Bermuda confirm that these species are able to travel long distances over water (Cryan, 2003). A more recent paper summarizes incidental observations of bats made at Southeast Farallon Island, 19.8 miles (32 km) south of Point Reyes, California, recorded between 1968 and 2005, which indicate that migratory hoary bats use the island as a stopover point during fall migration periods, occasionally forming migratory flocks (Cryan and Brown 2007). Additional published records of bats over coastal and marine habitats are limited and generally out-dated, but include the following. Migratory bats (eastern red, silver-haired, and hoary bats) were reported over coastal and marine areas in the fall during late-1800s in the vicinity of Highland Light, a near-shore lighthouse near North Truro, on Eastern Cape Cod (Miller, 1897). In 1907, what were believed to be silver-haired bats were observed roughly 5 miles (8 km) offshore, flying just above the water's surface toward the shoreline of Staten Island before sunrise. During October of the same year, bats that were presumed to be migrants that had crossed Long Island Sound were observed roosting under beach cliffs along the north shore of Long Island (Murphy and Nichols, 1913). In 1919, an eastern red bat was observed circling a ship that was out of view of land, an hour after sunrise. The bat was believed to be following a southern migration path over water, and had not merely been blown offshore due to weather conditions (Nichols, 1920). In September 1920, approximately 100 eastern red and silver-haired bats landed on a ship located 20 miles (32.1 km) off the coast of North Carolina (Thomas, 1921). In 1949, roughly 200 bats were seen flying around a ship 65 miles (104 km) offshore (85 miles [136.7 km] southwest of Nantucket Island) (Carter, 1950). There were multiple records of bats circling then coming to roost on ships that were roughly 100 miles (161 km) or more offshore (Mackiewicz et al., 1956; Griffin, 1940; Norton, 1930).

These observations indicate that bats, particularly the migratory tree-roosting species, frequently undertake long distance movements over water during certain times of year. Whereas no studies have occurred to track migration patterns of bats along the east coast, it is possible that certain species of migratory bats follow migration corridors along the Atlantic coast, in a manner similar to those followed by many migratory birds. However, historic observations of bat migration should be interpreted with caution. The observations of groups of hundreds of migrating bats seen offshore nearly one hundred years ago is likely a reflection of historically much more abundant bat populations. Though large flocks of over one hundred individuals of migratory red bats could once be observed, more recent observations have reported no more than 15 individual migrants at a time (England et al., 2001). The populations of many species of bats have suffered notable declines, including species that were once considered common (England et al., 2001).

No surveys specific to bats were conducted in association with the proposed action, and little is known about the frequency with which bats fly over water bodies such as Nantucket Sound. All seven species of bats found in southeastern Massachusetts were confirmed on Martha's Vineyard, and Nantucket is within the theoretical range of four species (little brown myotis, silver-haired bat, eastern red bat, and hoary bat) (DeGraaf and Yamasaki, 2001; Buresch, 1999). Little information is available of bat use of Nantucket Sound. Bats do inhabit islands in Nantucket Sound; therefore, over-water crossings do occur. An acoustical detection and netting study conducted in spring through fall 1997 and 1998 documented silver-haired bat, red bat, hoary bat, Eastern pipistrelle, big brown bat, little brown bat, and Northern long-eared bat on Martha's Vineyard. Data indicated that *myotis* species may be using Martha's Vineyard as a stopover point during spring dispersal: Higher levels of *myotis* acoustic activity detected in the spring and early summer was believed to be associated with seasonal dispersal activity (Buresch, 1999). These high detection levels did not occur within the fall. This was believed to be a result of a longer, more continual fall migration (Buresch, 1999). Surveys were also conducted at the Camp Edwards portion of MMR on Cape Cod in 1999 and 2000, and documented the presence of four bat species: the big brown bat, eastern red bat, northern myotis, and the eastern pipistrelle (Massachusetts Army National Guard, 2001).

Although all species of bats present in southeastern Massachusetts are theoretically capable of crossing Nantucket Sound and have been documented on Martha's Vineyard, the migratory tree bats (eastern red bat, silver-haired bat, and hoary bat) are the most likely species to travel through the area of the proposed action, as they are stronger fliers and have demonstrated ability to travel over large bodies of water. These species would be expected to be present in the area of the proposed action only during spring and fall migrations. No bat species are expected to forage within the area of the proposed action, and bats would likely pass through the area only during migration and when traveling from the mainland to island habitats.

#### 4.2.3.2 Reptiles and Amphibians

The amphibians and reptiles in the assessment area would be typical for the region including but not limited to the following species; pickerel Frog (*Rana palustris*); American bullfrog (*Rana catesbeiana*);

wood frog (*Rana sylvatica*); eastern American toad (*Bufo americanus americanus*); common garter snake (*Thamnophis sirtalis*); snapping turtle (*Chelydra serpentine*); painted turtle (*Chrysemys picta*) northern two-lined salamander (*Eurycea bislineata*); eastern Red-backed Salamander (*Plethodon cinereus*); eastern newt (*Notophthalmus viridescens*). The majority of the reptile and amphibian species would use the wetlands located adjacent to the proposed buried transmission cable system as breeding, foraging, and nesting habitat. The maintained utility ROW is more than likely to be traveled across by amphibians and reptiles migrating to the wetlands located along the ROW. There are numerous insect populations common to the region that would feed in the herbaceous plants that would be growing in the cleared ROW. These insects provided food for the insectivorous reptile and amphibians.

#### 4.2.3.3 Freshwater Fish

The proposed action has only one crossing where the presence of freshwater fish is a concern. The transmission cable crosses Thornton Brook, designated as intermittent. The proposed transmission corridor crosses Thornton Brook just after it exits Jabinettes Pond. Jabinettes Pond discharges into Thornton Brook, which appears to flow west and crosses beneath Higgins Crowell Road via a culvert. This stream channel was observed to be completely dry during the field reviews in October 2001 and December 2002 and the presence and the potential species of fish that could be impacted could not be assessed.

#### 4.2.3.4 Invertebrates

The invertebrate population in or near the proposed on-land transmission cable system route are typical of southeastern Massachusetts, consisting of, but not limited to, species such as:

- Red-legged locust (*Melanoplus femur-rubrum*)
- Field cricket (*Gryllus pennsylvanicus*)
- Meadow spittlebug (*Philaenus spumarius*)
- Eastern yellow jacket (*Vespula maculifrons*)
- Honey bee (*Apis mellifera*)
- American bumblebee (*Bombus pennsylvanicus*)
- Wood ticks (*Dermacentor* spp.)
- Black-legged ticks (*Ixodes* spp.)
- Daring jumping spider (*Phidippus audax*)
- Wolf spiders (*Pardosa* spp.)
- American house spider (*Achaearanea tepidariorum*)
- European earwig (*Forficula auricularia*)
- Convergent lady beetle (*Hippodamia convergens*)
- Black blister beetle (*Epicauta pennsylvanica*)
- Little black ant (*Monomorium minimum*)
- Rose weevil (*Rhynchites bicolor)*
- Eastern dobsonfly (*Corydalus cornutus*)
- Tent caterpillars (*Malacosoma* spp.)
- Gypsy moth caterpillar (*Lymantria dispar*)
- Woolly bear caterpillar (*Isia isabella*)
- Fall webworm (*Hyphantria cunea*)
- Monarch butterfly (*Danaus plexippus*)
- Earthworm (*Lumbricidae* spp.)
- Night crawler (*Lumbricus terrestris*)
- House mosquito (*Culex pipiens*)

According to the NHESP there are threatened or endangered invertebrate species along the proposed route. These state-listed T&E species are:

(1) Comet darner (*Anax longipes*), a species of special concern;
(2) New England bluet (*Enallagma laterale*), a species of special concern; and
(3) Water-willow stem borer (*Papaipema sulphurat*a), a threatened species.

### 4.2.4 Avifauna

Avian resources that are likely to occur in the area of the proposed action are protected under the Migratory Bird Treaty Act (16 USC §§ 703-712) and in some cases, the Endangered Species Act. Additionally, Federal projects are subject to Section 7 of the ESA (1973, as amended). Each Federal agency is required to ensure that any authorized project is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of critical habitat (7 USC § 136; 16 USC § 460 et seq. [1973]), as discussed in Section 4.2.9. Executive Order 13186 "Responsibilities of Federal Agencies to Protect Migratory Birds" (January 10, 2001) requires that Federal agencies evaluate the effects of agency actions on migratory birds.

Nantucket Sound is recognized as a regionally significant locale for waterbirds (Veit and Peterson, 1993). The Sound is located within the Atlantic flyway, and its position along the flyway is ideal for attracting thousands of waterbirds during migration. The Sound's location, the configuration of the surrounding landscape, the mixture of contributing waters, and the regional climate combine to attract many species of waterbirds year-round. To evaluate the potential effects of the proposed action, it is necessary to first understand the abundance and distribution of avian resources and their use of the area of the proposed action.

In Nantucket Sound, specific groups of species occur in various habitats at different times of the year. For this description, species are divided into three groups: terrestrial birds, coastal birds, and marine birds. Terrestrial birds are species that spend the majority of their time on land and may cross the area of the proposed action but do not linger or forage there. Coastal birds include shorebirds and wading birds that may cross the area of the proposed action but most likely do not linger or forage there. Marine birds are defined as those species that spend the majority of their time in Nantucket Sound away from shore and may be regular visitors to the Project Area for purposes of feeding or resting. T&E bird species are discussed in Section 4.2.9.

The following sections summarize the distribution, numbers, seasonality, and behavior of the various species groups based on pre-existing information and results of surveys conducted by the applicant and Massachusetts Audubon Society (MAS). From March 2002 through September 2006, aerial, boat, and radar surveys were conducted by the applicant. Additionally, the MAS conducted aerial and boat surveys from August 2002 through September 2004. Survey efforts attempted to estimate avian occurrence and distribution within Nantucket Sound, primarily in relationship to Horseshoe Shoals where the project is proposed. Between the two efforts, survey methods were similar but not identical; therefore, direct comparisons between the two data sets were made with caution. Table 4.2.4-1 shows the studies used during preparation of this description.

A Preliminary Avian Risk Assessment was conducted (Report No. 4.2.4-1). The initial assessment recognized that available information on bird use of Horseshoe Shoal is limited. The assessment indicated that studies should be directed to investigate bird use of the three shoal areas in Nantucket Sound and to estimate the potential effects of wind turbines on resident and migrant birds. The assessment specifically identified the need to understand waterbird abundance and distribution in Nantucket Sound. Based on this recommendation, terns, seaducks, seabirds, and diving birds were intensively studied throughout the year from March 2002 through March 2006, including aerial, boat, and radar surveys. Data was collected throughout Nantucket Sound, both inside and outside the area of the proposed action. Focal points of the survey efforts were three possible alternative sites: Horseshoe Shoal, Monomoy-Handkerchief Shoal, and Tuckernuck Shoal.

The applicant and MAS collectively flew 125 systematic aerial surveys to document avian species and distributions in Nantucket Sound (see Table 4.2.4-2 and Table 4.2.4-3). These surveys included parallel transects aligned north to south throughout the Sound (Report No. 4.2.4-2; Perkins et al., 2004). Surveys were conducted during the daytime throughout different seasons from March 2002 through March 2006. Surveys were flown during the tern breeding and fall staging periods. Surveys also occurred throughout the fall through early spring when large concentrations of wintering sea ducks and waterbirds congregate in Nantucket Sound. The applicant flew 46 aerial surveys from March 2002 through February 2004 and MAS flew 79 aerial surveys from August 2002 through March 2006 (Report No. 4.2.4-2). The applicant and MAS also conducted boat surveys to complement the aerial surveys and to make observations of avian behavior (e.g., traveling, feeding, resting), and to estimate flight heights when possible. A total of 17 boat surveys were conducted from May 2002- March 2005 during the same study periods as the aerial surveys and covered a similar area but generally did not follow the predetermined transects established for the flights. Observations were recorded on species presence, as well as their numbers, altitude, direction of flight, and other behaviors.

The applicant also conducted radar surveys during the spring and fall migration periods. The spring surveys were conducted from a jack-up lift barge located at the southern end of Horseshoe Shoal and the fall surveys were conducted from a cliff on Cape Pogue, on the northeastern tip of Martha's Vineyard. Horseshoe Shoal is located within the area of the proposed action while the Cape Pogue site is located approximately 10 miles (16.1 km) southwest of the area of the proposed action.

A summary of the Nantucket Sound radar surveys is provided in Table 4.2.4-4. The average flight heights documented over Nantucket sound are lower than those documented for nocturnal radar surveys conducted in terrestrial ecosystems. Additionally, the season mean nocturnal passage rates were lower over Nantucket Sound than at the majority of land-based radar sites. The difference in radar data between inland sites and in Nantucket Sound are likely the result of the different radar systems used. Inland radar surveys are typically conducted with X-band radar systems because they are capable of detecting small targets such as birds, bats, and even insects. These systems are also operated at a range setting of 0.86 miles (1.4 km) which is much smaller than the range settings used at Nantucket Sound. Operation at a smaller range setting allows for accurate distinction between individual targets. The low passage rates observed at Nantucket sound are likely an artifact of the TracScan (S-band) radar used to determine target position, speed, heading (horizontal data). As explained above, TracScan is not as effective as X-band radar for distinguishing between individual targets that may be flying close together or in flocks, especially using long range settings. Therefore, it is expected that fewer individual targets would have been identified using the TracScan (S-Band) radar system. The seasonal results of the Cape Wind radar surveys were significantly different than inland sites and are likely due to the combination of factors described above.

#### *4.2.4.1 Terrestrial Birds*

This section describes the landbird species that may cross the area of the proposed action but do not linger or forage there.

##### 4.2.4.1.1 Raptors (hawks, owls, eagles, falcons, etc.)

Except for an occasional osprey (*Pandion haliaetus*) and, perhaps, peregrine falcon (*Falco peregrinus*), these birds are not likely to be present at Horseshoe Shoals except by accident, when they are blown offshore or off course in storms, and on rare occasions during migration. There are no topographic features (such as shorelines or shortest crossings) that funnel such migrants to the area. A total of eight ospreys were observed during the boat surveys on August 15 and 22, 2002, and September 12, 2003, (Report No. 4.2.4-3 and Report No. 4.2.4-4). All were observed just offshore south of Falmouth, less than 1 mile (1.6 km) from the shore, and none were observed in the Horseshoe Shoal study areas. Osprey were observed foraging at a height of less than 50 ft (15.2 m), which is typical of their foraging behavior although they are known at times to forage from over 100 ft (30.5 m). Osprey likely forage in Lewis Bay, in proximity to the proposed submarine transmission cable route for the proposed action. No peregrine falcons were observed in the study area during any of the 2002 to 2005 surveys of Nantucket Sound.

#### 4.2.4.1.2 Other Landbirds – Migration

Large numbers of migrating landbirds pass over Horseshoe Shoal at a wide range of altitudes during autumn and spring (April through May and September through October, respectively). They are known to travel over a broad front rather than in narrow streams, but numbers flying over Nantucket Sound in both spring and fall are much lower than over the mainland to the northwest (Nisbet and Drury, 1967). Despite this, numbers estimated to migrate through Nantucket Sound are estimated to be in the millions (Report No. 4.2.4-1).

Geo-Marine, Inc. (GMI) conducted radar surveys for the applicant during four migration seasons to measure passage rates and flight height for both diurnal and nocturnal bird activity (Table 4.2.4-4). Surveys were conducted in spring and fall 2002 (Report No. 4.2.4-5), fall 2005 (Report No. 4.2.4-6), and spring 2006 (Report No. 4.2.4-7). The spring surveys were conducted from a jack-up lift barge located at the southern end of Horseshoe Shoal and the fall surveys were conducted from a cliff on Cape Pogue, on the northeastern tip of Martha's Vineyard. Horseshoe Shoal is located within the area of the proposed action while the Cape Pogue site is located approximately 10 miles (16.1 km) southwest of the area of the proposed action.

The radar surveys were conducted using two marine radars simultaneously 24 hours a day. Although surveys were targeted for continual operation there were some periods when data was not collected due to equipment malfunctions. An S-band radar was operated to detect targets within a range of 4.6 miles (7.4 km) during the spring and fall 2002, 6.9 miles (11.1 km) during the fall 2005, and 4.6 miles (7.4 km) during the spring 2006. An X-band radar was operated to document the vertical distribution of targets within a range of 1.7 miles (2.8 km) in altitude and 0.9 miles (1.4 km) downrange. The S-band radar operated horizontally and detected the abundance of targets and their flight direction as they passed through the radar's view while the X-band radar detected the targets flight heights as well as the percentage of targets flying below the height of the proposed turbines.

The results of the radar surveys conducted within the area of the proposed action show some consistent trends. The median flight heights observed during the day were lower than at night across all seasons and years. Another trend observed is that a greater percentage of targets were observed flying at altitudes below the proposed maximum turbine height during the day than at night. These trends are typical because the majority of nocturnal migrants are neotropical songbirds whose flight heights over land are typically at higher altitudes than waterbirds that typically migrate during the day.

Due to variation in bird populations and weather conditions some variation in the passage rate, or abundance, of birds was observed between seasons. For example, both night and day time passage rates were relatively consistent during the first three seasons but increased significantly during the spring 2006 survey. This may be the result of an increased survey effort during this time period. The spring 2006 survey included the entire time frame during which many birds in the northeast are known to migrate and several more nights of optimal migration conditions, and migrant abundance, could have been documented that season.

Very few songbirds or other similar passerines were observed during the visual surveys in the study area. None were observed during the aerial surveys, and only three individuals (two swallows and one American goldfinch) were observed during the boat-based surveys (Report No. 4.2.4-3 and Report No. 4.2.4-4). These results were expected, since most songbirds migrate at night and few would be expected to be found in the area of the proposed action during non-migratory, daytime activities. However, the small size of these birds means that they may be easily missed, and boat- or aerial-based visual observations are unreliable indicators of numbers passing through the area.

### *4.2.4.2 Coastal Birds*

This section describes the coastal bird species that may cross the area of the proposed action but most likely do not linger or forage there, other than at the transmission cable landfall area. Piping plover (*Charadrius melodus*) is a federally-threatened species, and is discussed in more detail in Section 4.2.9 and the BA in Appendix G.

#### 4.2.4.2.1 Shorebirds (sandpipers, plovers, etc)

Shorebirds are most numerous in the area as transients during migration when the large areas of sand and mud near North Monomoy provide important staging areas of internationally recognized importance. Much smaller numbers of shorebirds occur at other sites around Nantucket Sound. Fewer numbers of shorebirds are summer residents in the area. Only a few shorebirds were observed during surveys for the proposed action. It is possible that some shorebirds occasionally fly across the area of the proposed action, from one side of the Sound to another, but no such observations have been recorded, and sightings of shorebirds on beaches do not suggest any concentrated flightlines through the area of the proposed action.

Small numbers of three species/groups of shorebirds were observed during the aerial and boat surveys, including an American oystercatcher *(Haematopus palliatus)* in July, 2003 on the shoreline of Muskeget Island (Report No. 4.2.4-8). One red knot (*Calidris canutus*) and six unidentified sandpipers (*Calidris* spp.) were observed off Cape Poge during boat-based field surveys and 20 dunlins (*Calidris alpine*) were observed on Muskeget Island during an aerial survey in October 2002 (Report No. 4.2.4-9).

Migrating shorebirds typically climb rapidly when departing staging areas and are likely to fly over the Horseshoe Shoal area at high altitudes in the spring and fall, although they may fly at lower altitudes while descending to stopover sites such as Monomoy Island (Veit and Petersen, 1993). Identification of targets by radar is not definitive, but many shorebirds are thought to fly from New England directly to South America. It is not unreasonable to suspect that flights of shorebirds from Monomoy would pass east of the area of the proposed action (Griffin, 1974). Both piping plovers and American oystercatchers nest within the Cape Cod National Seashore. Migrating birds could potentially pass through Nantucket Sound and the project area on their way to and from nesting grounds to the north.

#### 4.2.4.2.2 Wading Birds (herons, egrets, ibis, etc.)

These birds are numerous during migration and the summer months along the shorelines of bays and estuaries of Nantucket Sound. Small numbers may fly over the area of the proposed action, but are unlikely to linger at Horseshoe Shoal as the water depths are too deep for them to wade. None were observed during surveys conducted by the applicant or by MAS.

### *4.2.4.3 Marine Birds*

This section describes the bird species that spend the majority of their time in Nantucket Sound away from shore and may be regular visitors to the area of the proposed action for purposes of feeding or resting. Roseate terns are a federally-endangered species and are discussed in more detail in Section 4.2.9 and the BA in Appendix G.

#### 4.2.4.3.1 Loons

Common loons (*Gavia immer*) and red-throated loons (*Gavia stellata*) are known to frequent the coastal waters of Massachusetts, particularly during migration and the winter months. The common loon is most often found in Nantucket Sound during spring and fall migrations with a few individuals remaining throughout the year. The common loon winters along the eastern seaboard after moving from inland lakes. The common loon is reported to be a diurnal migrant; migration routes follow coastlines and also pass overland (Williams, 1973; Viet and Petersen, 1993). The worldwide population has been estimated at 500,000 to 700,000 (Rose and Scott, 1996), the majority of which are found in Canada.

The red-throated loon breeds in tundra and far northern coastal regions. It is found wintering in coastal areas and is a common winter resident from southern Newfoundland to northern Georgia. Some subadults remain in wintering grounds all year and do not accompany adults to breeding grounds. In Massachusetts, spring migration peaks in April (Veit and Petersen, 1993). Fall migration into and through Massachusetts peaks in November (Kerlinger, 1998). There are currently no population estimates for red-throated loons in the Western Hemisphere though Canada is thought to have the second largest population after Russia's estimated 70,000. Swedish and Alaskan populations of red-throated loons experienced declines in the 1980s (SOF, 1990 *as cited in* Eriksson, 1994; Groves et al., 1996). It has been postulated that observed declines may have been an outcome, at least in part, of the acidification of some northern lakes (Pakarinen and Järvinen, 1984; Eriksson, 1994).

Because they are difficult to differentiate, particularly during aerial surveys, observations of both loon species were combined for this discussion. During the applicant's boat and aerial surveys a total of 8,229 loons were observed within the survey area of Nantucket Sound (see Table 4.2.4-5) with peak numbers observed during the aerial surveys on March 29 and April 5, 2002, (Report No. 4.2.4-4) and April 23, 2003, (Report No. 4.2.4-10). Thereafter, numbers observed dropped to nearly zero until November when their numbers increased considerably. In late December 2002 numbers observed dropped off once more and began to increase again in mid-February 2003 (Report No. 4.2.4-9). These changes reflect the timing of migrations by these species in the eastern United States and use of Nantucket Sound as a staging area during migration (Veit and Petersen, 1993). This trend continued through 2003 when observations of loons dropped off considerably in the summer months and increased again in November while migrating through the area in the fall of 2003 (Report Nos. 4.2.4-4, 4.2.4-8 and 4.2.4-10). It is evident from the surveys that more individuals migrate through the area in the spring than in the fall.

In winter, both species were detected throughout the study area (Report Nos. 4.2.4-4, 4.2.4-9, 4.2.4-10 and 4.2.4-11), and occurred singly or in small groups. In spring, flocks included as many as 100 individuals.

The MAS aerial surveys of Nantucket Sound documented very few loons in the Sound during August and September of 2002, 2003, and 2004 (see Table 4.2.4-6). The 34 surveys conducted in the premigratory staging period included 129 loon observations while six surveys during the 2003 and 2004 breeding periods included 62 loon observations in the Sound (Sadoti et al., 2005a, 2005b). Loon observations in the Sound were higher during the winter months. The 13 aerial surveys in the winter of 2003 to 2004 contained 3,756 loon observations (Perkins et al., 2004c). This represented less than 1 percent of all bird observations in Nantucket Sound during these surveys. Over 2,000 loons were observed on a single aerial survey in early April, indicating that spring migrants were moving through the Sound at this time. These trends of increased numbers in the early spring followed by greatly decreased numbers during summer and early fall were also observed during the applicant's surveys. During 41 boat surveys of Horseshoe Shoal in the Spring and Summer of 2003 and 2004, MAS observed 172 loons on the shoals, 11 of which were traveling above 40 ft (12.2 m) above mean sea level (AMSL). During boat surveys in Horseshoe Shoal 168 loons were recorded during the breeding period in 2003 and 2004 (Perkins et al., 2004a and Sadoti et al., 2005a).

###### 4.2.4.3.2 Grebes

Horned grebes (*Podiceps auritus*) and red-necked grebes (*Podiceps grisegena*) occur as winter residents within Nantucket Sound. Both species reliably appear in the Sound by October, but they rarely occur in large numbers. Grebes generally leave their wintering grounds by May. Because they are difficult to differentiate, particularly during aerial surveys, grebe observations were combined for this discussion.

Little was known about grebe use of the Sound prior to surveys of the study area in 2002 through 2005. Grebe observations made during surveys by the applicant and MAS are provided in Tables 4.2.4-7 and 4.2.4-8. Grebes were most often observed during the winter and spring months and peaked in March (Report No. 4.2.4-10) when 57 individuals were observed. They were not typically observed in summer or early fall (Report No. 4.2.4-10). The largest numbers of grebes were present in the study area during January, March, April, and December. Grebes were widely distributed across the study area in small numbers, but were more numerous in the southern section of the study area on Tuckernuck Shoals (Report No. 4.2.4-9 and Report No. 4.2.4-10). Grebes occurred singly or in small flocks on the water. As is typical of grebes, they were rarely observed flying. For example, of the 314 individuals observed during the aerial surveys, only one was seen flying; however, its flight altitude was within rotor height.

During their winter aerial surveys, MAS also observed few grebes (see Table 4.2.4-8). Winter boat surveys of Horseshoe Shoal in 2003 to 2004 documented a single horned grebe on the shoals (Perkins et al., 2004c). During 40 aerial and 39 boat surveys, MAS did not observe any grebes in Nantucket Sound in the breeding periods of 2003 and 2004 or premigratory periods of 2002, 2003, and 2004 (Sadoti et al., 2005a,b).

###### 4.2.4.3.3 Wilson's Storm-petrel

A summer visitor to the region (May through September), the Wilson's storm-petrel (*Oceanites oceanicus*) is generally abundant offshore (500 to 1,000 individuals per day per locality (Veit and Petersen, 1993). During aerial and boat surveys, the applicant did not find this species to be abundant (see Table 4.2.4-9). Observations tended to be located in the eastern third of Nantucket Sound (Report No. 4.2.4-3). Of the storm-petrels observed, all were spotted flying below 10 ft (3 m) AMSL. This species is not easily distinguished from Leach's storm-petrels (*Oceanodroma leucorhoa*), especially during aerial surveys. However, Leach's storm-petrels are not known to frequent Nantucket Sound but do occur in Buzzard Bay where there is a small nesting colony on Penikese Island (Veit and Petersen, 1993). For the purposes of this document, observed storm-petrels were assumed to be Wilson's storm-petrel.

The MAS aerial surveys (Perkins et al., 2003; 2004b; Sadoti et al., 2005b) observed 62 Wilson's storm-petrels in Nantucket sound during premigratory staging in 2002, 2003, and 2004 (see Table 4.2.4-10). A single individual was observed in 2002 on Horseshoe Shoal during a boat survey, and this storm-petrel was seen fishing over the shoal at a height of 2 ft (0.6 m) AMSL. During the breeding seasons of 2003 and 2004, 10 storm-petrels were seen during aerial surveys and 33 were seen during boat surveys (Perkins et al., 2004a; Sadoti et al., 2005a). The majority of these individuals, except for two seen fishing, were traveling across the Shoal at less than 15 ft (4.5 m) AMSL. As expected for a species that is a summer visitor, there were no Wilson's storm-petrels observed during the winter surveys.

#### 4.2.4.3.4 Northern Gannet

Northern gannets (*Morus bassanus*) breed in three colonies in the Gulf of St. Lawrence and three colonies on the Atlantic coast of Newfoundland. The breeding population in 1999, obtained from counts of aerial photographs, was at 72,289 breeding pairs. Northern gannets winter all along the Atlantic and Gulf Coast, and large concentrations have been observed off the coast of Massachusetts (Veit and Petersen, 1993).

Northern gannets typically occur in Nantucket Sound from mid-March to early June and from mid-November to mid-January. The highest counts of northern gannets were observed in April and May (Report Nos. 4.2.4-4, 4.2.4-9 and 4.2.4-10). Northern gannets occurred singly and in flocks numbering up to 80 individuals throughout the study area. One large flock of approximately 300 individuals was observed just north of the study area in mid-April 2003 (Report No. 4.2.4-10). Some individuals were detected on the water, but the majority was observed flying. Of the flying individuals, 28 (1.9 percent) of the 1,415 individuals were seen flying at rotor height. Of the 1,415 total gannet observations during the aerial surveys, 1,081 (76.4 percent) were observed outside the three shoal areas (see Table 4.2.4-11). Northern gannets tended to be most often detected in the southern and eastern parts of the Sound (Report Nos. 4.2.4-4, 4.2.4-9, 4.2.4-10 and 4.2.4-11).

Similar to the observations of the applicant, MAS also observed the majority of northern gannets in the late fall or spring (see Table 4.2.4-12). In the winter of 2003 to 2004, 629 northern gannets were seen in the Sound during aerial surveys. In two boat surveys, one northern gannet was observed over Horseshoe Shoal (Perkins et al., 2004c). During three seasons of premigratory aerial surveys, 13 northern gannets were observed, all in 2002 surveys (22,883 total birds observed). Throughout the summer of 2003 and 2004, 179 northern gannets were observed during boat surveys of Horseshoe Shoal, none of which were seen flying in the rotor swept zone. A total of 29 northern gannets were observed during 2003 and 2004 summer aerial surveys (2,685 total birds over 2 summers) (Sadoti et al., 2005a).

#### 4.2.4.3.5 Cormorants

Two cormorant species utilize Nantucket Sound, the double-crested cormorant (*Phalacrocorax auritus*) and the great cormorant (*Phalacrocorax carbo*). Great cormorants are primarily present within the area of the proposed action during winter, and double-crested cormorants are more abundant during summer months, although some winter presence is also common.

Double-crested cormorants winter and breed along the coast of Massachusetts (Hatch and Weseloh, 1999). Those that spend part of the winter in Massachusetts arrive in late March at the earliest. Peak autumn migration has been noted in the first half of October (Nisbet and Baird, 1959). Double-crested cormorants have typically been observed beginning migration flights soon after dawn and flying all day, though some flocks have been seen flying in the late evening with few stopping to roost for the night (Nisbet and Baird, 1959). Cormorants usually fly low over water in loose V-formations and follow the coastline but are known to fly overland to bypass Cape Ann and Cape Cod in Massachusetts. When flying overland, cormorants often fly up to 3,280 ft (1000 m) above ground. Populations are estimated at 350,000 breeding pairs in North America with 96,000 pairs breeding on the Atlantic Coast. Populations have been increasing significantly for about thirty years (Hatch and Weseloh, 1999).

Great cormorants winter along the Atlantic Coast and are seen intermingling with double-crested cormorants off the coast of Massachusetts. The North American population of great cormorants is relatively small. Hatch et al. (2000) estimated the northwest Atlantic population of great cormorants to be approximately 8,500 pairs; it was recently proposed that this number has since declined dramatically (Nisbet and Veit, in review).

The two cormorant species are not readily distinguishable; species counts were not differentiated in the field studies and are similarly combined in this account.

A total of 2,511 cormorants were observed within the study area during the aerial surveys (see Table 4.2.4-13). Most cormorant observations were within 3 miles (4.8 km) of shore. Of the total cormorant observations, 2,506 were observed outside the three shoal areas. Six individuals were observed on Horseshoe Shoal during boat-based observations. Cormorants were observed frequently in small groups or large dense flocks at daytime resting areas on Fernando's Fetch (a transient sandbar northwest of Muskeget Island), on Bishop & Clerks' Lighthouse near the northern edge of the Sound and along the shores of Muskeget Island. Those observed flying were typically low to the water's surface, yet one flock of 40 individuals was observed flying at rotor height. During aerial surveys conducted in September 2002 through February 2003, an average of 113.4 cormorants was seen in the project area (Report No. 4.2.4-9). Conversely, an average of 8.6 cormorants was seen in the project during the same aerial surveys conducted in September 2003 through February 2004 (Report No. 4.2.4-11). Outside the study area, cormorants were frequently observed close to shore and on the sandbars west of Monomoy, especially during post-breeding dispersal for double-crested cormorants in August (Report No. 4.2.4-9).

MAS observed very few cormorants during winter 2003 to 2004 surveys (see Table 4.2.4-14) suggesting migrants had left Nantucket Sound for more southern wintering grounds by early December. During boat surveys in the winter of 2003 to 2004, no cormorants were observed in Horseshoe Shoal, while only 7 were observed during aerial surveys. Cormorants were more often seen in the Sound during the breeding and premigratory staging period. Over two years of boat surveys during the breeding period, 28 cormorants were observed in Horseshoe Shoal and 16 were observed there during the three years of premigratory staging surveys. Aerial surveys of the Sound at these times show more activity than in the winter, though sightings averaged approximately 0.18 cormorants/ square mile (0.07 cormorants/$km^2$) (or 265 cormorants in 6 surveys) during the breeding period and <0.01 cormorants/square mile (<0.004 cormorants/$km^2$) (or 1,337 cormorants in 34 surveys) during the staging period (Sadoti et al., 2005b; Perkins et al., 2004b).

### 4.2.4.3.6 Seaducks

Five species of seaducks migrate in large numbers through Nantucket Sound and adjacent waters in the spring and fall, and many are winter residents. These seaducks are divers that feed principally on benthic mollusks and crustaceans, although some species readily feed on fish. In summer, when most individuals have left the area, small numbers of common eiders (*Somateria mollissima*) nest on Muskeget Island and also on the Elizabeth Islands outside of Nantucket Sound (Veit and Petersen, 1993). A brief discussion of each of the five species of seaducks observed is presented below.

**Common Eider**

Common eiders are known to both breed and winter along the Massachusetts coastline (Veit and Petersen, 1993). Fall migration brings thousands of eiders to Massachusetts in October and November (Veit and Petersen, 1993). Large rafts of eiders commonly assemble in locations where prey is available in high concentrations, particularly in shallow water (Guillemette et al., 1993). Migrants tend to follow the coastline when moving south (Reed, 1975). In spring, eiders migrate more quickly, sometimes taking shorter, overland routes. The total winter population of common eiders for North America is estimated to be 600,000–750,000 individuals (Goudie et al., 2000). Bourget et al. (1986) estimated that 181,000 common eiders winter from Maine to Massachusetts.

During aerial surveys conducted by the applicant, a total of 110,555 eiders were observed within the study area (see Table 4.2.4-15). Eiders accounted for approximately one-quarter of all birds observed in Nantucket Sound during winter surveys. From October to April, eiders were present in substantial numbers, often occurring in large, dense "rafts" numbering thousands of birds. These large rafts often extended beyond the edges of the study transects and therefore were not counted completely. Eider numbers were observed to decrease significantly during the aerial surveys conducted in February when large sections of the study area were frozen over (Report No. 4.2.4-9 and Report No. 4.2.4-11). During the summer, small numbers were observed near Muskeget Island, where a few pairs have nested each year since about 1973 to 1975 (Veit and Petersen, 1993).

Approximately 90 to 97 percent of all eiders detected during two winters of aerial surveys were observed outside the shoal areas (see Table 4.2.4-16). The average number of common eiders counted in Horseshoe Shoal was between 2 and 8 percent of the average number of all eiders counted. For Monomoy-Handkerchief and Tuckernuck Shoals, eider count averages were below 2 percent. Most observations of eider were in the southern part of the study area, between Tuckernuck Shoal and Martha's Vineyard, and in the northeastern part of the Sound near Monomoy Island (Report Nos. 4.2.4-3, 4.2.4-4, 4.2.4-9 and 4.2.4-11). Eiders were observed both on the water and flying; of the 110,555 individuals detected during aerial surveys, none were observed flying at rotor height.

During boat surveys conducted by the applicant, 279 eiders were observed in April 2002, 77 were observed in October 2002, 155 were observed in April 2003, and 1 was observed on August 27, 2003 (Report Nos. 4.2.4-3, 4.2.4-4, 4.2.4-9 and 4.2.4-11). Eider counts during boat surveys were considerably lower than those of aerial surveys, which were conducted at roughly the same time.

MAS observed one eider during two years of aerial surveys conducted during the breeding season and 86 eiders during boat surveys, most of which were observed on a single day in April 2004. All of these were traveling in smaller groups at a height of 4 ft (1.2 m) above the water. Of the waterbirds counted during each of 13 aerial surveys conducted during the 2003 to 2004 winter surveys, between 30 and 88 percent were Common Eiders (see Tables 4.2.4-15 and 4.2.4-16). The two highest counts for the season were 53,278 on January 22, 2004, and 40,551 on March 10, 2004. Of all the eider observed in the Sound in winter 2004, 8.3 percent were seen in Horseshoe Shoal and 90.3 percent were outside of the study area (Perkins et al., 2004c).

### Long-tailed Duck

Long-tailed ducks (*Clangula hyemalis*) winter on both coasts of North America and remain in the northern areas as long as waters remain open (Robertson and Savard, 2002). The ducks begin northward migrations in late-March or early-April and gather in large flocks in arctic waters until inland breeding grounds have opened (Veit and Petersen, 1993; Robertson and Savard, 2002). Fall migrants move south from molting grounds and numbers tend to peak in late-November and December (Veit and Petersen, 1993). The Atlantic coast wintering population has been difficult to estimate due to this species offshore foraging habits and light colored plumage, which make long-range observation difficult (Robertson and Savard, 2002).

Long-tailed ducks are understood to roost at night in Nantucket Sound and then fly in large flocks over Nantucket and Tuckernuck Islands to forage over the Nantucket Shoals during the day (Davis, 1997). These birds fly in flocks between daytime feeding areas on the shoals southeast of Nantucket and nocturnal roosts in the Sound (Davis, 1997). During a preliminary project survey flight in December 2001, a large roost was located in the southern part of the Sound, north of Tuckernuck. Several attempts were made during the aerial surveys to investigate this phenomenon but were unsuccessful, in part because the birds start moving before sunrise and continue after sunset. Long-tailed ducks were observed flying below 35 ft (10 m) AMSL during all observations made from plane or boat. They are known to fly at higher altitudes over or near land during foraging and roosting flights.

Aerial surveys conducted by the applicant are summarized in Table 4.2.4-17. Seasonal occurrence of long-tailed Ducks in Nantucket Sound was generally from October through April. No Long-tailed Ducks were recorded in summer. The largest numbers were counted during aerial surveys in March 2002 and November 2003, when migrants may use the Sound as a staging area. They were absent from May through September and were first observed in October each year. During the aerial surveys, 52,192 individuals were recorded. Of these, 4,103 (8 percent) were observed in Horseshoe Shoal, 2,685 (5 percent) were observed in Monomoy-Handkerchief Shoal, 2,493 (5 percent) were observed in Tuckernuck Shoal, and 42,911 (82 percent) were observed outside the three shoal areas. These ducks were more numerous in the northeastern corner and southern section of the Sound (Report Nos. 4.2.4-3, 4.2.4-4, 4.2.4-9 and 4.2.4-11).

MAS also documented long-tailed ducks only in the winter and spring (see Table 4.2.4-18). During MAS aerial surveys from December 2003 through April 2004, 33,379 long-tailed ducks were observed, representing about 8.1 percent of all birds counted during this survey period. The largest numbers were seen in December and January, though thousands of ducks were still documented in early April. Long-tailed ducks were found to be more evenly distributed throughout the Sound than common eider or the long-tailed duck observations recorded by the applicant. MAS observations of 1,209 long-tailed ducks during two boat surveys in the winter of 2003 to 2004 constituted about 31 percent of all birds counted (Perkins et al., 2004c).

In order to better understand long-tailed duck flights in and out of the Sound and find nighttime roosting locals, a study was conducted from December 2005 through March 2006 (Report No. 4.2.4-12). Land-based observations combined with boat surveys and airplane reconnaissance were used to observe duck movements in Nantucket Sound and Horseshoe Shoal. Land-based surveys were conducted from the western end of Nantucket Island at sunrise and sunset in order to record the flight paths and heights of birds leaving and returning to roosting areas. Land surveys were performed in varying weather conditions though at times this meant reduced observation of commuting ducks. Boat-based crews made observations from within the Sound in order to track duck flights and roosting behavior in the area of the proposed action. The study attempted to obtain information on flight paths, flight altitudes, and roosting locales of commuting ducks.

During morning surveys (Report No. 4.2.4-12), long-tailed ducks were seen flying due south through Tuckernuck Channel, coming from the northeast and turning as they passed Eel Point. The majority of ducks observed (67 percent) followed this flight path. Others flew southeast and southwest as they passed Eel Point. Roosting areas in Nantucket Sound could not be determined for long-tailed ducks, so the origination of these flights is unknown; however ducks were observed moving to the northeastern part of the sound during boat and land surveys. One morning in December during this study, nearly one hundred thousand long-tailed ducks were counted making this commute from their nighttime roosting area to their daytime feeding area. These kinds of numbers are not unusual in Nantucket Sound in winter (Davis, 1997). A winter nocturnal duck study conducted for two nights in March 2005 did not find evidence of large gatherings or flights of long-tailed ducks moving into Nantucket Sound in the late evening (Report No. 4.2.4-13). However, hundreds were seen in the southeastern part of the Sound in an area outside of the usual aerial survey transects (Report No. 4.2.4-13).

During the evening surveys 99 percent of all ducks were observed moving north or northeast as they passed Eel Point and as they returned to the Sound. During flights between roosting and foraging areas the ducks were observed flying at lower altitudes when flying into a headwind, 66 percent flying less than 25 ft (7.6 m) above the water, 34 percent flying between 25 and 150 ft (7.6 and 45.7 m). Conversely, ducks were seen flying at higher elevations when flying with a tailwind. Under these conditions the majority (84 percent) were seen flying between 25 and 150 ft (7.6 and 45.7 m) AMSL, and 15 percent flying higher than 150 ft (45.7 m). During evening flights it was noted that ducks increased their flight altitude as they passed over land, and then quickly returned to lower elevations once over water again. This behavior was observed except when ducks were flying into a strong headwind, in which case they flew very low (within 10 ft [3 m]) over land (Report No. 4.2.4-12).

A satellite telemetry study investigated the movements of six long-tailed ducks in Nantucket Sound and Nantucket Shoals from December 2007 to April 2008 (Allison et al., 2008). The study attempted to determine night-time roosting locales for long-tailed ducks. More than 650 satellite fixes of the six ducks gave no evidence that commuting long-tailed ducks used Horseshoe Shoal for night-time roosting.

Black scoters (*Melanitta nigra*), white-winged scoters (*Melanitta fusca*) and surf scoters (*Melanitta perspicillata*) are all known to migrate through or winter off the coast of Massachusetts (Veit and Petersen, 1993). All three species of scoters were present in Nantucket Sound in large numbers through the winter, and migrants are known to pass through the area. Together the scoters comprised the largest group of birds observed during the study year, representing 51.6 percent of the total count.

A total of 212,872 scoters were observed by the applicant during the study period (205,802 during aerial surveys and 7,070 during boat surveys). The three species were combined in the reports because the sightings could frequently not be identified to species, especially when conditions for observation were less than ideal or when the scoters were in mixed flocks. Peak numbers were observed from October through April, with the numbers starting to decline in mid-April (see Table 4.2.4-19). The largest numbers of scoters were observed during the November 2003 aerial surveys when individuals were arriving for the winter and migrating through from their breeding colonies (Report No. 4.2.4-3, additional data in Report No. 4.2.4-11). Scoters occurred in small groups and loose flocks numbering up to thousands of individuals, and were widely distributed in the Sound. Of the 205,802 observed during the aerial surveys, 15,222 (7.4 percent) were observed in Horseshoe Shoal, 18,678 (9.1 percent) were observed in Monomoy-Handkerchief Shoal, 30,419 (14.8 percent) were observed in Tuckernuck Shoal, and 141,483 (68.7 percent) were observed outside the three shoal areas. Only 13 scoters were observed during the summer months in all of Nantucket Sound. Flying scoters were generally observed at altitudes less than 15 ft (4.6 m) AMSL, with the exception of flocks of possible migrants at about 65 ft (20 m) AMSL. Large numbers of scoters were observed southwest of Martha's Vineyard in flocks numbering up to 3,000 individuals on March 24, 2003. Of the 212,872 scoters observed during the aerial and boat surveys, four individuals were documented flying within the height of the rotors (Report No. 4.2.4-10).

MAS also observed a preponderance of scoters during winter surveys (see Table 4.2.4-20). A total of 94,631 were seen during the study period, 91,244 of which were observed from December 2003 to April 2004. The largest number of scoters was seen during an aerial survey on January 22, 2003, when 25,727 individuals were observed in the Sound. During the winter period, 56.3 percent of scoters observed in the Sound were outside of all three alternative sites. On average, 15.8 percent were seen in Horseshoe Shoal over the course of the 2003 to 2004 winter surveys. During two boat surveys of Horseshoe Shoal in this same winter, 1,750 scoters were observed on the shoals. During MAS surveys, scoters made up 22 percent of all bird observations in the Sound and were the second most abundant group of birds after the common eider in the winter of 2003 to 2004 (Perkins et al., 2004c).

### Red-breasted Mergansers

The red-breasted merganser (*Mergus serrator*) is present as a wintering bird along the Massachusetts coast. These mergansers are known to migrate into the area in late October and November and stay until early May. Generally this bird is not known to migrate or winter in mixed flocks with other species.

Flights overland from inland breeding grounds may occur at night, though red-breasted mergansers are generally known to migrate along coastlines during the day in small flocks of 5 to 15 (Titman, 1999).

A total of 1,452 red-breasted mergansers were observed within the study area during field investigations by the applicant (Report Nos. 4.2.4-3, 4.2.4-4 and 4.2.4-9). Red-breasted mergansers were observed from October through April and they were not observed from late April through September during both study years (Table 4.2.4-21). Of the 1,218 observations during the aerial surveys that distinguished between alternative sites, 117 (9 percent) were observed in Horseshoe Shoal, 0 (0 percent) were observed in Monomoy-Handkerchief Shoal, 0 (0 percent) were observed in Tuckernuck Shoal, and 1,101 (90 percent) were observed outside the three shoal areas. Of the 117 observed within Horseshoe Shoal, 107 were seen on November 24, 2003. They generally occurred close to shore, near Muskeget and Tuckernuck Islands. None were observed flying at rotor height.

MAS observed 56 red-breasted mergansers during the winter 2003 to 2004 surveys (see Table 4.2.4-22). One merganser was observed in the Sound during an aerial survey in late September 2003 (Perkins et al., 2004b). The largest number of mergansers seen in a single survey by MAS was 32 individuals in December, 2003 (Perkins et al., 2003).

**Goldeneyes**

The common goldeneye (*Bucephala clangula*) and Barrow's goldeneye (*Bucephala islandica*) are known to be present in Nantucket Sound in the winter or as winter migrants but are generally low in numbers. The applicant observed eight goldeneyes, in similar coastal locations as the red-breasted merganser observations. Of the eight observed, six were observed during the aerial surveys, all of which were observed outside of the three alternative sites. None were observed flying at rotor height. MAS did not observe any goldeneyes during surveys (Perkins et al., 2004a,b,c; Sadoti et al., 2005a,b).

#### 4.2.4.3.7 Gulls

Six species of gulls were observed during the surveys. Gulls are abundant as year-round residents and migrants that travel over large areas of the Sound in search of food, often targeting schools of fish or working fishing boats. Approximately 65,000 nest in Massachusetts (Blodget and Livingston, 1996). A total of 6,229 individuals were observed during the boat and aerial surveys conducted by the applicant with 5,500 being observed during the aerial surveys (see Table 4.2.4-23). Gulls were observed during all aerial surveys during the study years. Of these, the great black-backed gull (*Larus marinus*) was the most abundant (2,220), followed by the herring gull (*Larus argentatus*) (1,605), Bonaparte's gull (*Larus philadelphia*) (1,444), black-legged kittiwake (*Rissa tridactyla*) (319), laughing gull (*Larus atricilla*) (150), and ring-billed gull (*Larus delawarensis*) (2). In addition, a total of 414 other individual gulls recorded during the surveys were not identified to species.

Gulls were sparsely and relatively evenly spaced throughout Nantucket Sound (Report Nos. 4.2.4-4, 4.2.4-8, 4.2.4-9, 4.2.4-10 and 4.2.4-11). Of the 5,500 individuals observed during the aerial surveys, 227 (5.0 percent) were observed in Horseshoe Shoal, 132 (2.4 percent) were observed in Monomoy-Handkerchief Shoal, 552 (10.0 percent) were observed in Tuckernuck Shoal, and 4,539 (82.5 percent) were observed outside the three shoal areas. They were most common in November and December during both study years, primarily due to the presence of Bonaparte's gulls within the study area during that time of year. Many gulls were observed on the water and flying, with a total of 85 of the 5,500 individuals observed during aerial surveys (mostly herring and black-backed gulls) seen in flight at rotor height. Four parasitic jaegers (*Stercorarius parasiticus*) were observed foraging off Monomoy Island on the September 12, 2003, boat surveys.

A total of 8,030 gulls of six species were observed in the Sound during MAS aerial surveys. In these aerial surveys the herring gull (1,610) was most abundant, followed by the greater black-backed gull (1,902), the black-legged kittiwake (578), Bonaparte's gull (61), and the laughing gull (59). A large number (3,820) of unidentified gulls were also seen throughout the aerial surveys. These same gulls were commonly seen during boat surveys of Horseshoe Shoal as well. Greater black-backed gulls (513), herring gulls (193), undifferentiated gulls (77), laughing gulls (7), black-legged kittiwakes (6), and Bonaparte's gulls (6) were all counted on the shoals in all seasons of survey. In addition, a single jaeger (*Stercorarius* spp.) was seen traveling at 4 ft (1.2 m) AMSL over Horseshoe Shoal during the breeding period of 2004 and eight jaegers (*Stercorarius* spp.) were seen traveling in the Sound on aerial surveys from September 2002 to September 2004 (Sadoti et al., 2005a; Sadoti et al., 2005b; Perkins and Allison, 2003; Perkins et al., 2004b).

#### 4.2.4.3.8 Terns

Common (*Sterna hirundo*), roseate (*Sterna dougallii*), arctic (*Sterna paradisaea*), and least (*Sternula antillarum*) terns can all be found nesting along the shoreline of Nantucket Sound. These birds are summer residents, almost 20,000 pairs of the four species nest in Massachusetts, the majority in the southeastern part of the state (Blodget, 2001 *as cited in* Perkins et al., 2003). Roseate terns are a federally-endangered species and are discussed in more detail in Section 4.2.9 and the BA in Appendix G; the other three tern species are of Special Concern in Massachusetts. In 2005, there were 15,447 pairs of common tern at 34 sites in Massachusetts, 90 percent of which were concentrated at the Monomoy National Wildlife Refuge, Chatham, and Bird and Ram Islands (Mostello, 2007). As of 2002, least terns bred at 54 locations in Massachusetts; there were 3,420 breeding pairs in the state in 2001 (Mostello, 2002). Breeding common and least terns are considered to be locally abundant in Nantucket Sound. However, there are concerns about populations of these two species in other geographic locations, and many terns do migrate through Nantucket Sound from other breeding populations that may be more at risk.

Terns are typically present in the Sound from early April until late September at breeding colonies and staging areas. The extent to which terns use Nantucket Sound is not fully understood. However, fewer terns were observed on Horseshoe Shoal during surveys conducted by the Applicant and MAS during the breeding season.

The applicant and MAS conducted aerial and boat surveys from June 2001 through September 2004 to determine tern distribution and abundance in Nantucket Sound and the area of the proposed action, as well as to document tern behavior within the area of the proposed action. These surveys were timed to capture spring migrant, breeding population and pre-migratory staging use of the Sound. Five species of tern were observed during these surveys with common, roseate and least terns being the most abundant (Perkins et al., 2004a,b; Sadoti et al., 2005a,b; Report Nos. 4.2.4-3, 4.2.4-8, 4.2.4-9, 4.2.4-10 and 4.2.4-11). Small numbers of black and Forster's terns were also observed, typically in mixed flocks with common and roseate terns (Report No. 4.2.4-4).

The earliest tern sightings in Nantucket Sound occurred in April. Nineteen common terns were seen in April, 2002, (Report No. 4.2.4-4) and two common terns were seen on April, 2003, (Report No. 4.2.4-10). These individuals appeared to be spring migrants, newly returned to the Sound (Perkins et al., 2003a). The largest numbers of terns were observed in mid-May before nest initiation of terns breeding within the Sound and likely included migrants traveling through the Sound on their way to more northern and eastern breeding colonies (Perkins et al., 2004a; Sadoti et al., 2005a).

A total of 8,755 terns were observed within the study area from April to September in 2002 and from April to November in 2003 (Report Nos. 4.2.4-3, 4.2.4-4, 4.2.4-8, 4.2.4-9, 4.2.4-10 and 4.2.4-11).

Common terns were the most abundant (5,313), followed by roseate terns (447), and least terns (198), black terns (40), and Forster's terns (2). However, 2,755 individual terns could not be identified to species, because roseate and common terns are similar in appearance and often occur in mixed flocks. A few black terns and Forster's terns were observed during the summer of 2003. Observations outside the study area suggest that terns were more numerous along the shore than in the study area, which is influenced by the proximity of a concentrated prey base that occurs in shallower waters.

During all of the aerial surveys, a total of 2,888 individuals were observed within the study area, of which 277 (9.6 percent) terns were observed in Horseshoe Shoal, 76 (2.6 percent) were observed in Monomoy-Handkerchief Shoal, 164 (5.7 percent) were observed in Tuckernuck Shoal, and 2,371 (82.1 percent) were observed outside the three shoal areas. During the aerial surveys, the number of flying terns recorded in each observation ranged from 1 to 201. Larger aggregations were infrequently encountered at roosting sites such as Fernando's Fetch (a transient exposed sandbar, present northwest of Muskeget Island during the surveys).

MAS (observed a total of 18,257 terns in the Sound from August 2002 to September 2004 (Perkins et al. 2003, 2004a,b,c, Sadoti et al., 2005a, 2005b). Common terns were more abundant (4,779) than roseate terns (832) though the majority of terns observed (12,646) were identified only as common/roseate type.

#### 4.2.4.3.9 Auks (alcids)

A total of 3,530 large alcids were observed in the study area during the study period (see Table 4.2.4-24). These were much more likely to be razorbills (*Alca torda*) than murres, puffins, or guillemots (Veit and Petersen, 1993), but specific identification was not established for most individuals. Alcids were seen throughout the study area from November to April, with an unusual, unconfirmed individual in June, 2002. Alcids occurred singly or in groups numbering up to 35 individuals and were relatively evenly distributed throughout the study area (Report Nos. 4.2.4-4, 4.2.4-9, 4.2.4-10 and 4.2.4-11). Aerial surveys conducted by the applicant documented a total of 3,455 individuals within the study area, of which 426 (12.3 percent) were observed in Horseshoe Shoal, 290 (8.4 percent) were observed in Monomoy-Handkerchief Shoal, 408 (11.8 percent) were observed in Tuckernuck Shoal, and 2,331 (67.5 percent) were observed outside the three shoal areas. Other observations of alcids included a total of 50 dovekies, recorded from January to May and one Atlantic puffin observed in March, generally in association with razorbills. All alcids seen flying were observed below approximately 50 ft (15 m) AMSL. MAS surveys observed 2,576 razorbills and 4 unidentified alcids during aerial surveys from fall 2003 to spring 2004 (Perkins et al., 2004c). Of these, 19 razorbills and one dovekie were observed in Horseshoe Shoal (Perkins et al., 2004c).

### *4.2.4.4 Additional Waterbirds Observed*

The following waterbirds were additional species/species groups that were observed in the study area during the study years but do not necessarily represent abundant species (Report No. 4.2.4-8 and Report No. 4.2.4-9).

#### 4.2.4.4.1 Sooty Shearwater

This visitor from the southern hemisphere is seen regularly in Massachusetts coastal waters in the summer, and was recorded in Nantucket Sound on 6 dates during May, June, August, and October. Ten individuals were observed within the study area during the study period, which involved periodic studies over more than two years. All were seen flying below approximately 25 ft (7.5 m) AMSL. Only one was observed during the aerial surveys.

##### 4.2.4.4.2 Other Ducks

A total of 14 greater scaup (*Aythya marila*) were observed in the southern section of the study area during an aerial survey in June, 2003. None were flying at rotor height. Also, a total of 109 American black ducks (*Anas rubripes*) were observed on Muskeget Island on four aerial surveys in the fall of 2003.

##### 4.2.4.4.3 Geese and Non-Seaducks

Large numbers of geese and non-seaducks pass close to shore during migration. The few that were observed during field studies included small numbers of Canada geese (*Branta canadensis*) that may have been residents. The Canada geese were observed at Muskeget Island and flying over Tuckernuck Island. In addition, a flock of 25 was observed flying through the study area in December, 2002, and 10 were observed in June, 2003. During boat surveys in September 2002, small numbers of high-flying snow geese (*Chen caerulescens*) were observed from the bluff at Cape Poge. Of the 35 geese observed during the aerial surveys, none were flying at rotor height. In addition, seven brants (*Branta bernicla*) were observed on the eastern part of the study area in February, 2004.

### 4.2.5 Subtidal Offshore Resources

#### *4.2.5.1 Introduction*

A description of existing hard and soft-bottom benthic habitats and species, shellfish, meiofauna and plankton resources in the area of the proposed action is presented in this section. Information presented was derived from a review of the scientific literature, performance of site assessments, review of existing site assessment data, and agency consultation. As part of a characterization of shellfish resources in Nantucket Sound commercial shellfish resource information for the Sound from NMFS and MDMF data, including information on commercial shellfish species such as soft shell clams, surf clams, quahogs, bay scallops, mussels and conch whelk were evaluated. Further information on commercial and recreational shellfishing was obtained during a Survey of Commercial and Recreational Fishing Activities which involved interviewing shellfish and coastal officers. Shellfish resource information for the nearshore area of the proposed action including the landfall locale was obtained through communication with MDMF and Town shellfish constables. The information gathered during this research is presented here and used to determine the potential impacts of the proposed action in Section 5.3.2.5.

Macrobenthic organisms are those organisms that live on or beneath the seafloor. Macrobenthos includes organisms, such as polychaete and oligochaete worms, clams, snails, crustaceans, seastars, brittle stars, sand dollars, and other large invertebrates. As opposed to these larger benthic invertebrates, small benthic invertebrates, often referred to as meiofauna, are discussed in Section 4.2.5.5.1. For the purposes of this analysis, meiofauna are considered to be small benthic invertebrate animals ranging in size from 0.02 to 0.002 in (0.5 mm to 0.045 mm). Macrofauna are larger benthic invertebrate organisms (i.e., greater than 0.02 in (0.5 mm) in length). The evaluation of benthic resources has been in accordance with specific requirements that were established for this proposed action as part of the MEPA scoping process and then modified in the USACE EIS Scope of Work. As a result of agency communication with the USEPA (Colarusso, 2002) and the USACE (2002a, 2002b) a sampling design, protocol, and methodology were designed and implemented by the applicant. The benthic database for the project was updated during November 2005 following these same approaches in order to obtain additional benthic community information in areas of the proposed action that were not previously investigated due to a revised proposed action layout.

### *4.2.5.2 Hard Bottom Benthic Communities*

Hard bottom areas with scattered boulders, cobble, and gravel have been confirmed by conducting side-scan sonar surveys of the project areas as well as more focused underwater video surveillance. Areas with this type of substrate are shown in Figure 4.2.2-1, Benthic Habitat Map. The side-scan sonar returns collected during three geophysical surveys were interpreted to represent scattered boulders (1 to 10 ft [0.3 to 3.0 m] in diameter) on the seafloor over approximately 10 percent of the area of the proposed action on Horseshoe Shoal with the remaining 90 percent of the shoal area relatively free of hard bottom substrate or boulders. The strong sonar returns indicative of glacially-deposited erratics are located primarily northwest of the ESP and along the western border of the array, though intermittent cobbles to boulders may be found scattered across the entire area of the proposed action. Along the submarine transmission cable route to the landfall in Yarmouth, the side-scan sonar results indicate rocky seafloor and boulders within an approximate 250 linear foot (76 m) length of the cable corridor south of Point Gammon and the entrance to Hyannis Harbor. This area corresponds to a zone of glacial drift paralleling and just offshore the present south coast of Cape Cod. The drift may be remnants of relict ice contact deposits left by an ice front temporarily stalled at this location during glacial retreat. The remaining seafloor along the submarine transmission cable route is interpreted as primarily unconsolidated sand-sized sediments.

Field sampling programs conducted in the areas of cobble as part of the Submerged Aquatic Vegetation Investigation (Report No. 4.2.2-1) indicated this type of habitat has macroalgae and attached invertebrates such as sponges. Although not observed or collected as part of the Submerged Aquatic Vegetation Investigation, other invertebrates that could be expected to occur include barnacles, mollusks and tunicates and various species of mobile invertebrates such as crabs, seastars, gastropods, and fish such as tautog.

### *4.2.5.3 Soft-Bottom Benthic Communities*

From a review of the scientific literature, sand is a dominant bottom substrate in the area of the proposed action with mud and other fine-grained sediments occurring to a lesser extent. SAV, boulders and cobbles are not common. However, these types of substrates were reported to occur occasionally throughout the proposed action locale. Earlier studies of the area present information that focuses on the benthic community that is associated with the sandy substrate when describing and quantifying benthic resources of this area. Bottom sediment mapping for the area of the proposed action is provided in Figure 4.2.2-1, Benthic Habitat Map, and in Report No. 4.2.5-1.

Field studies performed within the area of the proposed action during the summer of 2001 and the spring of 2002 were designed to provide a general characterization of the benthic community in habitats present that include fine-grained sand, coarse-grained sand, presence or absence of sand waves, and differing depths. In no manner was the intent to provide quantitative species or population numbers for everywhere the project might disturb the seafloor. This approach is consistent with general scientific principles of subsampling in order to provide an understanding of a much bigger area. These field studies were performed during seasonal periods generally reported to have the greatest biological diversity and highest abundance of macroinvertebrates. For the purpose of biomonitoring or community characterization, late spring to early summer benthic sampling in North Atlantic coastal waters is widely supported in the literature (Rudnick et al., 1985; Heck, 1987; Holland et al., 1987; Sardá et al., 1995; Alden et al., 1997; NOAA National Centers for Coastal Ocean Science, 2006). Furthermore, single- or double-season sampling is just as effective as multi-season sampling, especially when conducted during the spring and/or summer (Alden et al., 1997). One reason for this is that benthic abundance and productivity in these waters are typically highest during the spring and early summer (Rudnick et al., 1985; Heck, 1987; Holland et al., 1987; Sardá et al., 1995). While this is most notable in intertidal and estuarine habitats (due to greater seasonal variation in environmental variables), it is also observable in subtidal marine waters (Whitlatch, 1977). In general, increased energy inputs during the spring translate into high abundance and diversity in coastal waters. Recruitment of most marine benthic taxa in the temperate zone crests during the spring (Alden et al., 1997; Chainho et al., 2006). The increase in energy availability that typifies environmental conditions at this time provides sufficient resources for the annual recruitment of a wide range of taxa. In Narragansett Bay, Rudnick et al. (1985) attribute the spring-early summer peak specifically to a combination of warming temperatures and the increased availability of diatomaceous detritus – a major food source for many benthic meio- and macrofaunal taxa – which reaches maximum availability in the spring and is typically exhausted by late summer. Recruitment success during this spring-early summer period is therefore critical to the maintenance of patterns in community structure over time across the region.

With a focus on dominant habitats during the period of peak abundance, this characterization of the soft-bottom benthic community describes existing conditions that are likely to approximate the maximum regarding the soft-bottom benthic community's diversity and abundance for the area of the proposed action.

#### 4.2.5.3.1 Review of Scientific Literature

Benthic fauna data that are available for Nantucket Shoals were obtained and reviewed by Battelle (2001). Based on a review of scientific literature, Nantucket Sound has been generally reported to be a highly productive area for benthic invertebrates. Numbers of benthic organisms typically average in excess of 186 organisms/square foot (2,000 organisms/m²) (Theroux and Wigley, 1998). The average faunal density throughout the entire area of the proposed action studied in 2001 was 388 organisms/square ft (4,180 organisms/m²) and 704 organisms/square ft (7,574 organisms/m²) across three shoals studied in Nantucket Sound in 2002. The average faunal density for four sites sampled in 2005 at new turbine locations was 1007 organisms/square ft (11,589 organisms/m²). It is likely that the abundance averages recorded during these studies are higher due to data collection in spring and summer which are typically periods of peak abundance. Also, the 2005 samples were collected in the fall when the community is dominated by a larger number of smaller organisms (Sanders, 1956). It is also a possibility that the higher numbers of organisms found in the recent studies may be due to differences in gear used. Historically, mesh size used for sieving samples may have been larger than the 500µm-mesh size used in the recent studies that may have resulted in retention of more organisms on the sieve. Benthic faunal diversity (i.e., numbers of species and numbers of individuals per species) in Nantucket Sound has been reported to be lower than diversity in the rest of the Southern New England Shelf (Theroux and Wigley, 1998).

As described in Section 4.1 and Report No. 4.2.5-1 Nantucket Sound has a sandy substrate that is mobile and dynamic as shown by the sand waves and ripple marks. Frequency and magnitude of the sand movements greatly influences the structure and abundance of benthic communities. The organisms that live in or on such sandy sediments are well adapted for settlement or movement in sand and also for recovery from natural burial.

A review of the literature shows that the most abundant taxa (in this document the term taxa is defined as either a distinct species or a group of similar species based on level of taxonomic identification used) in Nantucket Sound benthic fauna include crustaceans and mollusks followed by polychaete worms (Avery et al., 1996). Of the crustaceans, amphipods are noted to be most abundant. The sandy sediments in Nantucket Sound are reported as supporting a diverse assemblage of species of amphipods. The field studies and assessments performed for the proposed action during 2001 and 2002 support these conclusions (Report No. 4.2.5-1 and Report No. 4.2.5-2). Samples that were collected from offshore waters during 2002 were, however, dominated by large Nematoda (roundworms) that made up (by number) 45 percent of macroinvertebrate communities that were sampled from Horseshoe Shoal (see Table 4.2.5-1).

The literature reviewed indicated bivalves to be the most important and diverse of mollusks with gastropods also noted as commonly occurring (Pratt, 1973). MDMF (2001) indicated there is reported to be a heavily populated area of northern quahog (*Mercenaria mercenaria*) in shoals that are east of Horseshoe Shoal. Shellfish suitability areas for quahog in the area of the proposed action are shown in Figure 4.2.2-1, Benthic Habitat Map. It has been reported that bay scallops (*Argopecten irradians*) occur in shallow waters of Nantucket Sound especially near seagrass beds. Shellfish suitability areas for bay scallops in the area of the proposed action are shown in Figure 4.2.2-1, Benthic Habitat Map. It has also been reported that species of large gastropod whelks (*Busycon carica* and *Busycotypus canaliculatum*) are abundant in Nantucket Sound coastal waters (Davis and Sisson, 1988). The 2001 field study program was not specifically designed for capturing large size commercial shellfish. However, the 2002 field study program was modified through the use of a Van Veen grab sampler so that some larger organisms occurring deeper in the sediment would be accounted for in the analyses. While the addition of the Van Veen grab sampler, improves capture of larger benthic infauna and epifauna, it does not measurably improve the effectiveness of capturing species such as large gastropod whelks sea cucumbers, sea stars, or quahogs as these types of grabs are not always effective in capturing the adults of these species groups. A shellfish survey was conducted in 2003 in Lewis Bay to locate larger mollusks in the Project's landfall locale (Report No. 4.2.5-3). Documentation of northern quahogs in near shore areas was associated with Town of Yarmouth shellfish beds.

### 4.2.5.3.2 Project Field Surveys

The applicant conducted comprehensive benthic field sampling programs, in addition to the literature review of benthic conditions in Nantucket Sound and agency consultations. Five separate field surveys were performed in the area of the proposed action from 2001 through 2005. Ninety benthic samples were collected and analyzed. The field surveys in the area of the proposed action are summarized here. Data collection efforts performed are not as robust as needed for statistical analyses that provide a truly valid scientific quantitative characterization of benthic habitats over such a large area and variable conditions, however they still provide insight into the nature and general characteristics of the benthic communities present in the proposed action area, and to allow for a characterization of potential affects.

**2001 Benthic Macroinvertebrate Field Sampling Program**

During August 2001, an assessment of benthic organisms was performed along the proposed and alternative submarine transmission cable routes connecting Horseshoe Shoal to Lewis Bay and Popponesset Bay, respectively, along with an assessment of benthic organisms associated with the site of the proposed action (Report No. 4.2.5-2). The survey was conducted in order to characterize the composition of the benthic community of the proposed action area. One benthic sample was collected by surface grab methods at each of 46 locations, consistent with the proposed action's sediment core sampling program (see Figure 4.2.5-1). The sampling locations were selected to reflect the range of benthic habitats (Gibson et al., 2000) that occur along the proposed and alternative cable routes that originate from Lewis Bay and Popponesset Bay and from within the site of the proposed action on Horseshoe Shoal. Benthic macroinvertebrates from each sample were separated from sediment and debris, were identified to the lowest practical taxonomic level, and were counted.

The following information is a summary of the detailed results of the 2001 sampling Program found in Report No. 4.2.5-2. Amphipoda was the most abundant and diverse taxonomic class found. Amphipods dominated seven of the 46 grab sites in Nantucket Sound, with a maximum of 95 percent (by number) occurring at one site (BG-G7) that was located approximately 1.5 miles (2.4 km) north of Halfmoon Shoal. Two amphipod taxa reaching greatest abundance (> 1208/square ft [13,000/m$^2$]) include the Ampeliscidae and Ischyroceridae families. When amphipods were found in these high densities the samples had been collected in areas on or in the immediate Horseshoe Shoal locale. These findings are consistent with the data reported in the literature (Sanders, 1958; Avery et al., 1996) that noted very high densities of amphipods in the sandy bottom substrates that were sampled in shallow waters in Nantucket Sound.

Sampling also revealed a wide variety of gastropods in the proposed action locale. Relatively high densities of gastropods were often found including areas along the proposed submarine transmission cable route. The species composition documented during this study was basically consistent with the data that was reported in earlier studies of Nantucket Sound, Georges Bank, and the Southern New England Shelf (Wigley, 1968; Pratt, 1973; Theroux and Wigley, 1998).

**Results of the 2001 Benthic Sampling Program Outside Massachusetts Waters**

Data from samples collected during the 2001 benthic sampling program that were collected from Horseshoe Shoal and from the sections of the two alternative interconnecting routes located outside of the 3.5 mile (5.6 km) limit describe the composition of the benthic community outside the 3.5 mile (5.6 km) limit. The data indicate that Amphipoda dominate the benthic community in this locale. Ampelisidae and Ischyroceridae comprised greater than 68 percent of the macroinvertebrate community by number in this locale in 2001. Other common taxa that were reported from this area included convex slippersnail *(Crepidula convexa),* common Atlantic slippersnail (*Crepidula fornicate),* Bloodworm *(Glycera dibranchiate)* and Nematoda and comprised 18 percent of the macroinvertebrate community by number. These six taxonomic groups comprised 86 percent of the organisms by number in the locale in the 2001 study. There were 65 benthic taxa reported as occurring outside the 3.5 mile (5.6 km) limit and in the area of the proposed action at Horseshoe Shoal. Average numbers of taxa per sample in this locale in 2001 were 9.2 taxa/sample. The average number of organisms/square ft (organisms/m²) in this locale in 2001 was reported to be 521 (5,611).

**Results of the 2001 Benthic Sampling Program inside Massachusetts Waters**

During the 2001 sampling program 46 samples were collected in the area of the proposed action. Of these samples three were collected in Lewis Bay and five were collected along the route, within the 3.5 mile (5.6 km) limit of the area of the proposed action that connects Horseshoe Shoal with Lewis Bay. During this study the benthic community in this locale was dominated by the gastropod species (*Crepidula convexa* and *Crepidula fornicata)*. Slipper snails were documented in seven of the 46 samples collected in 2001. When found they occurred in very high densities (>743/square ft [8,000/m²]). Patchiness in the slippersnail distribution may be due to their dependence on stones and boulders which are scattered within the mainly sandy material. Slippersnails disperse via planktonic larvae (Collin, 2001) and can form accumulations of free-standing clusters on the seafloor if the larvae settle and then metamorphose on a stone. Additional larvae can then settle on the pioneer slippersnail and when that slippersnail dies and the attachment to the substrate is released the cluster can then become free-standing (Rayment, 2001). *Crepidula fornicata* is commonly reported attached to stones and shells in soft substrates or in muddy/mixed muddy areas (Rayment, 2001). *Crepidula fornicata* has been reported to alter sediment characteristics by removal of a large volume of suspended organic material from the water column and depositing that filtered material on the bottom as pseudofeces (GISD, 2008; MarLin, 2008). *Crepidula fornicata* is a suspension feeder and its diet has been noted to be composed mainly of pelagic algae of various sizes and forms, but also benthic ones, and detritic and bacterial material (GISD, 2008). JNCC (2008) notes that *Crepidula fornicata* competes with other filter-feeding invertebrates for space and food. Effects of *Crepidula fornicata* on benthic communities differ depending on the habitat they colonize: in muddy sediments, presence of *Crepidula fornicata* apparently stimulates the zoobenthic community diversity and abundance (mainly deposit-feeders); in coarser sediments, macrofauna community is different (more suspension-feeders) from the community that is associated with *Crepidula fornicata* (de Montaudouin and Sauriau, 1999). Additional taxa that were common from samples in this locale included Phoxocephalidae (hood-headed amphipods), *Lumbrineris* sp., Nematoda (roundworms), and Oligochaeta (aquatic worms). These six taxonomic groups made up almost 69 percent of organisms (by number) identified from samples in the locale. There were 50 benthic taxa reported as occurring in the samples collected within the 3.5 mile (5.6 km) limit. The average number of taxa per sample in this locale in 2001 was 11.6 taxa. The average number of organisms/square ft (organisms/m²) in this locale in 2001 was reported to be 188 (2,017).

**2002 Benthic Macroinvertebrate Field Sampling Program**

During late spring of 2002 assessments of the benthic macroinvertebrate community were performed at the site of the proposed action (Horseshoe Shoal), Monomoy-Handkerchief Shoal and Tuckernuck Shoal in Nantucket Sound (see Figure 4.2.5-1). All of these areas are located outside the 3.5 mile (5.6 km) limit. These three Nantucket Sound study areas were evaluated taking into consideration specific habitat variables including sand wave presence, sediment type, and water depth. These habitat variables are generally accepted as primary factors that influence benthic community abundance and diversity in Nantucket Sound (Theroux and Wigley, 1998; Zajac, 1998; Colarusso, 2002). Published charts and reports (O'Hara and Oldale, 1987; NOAA Fisheries, 2001), results from geophysical surveys conducted in 2001, and surficial marine sediment classification obtained from vibracores, borings, and benthic grab samples collected in 2001 and 2002 were reviewed in order to characterize conditions across the three areas (Report No. 4.2.5-1).

One benthic sample was collected using a surface grab from each of 33 selected locations (Report No. 4.2.5-1). The sampling locations included benthic habitats such as various sand wave conditions, different sediment types, and differing depths. All areas evaluated did not necessarily contain all of these habitat conditions. Shallow depths were not present at the Monomoy-Handkerchief Shoal Site and sand waves occurred only at the Horseshoe Shoal site. The field sampling program was designed so that statistical comparisons could be made among the physical oceanographic parameters and the benthic organism community composition. Communication with USEPA (Colarusso, 2002) indicated that a minimum of five samples per habitat type would provide sufficient statistical power for the evaluation of differences in benthic resources associated with major habitat types such as sand wave presence, substrate type and depth in each of the three study areas in Nantucket Sound.

The following information is a summary of detailed results of the 2002 Sampling Program found in Report No. 4.2.5-1. Since the 2002 survey was conducted in the spring a comparison could be made to summer surveys conducted in 2001. Information from the Horseshoe Shoal portion of this sampling program is summarized in this section.

For the 2002 sampling program, samples from 12 sampled sites were evaluated and 48 benthic invertebrate taxa from nine different Classes were identified. During the 2002 spring season, data indicated that Horseshoe Shoal supported a macroinvertebrate community that had an average diversity of 9.9 taxa per sample and an average abundance of 842 organisms/square ft (9,060 organisms/m²). Six dominant taxa represented over 90 percent of the macroinvertebrate community at Horseshoe Shoal in 2002, while in comparison. These six taxa represented over 75 percent of the macroinvertebrate community at Horseshoe Shoal in 2001. The most dominant taxon (by number [average number individuals/ m²]) was reported to be Nematoda (roundworms) followed by Ampeliscidae (four-eyed amphipods).

The six dominant taxa at Horseshoe Shoal in the spring of 2002 differed when compared to those dominant in late summer of 2001. Nematoda were more dominant in spring of 2002 than in summer of 2001. Two snail species, *Crepidula convexa* and *Crepidula fornicata* ranked in the top six taxa that were collected during the summer 2001 whereas they were not in the spring 2002 top six taxa. Also, three families of crustaceans were ranked in the six dominant taxa during summer 2001 and only two were so ranked in the spring 2002 sampling effort. These variations may be due to life cycles of these organisms that result in varying seasonal abundance patterns or to annual variability of these populations.

Benthic organisms from sediment depths greater than 5 cm were noted. Some of these organisms are not typically found in the deeper sediments and may have become included with deeper sediment organisms due to sediments from the upper 5 cm of the collected sample passing through the sieve. Even though the residual organisms were present, few organisms were noted in the sediment depths that were greater than 5 cm. This analysis reveals that most of the benthic organisms that occur at Horseshoe Shoal live in the top 5 cm of the substrate. This may be due to the presence of shifting sediments in this area that would have greater potential for burying organisms that are sedentary or deeply embedded (Sanders, 1956; Rhoads et al., 1978). Data analyses indicate that during the late summer 2001 sampling period and the spring 2002 sampling period benthic community abundance and diversity was not significantly different in the Horseshoe Shoal area.

**2003 Benthic Macroinvertebrate and Shellfish Survey of Lewis Bay**

During the summer of 2003, a benthic organism and shellfish sampling program was performed in order to describe shellfish and other benthic organisms that occur in Lewis Bay in the Town of Yarmouth shellfish area, an area that would be crossed by the proposed cable route (Report No. 4.2.5-3). Shellfish and other benthic organisms were sampled at specific locations (see Figure 4.2.5-2) along the proposed route in Lewis Bay with a clam rake, a ¼-inch mesh box sieve, and a manually operated dredge, when appropriate. All sample locations were mapped. The clam rake, box sieved samples, and dredge were each used at each sampling location so that all components of the benthic community could be adequately evaluated. The recreational shellfish bed in Lewis Bay (approximately 600 ft (61 m) in width) will be crossed entirely by jet plow. The 200 ft (61 m) closest to shore, which is landward of the recreational shellfish bed limit is to be crossed by using HDD with the remaining 400 ft (122 m) to be crossed using a jet plow. The cofferdam, and any impacts that may be associated with it, will be located approximately 200 ft from shore and landward of the recreational shellfish bed. Also, for the transition from the seaward terminus of the HDD conduit to the submarine transmission cable system a pre-excavation pit would be required.

The following information is a summary of the detailed results of the 2003 Sampling Program found in Report No. 4.2.5-3. Areas sampled are all located in Massachusetts waters. The benthic macroinvertebrate community in the locale of the Town of Yarmouth's recreational shellfish bed had a variety of organisms including worms, crustaceans, clams and snails. Thirty-one benthic macroinvertebrate taxa from seven taxonomic classes were recorded in samples evaluated from four sites using the three sampling techniques. The sample site located furthest from shore (BGL1A) had the highest overall macroinvertebrate abundance (organisms/square ft [organisms/m²]), as evaluated by the dredge technique. Abundance of large shellfish, including the northern quahog, as evaluated by the clam rake technique, was similar at all four sites.

Of macroinvertebrates found in Lewis Bay, the Polychaeta were the most diversely represented class. Thirteen different taxa were present in dredge and sieved samples combined. *Streblospio benedicti* (mud worm) were most abundant with *Prionospio* spp. (mud worm), Family Syllidae, and Capitellid thread worms commonly occurring. The most abundant class observed using the dredge technique was the Nematoda (round worms) with the Class Oligochaeta also being abundant. The most abundant class of macroinvertebrates in clam rake samples was bivalves with the most abundant species being the northern quahog. *Anadara ovalis* (blood ark) was also commonly found. The density of macroinvertebrates collected in this survey averaged 5,406 individuals/square ft (58,168 individuals/m²) compared to an average of 517 individuals/square ft (5,558 individuals/m²) on Horseshoe Shoal in 2001 and 842 individuals/square ft (9,060 individuals/m²) on Horseshoe Shoal in 2002. The density of macroinvertebrates that were collected in the deeper waters of Lewis Bay in 2001 averaged 188 individuals/square ft (2,017 individuals/m²) which is lower than the densities recorded from Horseshoe Shoal at that time. Comparison with previously collected Nantucket Sound data notes a marked absence of the Order Amphipoda in Lewis Bay during this study. A possible reason for the absence of amphipods in Lewis Bay could be their sensitivity to environmental stresses or disturbances (Pratt, 1973). Many dominant taxa found in Lewis Bay in this study are described as either pollution tolerant, opportunistic in nature, or early colonizers following an environmental disturbance.

**2005 Benthic Macroinvertebrate Field Sampling Program at New Turbine Locations**

During November 2005 the benthic database for the proposed action was updated to obtain additional benthic community information in areas not investigated previously due to a revised turbine layout. The benthic macroinvertebrate community was assessed at four new locations in a manner that was consistent with methods previously established for the 2001 and 2002 field sampling programs in order to maintain consistency among the surveys (Report No. 4.1.1-1).

The following information is a summary of the detailed results of the 2005 Sampling Program found in Report No. 4.1.1-1. Results from the analyses of samples from the four new locations indicated a presence of 20 benthic macroinvertebrate taxa (Report No. 4.1.1-1). The average taxonomic richness for the four sites sampled was 9.5 taxa per sample, with a total taxonomic richness for areas sampled being 20 taxa. Site BG05-04 that is located at a depth of 27 ft (8.2 m) had the highest taxonomic richness with 16 taxa recorded. Site BG05-02 had the lowest taxonomic richness with only 4 taxa recorded at each site. For the four sites sampled the average faunal density was 1,102 individuals/square ft (11,589 individuals/m²) (Report No. 4.1.1-1). Site BG05-04 on Horseshoe Shoal's western edge had the highest faunal density with 1,942 individuals/square ft (20,898 individuals/m²). Sites BG05-02 and BG05-03, which are located at the center and to the north of Horseshoe Shoal, respectively, had the lowest faunal density with 504 individuals/square ft (5,418 individuals/m²). Average density for the four locations was higher than densities reported during the 2001 sampling program (521 individuals/square ft [5,611 individuals/m²]) and during the 2002 sampling program (842 individuals/square ft [9,060 individuals/m²]). These differences may be the result of community shifts expected from differences between seasons sampled with the 2001 and 2002 being late spring and summer samples while the 2005 samples were collected in the fall when the community is dominated by a larger number of smaller organisms (Sanders, 1956).

In the 2005 sample, Nematoda were more abundant than any other group, comprising 70 percent of the total number of individuals/square ft (individuals/m²) of all the samples. Nematoda were dominant in each sample with over 50 percent in BG05-01, BG05-02, BG05-03 and 47 percent in BG05-04. Oligochaeta was the only other taxon that met criteria for being dominant and was 27 percent dominant in sample BG05-04. The gastropod *Crepidula fornicata* made up 17 percent of the sample. At site BG05-01 Platyhelminthes, *Ophelia* spp. and *Scoloplos* spp. had significant individuals/square ft (individuals/m²) with three percent, four percent and two percent of the sample count, respectively. At sample site BG05-02 Platyhelminthes and *Glycera* spp. were present in significant numbers at four percent and three percent of the sample count, respectively. At site BG05-03 Platyhelminthes (four percent) were also present along with *Scoloplos* spp. (five percent) of the sample count. The only taxa identified on the sieve portion of any of the four samples were three specimens of *Macoma balthica* at site BG05-03.

**2005 Macroinvertebrate Survey of Meteorological Tower Colonization**

During June 2005 an assessment was made of the macroinvertebrate community colonizing the meteorological tower installed within the proposed offshore area of the proposed action. The tower platform is supported by three steel pilings that are not identical in size to the proposed monopiles, but have the same smooth steel surface. In addition, scour control mats that are proposed for the monopile foundations protected one of the three pilings. The meteorological tower, installed in April 2003, had been in place for more than two years allowing for a macroinvertebrate community to be established. It was hypothesized that the macroinvertebrate community that became established on the support pilings would be similar to a community that may establish itself on the proposed monopiles.

During the survey observations made by divers indicated that similar macroinvertebrate communities were established on the three support pilings, with distinct colonization patterns at different water depths. Vacuum suction techniques were used to collect three samples. Benthic organisms and other attached material were completely removed from 0.14 square ft (0.013 m²) of surface area from one of the support pilings. A sample was collected from each of three localities: one from an area of the piling that was just above the sea floor, one from within a mid-depth range of the piling, and one just below the low water mark located on the piling.

The following information is a summary of the detailed results of the 2005 Survey of Meteorological Tower Colonization found in Report No. 4.2.5-4. The purpose of this survey was to provide a qualitative assessment of the nature and rate of expected patterns of colonization on the proposed WTG monopiles based on the benthic community colonizing the existing meteorological tower support pilings. The survey results indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized the support pilings. However, taxa were reported that had not been previously noted in the sandy bottom habitat. Twenty-six taxa, including seven species not observed during other baseline surveys at Horseshoe Shoal, were noted during the macroinvertebrate sampling on the tower support pilings (see Table 4.2.5-2). The seven new species reported included blue mussel (*Mytilus edulis*), sea flea (*Photidae* spp.), sea slug (*Sacoglossa* spp.), mud worm (*Polydora* spp.), large-eyed feather duster worm (*Potamilla reniformis*), purse sponge (*Scypha ciliata*) and a sea spider (*Tanystylum orbiculare*). These new taxa are likely to be in the area of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders. Average taxonomic richness for the three piling sites that were sampled was 14.3 taxa/sample. Though this sampling effort was limited, it is expected that pilings would support more taxa since they may attract organisms from both the sandy substrate habitat and those that would be attracted to fixed structures. Supporting this conclusion are the results of field observations that noted the most abundant and diverse communities near the base of pilings close to the naturally occurring substrate. The three piling sites sampled had an average faunal density of 106 individuals/square ft (1,145 individuals/m²), lower than values noted from benthic samples evaluated during the 2001 and 2002 surveys (521 individuals/square ft [5,611 individuals/m²] and 842 individuals/square ft [9,060 individuals/m²], respectively).

**Conclusions from Benthic Field Investigations**

From 2001 to 2005 there were 90 benthic samples collected in Nantucket Sound. Each of the dominant benthic habitats that occur in the site of the proposed action area and in surrounding sites was sampled during a variety of seasons. Overall, benthic community composition documented during the studies was consistent with data noted in previous studies in Nantucket Sound, on Georges Bank, and the Southern New England Shelf (Sanders, 1956; Wigley, 1968; Pratt, 1973, Theroux and Wigley, 1998). These earlier studies indicated that the Nantucket Sound benthic community had a lower than average invertebrate density when compared with the rest of the Southern New England Shelf. However, biomass and density were found to be relatively high. Certain benthic taxa are more adapted to the shifting sand substrates that are characteristic of shallower waters. Thus, productive shallow water habitats can support greater densities of these adapted organisms but have lower overall densities compared to more stable, often deeper water benthic habitats.

There is natural variability in most benthic communities since the communities are subject to combinations of biological and physical factors that result in a high degree of environmental variability

(Sanders, 1958; Zajac, 1998). A high sample-to-sample variability in total invertebrate abundance was also found. This supports conclusions of previous research efforts that indicated the Nantucket Sound benthic community was highly variable from one location to another and from one season to another (Wigley, 1968). The patchy nature of "microhabitats" (specific combination of habitat elements in a place that is occupied by an organism for a specific purpose) in terms of parameters like depth, currents, sediment type, light penetration, temperature, availability of food, disturbance, predation and shelter is believed to be a reason for this variability (Sanders, 1956; DeLeuw et al., 1991; Howes et al., 1997).

Results from benthic samples evaluated reveal a link between sediment type, depth, and macroinvertebrate community diversity. Data also showed there was not a link between the above variables and overall macroinvertebrate abundance. The microhabitat variable evaluated that significantly ($P<0.10$) affected macroinvertebrate abundance was presence/absence of sand waves. Unstable sand wave environments are mainly inhabited by motile organisms that can avoid shifting sands (e.g., certain amphipod taxa and the tanaid *Leptognathia ceaca*) or by organisms that are capable of burrowing from beneath shifting sands if they get buried (e.g., certain polychaetes, Nematoda, Oligochaeta, and the bivalve *Tellina agilis*). *Tellina agilis* was the only shellfish collected in a sample from a sand wave. This mollusk has been described as an actively burrowing and mobile bivalve (Gosner, 1978).

Although limited numbers of samples were collected from the meteorological tower support pilings, the survey results indicate the benthic community that colonized them was similar in nature to the nearby sea floor community. Several new taxa noted on the pilings had not been recorded during previous sampling efforts from gravelly, sand or mud substrates. It is likely these new taxa colonized through their planktonic larvae or migrated to the pilings from other stationary hard substrate habitats in the proposed action locale such as rocky shoals or boulders.

### *4.2.5.4 Shellfish Resources*

Review of the scientific literature has indicated that few studies related to shellfish resources have occurred in the proposed action locale and submarine route in Nantucket Sound. Information related to commercial shellfish resources in the larger area of Nantucket Sound is available from NMFS and MDMF. In addition, in Massachusetts, local shellfish constables serve to manage shellfishing activities in each town. Certain areas can be designated by shellfish departments to be used for recreational or family harvesting. Other specified areas may be privately licensed shellfish areas. There may also be areas for grants that are managed privately for certain shellfish species.

Shellfish suitability area information for blue mussel, bay scallop, sea scallop, surf clam, soft shell clam, quahog, and also Yarmouth aquaculture lease areas was obtained from the MassGIS database and is shown in Figure 4.2.2-1, Benthic Habitat Map.

#### 4.2.5.4.1 Massachusetts Department of Marine Fisheries Research Trawls

One source of information for shellfish resources is the MDMF bi-annual research trawls that are designed for collecting fishery-independent information on distribution and abundance of invertebrates and fish in Massachusetts' waters. These trawl surveys have been performed yearly in May and September since 1978, and are based on a stratified random design using depth strata and a 1 square mile nautical grid. Coastal waters are stratified into geographic zones or strata according to depth and area. The pre-determined trawl locations are assigned in proportion to the area of each stratum and are then selected randomly in each stratum. Since timing of the surveys is May and September, this does not allow the surveys to represent abundance and distribution of fish or invertebrates over a whole year. The timing coincides with seasons when adults or juveniles are in the inshore areas. The trawling surveys are also more effective for collection of semi-pelagic and demersal species. Information is available on a Nantucket Sound-wide basis for a 27 year period (Report No. 4.2.5-5).

The review of MDMF trawl information from 1978 to 2004 (see Figures 4.2.5-3 through 4.2.5-6) showed that in the fall resource trawls the knobbed whelk and lady crab were included in the top 10 species by catch weight (Report No. 4.2.5-5). In the fall resource trawls, spider crabs and lady crabs were ranked in the top 10 species by catch number. In the spring resource trawls, spider crabs were ranked in the top 10 species by catch weight. In the spring resource trawls, spider crabs and Atlantic rock crabs were ranked in the top 10 species by catch number.

#### 4.2.5.4.2 Massachusetts Department of Marine Fisheries and National Marines Fisheries Service Commercial Harvest Data

In addition to the research trawls, the MDMF collects information on commercial harvesting of shellfish, lobster, and other "regulated" fisheries, which is maintained through the Management Information Systems and Fisheries Statistics Project. In order to monitor fishery resources in Massachusetts' waters, coastal waters have been divided into statistical areas with Nantucket Sound identified as Statistical Reporting Area 10. Reporting procedures include commercial fishermen submitting catch reports that address several shellfish species, including the lobster, shellfish and conch pot fisheries. A 15-year period (1990 through 2004) of MDMF catches data for available shellfish species from MDMF Area 10 were obtained from MDMF.

For monitoring commercial fishery landings, NMFS separates U.S. coastal waters into statistical areas. With Nantucket Sound designated as Statistical Area 538/Sub-area 075, which is comparable to MDMF Area 10 (see Section 4.2.7.1 for Report No. 4.2.7-1 - figure in Attachment A and figure in Attachment B). Landings information (including certain species of shellfish) from commercial fishermen is reported to NMFS via a mandatory reporting system. These data are called "vessel trip reports (VTR)." The VTR data covering an eleven-year period (1994 to 2004) for available shellfish species in Sub-area 075 were obtained from NMFS. This information was utilized to describe commercial shellfish resources and landings in Nantucket Sound (Report No. 4.2.5-5).

Shellfish landings in the federally-reportable Area 075 between 1994 and 2004 were represented by several species that included conch (whelk), quahogs, scallops and clams. Conch is a general term for several species of whelk such as the knobbed whelk, channeled whelk and lightning whelk that are found in Southern New England waters. The NMFS VTR data indicate several species of conch make up an important fishery in Nantucket Sound. From 1994 through 2004, conch species made up 80 percent of the total annual shellfish landings (see Figure 4.2.5-7). From 1994 through 2004, federally-reportable shellfish harvested in Nantucket Sound totaled approximately 1.8 million lbs (816,466 kg) (see Table 4.2.5-3). Lowest shellfish landings were reported in 1996 (approximately 10,600 lbs [4,808 kg]) and highest shellfish landings were reported in 2001 (approximately 448,000 lbs [203,209 kg]) (Report No. 4.2.5-5).

The fish pot fishery for conch in Nantucket Sound is monitored by MDMF separately from shellfish that are harvested by other methods. From 1992 through 2004 the state-reportable conch landings from conch pots in the Nantucket Sound area totaled approximately 14.6 million lbs (6,622,449 kg) (Report No. 4.2.5-5). Landings information prior to 1992 is not available since catch reports for conch were not required prior to 1992. On an annual basis, state-reported conch landings from pots fished in Nantucket Sound have generally decreased from a high in 1992 (approximately 2 million lbs [907,185 kg]) to a low in 1998 (478,000 lbs [216,817 kg]). Landings have increased since 1998 going from 939,000 lbs (425,923 kg) in 1999 to 1.1 million lbs (498,952 kg) in 2004. During the timeframe from 1998 through 2004 a low of 685,000 lbs (310,711 kg) was reported in 2001. On a seasonal basis, the state-reported conch landings are usually high in June through August (Report No. 4.2.5-5).

State-regulated species of shellfish that are harvested from Nantucket Sound using methods other than fish pots include ocean quahogs, mixed quahog species, sea clams, soft shell clams, bay scallops, sea scallops, mussels and conch. American lobster landings are reported separately. From 1990 through 2004, total landings for the above shellfish species in Nantucket Sound were approximately 27.1 million lbs (12,292,353 kg) (see Table 4.2.5-4). During 1990 and 1992, these state-reported shellfish landings for Nantucket Sound showed an increase from approximately 80,000 lbs (36,287 kg) to approximately 5 million lbs (2,267,962 kg). In 1993, these state-reported shellfish landings decreased and then increased in 1994 to a 10 year high of 7.9 million lbs (3,583,380 kg). In the following years these state-reported shellfish landings in Nantucket Sound decreased in 1999 to 65,000 lbs (29,484 kg), in 2000 to 83,000 lbs (37,648 kg), and in 2003 to 55,000 lbs (24,948 kg) (see Figure 4.2.5-8). Common species harvested over the 15-year period in Nantucket Sound include the sea clam which made up approximately 47 percent of the state shellfish landings during this timeframe. The second most common species were mussels and the third most common species were conchs making up approximately 32 percent and 14 percent, respectively of shellfish reported harvested in Nantucket Sound by state permitees. Quahogs, including ocean quahogs, mixed quahogs, littlenecks and cherrystones, made up approximately 6 percent of the total state-reported shellfish landings. Soft shell clams, bay scallops and sea scallops made up less than 1 percent of the total state shellfish landings during the 15-year timeframe (see Figure 4.2.5-9).

Though northern quahogs (*Mercenaria mercenaria*) have been noted as making up a small percentage of state-reported shellfish landings, they have been reported as an important fishery in Massachusetts (MDMF, 2001) and also to be abundant in the coastal estuaries emptying into Nantucket Sound (MacKenzie, 1997). The MDMF staff (MDMF, 2001) has indicated there is a heavily populated northern quahog area present east of Horseshoe Shoal. A shellfish suitability area for quahogs is shown east of Horseshoe Shoal in Figure 4.2.2-1, Benthic Habitat Map. This locale is called the “quahog grounds” and is described as an area targeted by commercial fishermen (MDMF, 2001).

Bay scallops (*Argopecten irradians*) occur in Nantucket Sound in shallow areas mainly in proximity to seagrass beds. Shellfish suitability areas for scallops along the shoreline in Lewis Bay and along Nantucket Sound shoreline areas in proximity to Lewis Bay are shown in Figure 4.2.2-1, Benthic Habitat Map.

American lobsters (*Homarus americanus*) occur throughout New England. There is a commercial fishery for this species in coastal states from Maine to Delaware. Commercial permits for this species are issued to offshore fishermen (outside of the 3.5 mile [5.6 km] territorial limit) and inshore fishermen (within the 3.5 mile [5.6 km] territorial limit). The MDMF has designated 14 areas in Massachusetts nearshore waters for the reporting of lobster catch. The area of the proposed action is located within MDMF Area 10 that includes Nantucket Sound.

The lobster fishery in Nantucket Sound does not appear to be a major fishery. Massachusetts lobster fishery statistics for 2004 (Dean et al., 2006) reported that the Area 10 (Nantucket Sound) lobster fishery included 0.3 percent (of nearly 9 million lbs [4,082,331 kg]) of the total Massachusetts coastal permit harvest in 2004. Adjacent areas (Areas 9 and 11 through 14) had low yields, each having 5 percent or less of the total harvest. Areas 2 though 8 that are located along the northern coast above Cape Cod Bay had the highest catches in territorial waters.

From 1990 through 2004 the total state-reportable lobster landings for Area 10 (Nantucket Sound) were estimated to be approximately 457,000 lbs (207,292 kg) (see Figure 4.2.5-10). The lobster landings increased from 8,000 lbs (3,629 kg) to approximately 50,000 lbs (22,680 kg) during the timeframe of 1990 through 1993. From 1994 to 1999, lobster landings varied from a low of 28,000 lbs (12,701 kg) to a high of approximately 48,000 lbs (21,772 kg) followed by a decline in 2000 to below 20,000 lbs (9,072 kg). Between 2001 and 2004, for Nantucket Sound the lobster landings stayed at approximately 20,000 lbs (9,072 kg) except in 2002 when landings of approximately 42,000 lbs (19,051 kg) were reported. On a seasonal basis, state-regulated lobster landings increased in June, peaked in July, and declined from August through December (see Figure 4.2.5-11) (Report No. 4.2.5-5).

#### 4.2.5.4.3 Survey of Commercial and Recreational Fishing Activities

Additional information on commercial and recreational shellfishing was obtained as part of a survey of commercial and recreational fishing activities. Five shellfish and coastal officers were interviewed during this survey (Report No. 4.2.5-6).

In Edgartown it was reported that shell fishermen reportedly harvest scallops on both sides of Cape Poge, in outer Edgartown Harbor and along the channel area. It was reported that sometimes littlenecks (small quahogs) and surf clams were harvested on Horseshoe Shoal. It was noted that conch fishermen frequent Horseshoe Shoal. The Edgartown shellfish constable commented that Horseshoe Shoal is not a productive area for lobsters, since it is too sandy.

The Barnstable shellfish officer noted that clamming occurs off Squaw Island, Halls Creek and Dead Neck in the Barnstable waters of Nantucket Sound. The Officer commented that the Vineyard and Nantucket are traditional scalloping grounds and Egg Island north of Point Gammon once had a scallop fishery, and noted that draggers harvest quahogs in beds found four to five years ago off Harwich, Brewster and Chatham. The Officer's comments did not include knowledge of scallops in the Horseshoe Shoal locale.

Based on knowledge of those interviewed, no commercial or recreational harvesting of soft shell clams, razor clams, bay scallops or sea scallops was reported on Horseshoe Shoal. It was reported that conch trapping by fixed gear fishermen does occur on Horseshoe Shoal. One municipal official commented that Horseshoe Shoal was too sandy to support a viable lobster fishery. Of the 41 survey participants (18 commercial fishermen, one commercial fish dealer, eight recreational fishermen, four bait and tackle shop staff, five harbor masters, and the five shellfish and coastal officers) none reported lobstering on Horseshoe Shoal (Report No. 4.2.5-6).

#### 4.2.5.4.4 2003 Shellfish and Benthic Macroinvertebrate Survey of Lewis Bay

During the summer of 2003 shellfish and benthic organism sampling program was performed in order to describe shellfish and other benthic organisms that occur in Lewis Bay in the Town of Yarmouth shellfish area to be crossed by the proposed cable route (Report No. 4.2.5-3). Results of the sampling indicated that the abundance and diversity of shellfish and benthic organisms were similar to previously conducted studies in similar types of areas. Results from this survey were also discussed previously in Section 4.2.5.3.2.

#### 4.2.5.4.5 Municipal Shellfish Resources

Certain towns, including the Town of Yarmouth, have shellfish management programs that involve purchasing seed and adult shellfish for propagation and enhancement of natural shellfish stocks in stretches of waterbodies within the respective town. In cooperation with MDMF, shellfish departments that participate in such programs have a rotating schedule for opening and closing such areas based on water quality information and availability of shellfish.

In the routing from offshore to the Cape Cod shoreline the proposed submarine transmission cable route crosses the 3.5 mile (5.6 km) state jurisdictional limit and enters Town of Yarmouth waters, then enters Town of Barnstable waters at the outer section of Lewis Bay, and proceeds to the inner section of

Lewis Bay back in the Town of Yarmouth and to the proposed landfall site at New Hampshire Avenue in the Town of Yarmouth (see Figure 4.2.2-1, Benthic Habitat Map).

A short section of the submarine transmission cable route passes through jurisdiction of the Town of Barnstable, mostly located in the outer section of Lewis Bay, which has been described as not having substantial recreational or commercial shellfishing harvesting or aquaculture lease areas (Marcotti, 2002). Shellfish expected in this section of Lewis Bay include soft shell clams, quahogs and scallops. Scalloping activity takes place near Egg Island and the Town of Barnstable may open some areas offshore for quahog harvesting (Marcotti, 2002). The Town of Barnstable has no privately-licensed shellfish grants or shellfish propagation projects in the outer section of Lewis Bay. The section of Lewis Bay within the Town of Yarmouth has been described as containing quahogs, soft shell clams, scallops, and limited numbers of eastern oysters (*Crassostrea virginica*). Although there is limited shellfish life in Lewis Bay, quahogs are the most prevalent shellfish species primarily due to the seeding of the recreational shellfish beds. In this section of Lewis Bay shellfish resources occur in privately licensed shellfish grant areas or areas that are managed through the Town of Yarmouth's shellfish propagation program (Caia, 2002).

Several locations in the Town of Yarmouth have designated recreational shellfish areas open only to Town residents for recreational purposes. One such area is within the direct path of the submarine transmission cable route – extending from Colonial Acres east to the Englewood Breakwater (see Figure 4.2.2-1, Benthic Habitat Map). Another such area is located outside of the submarine transmission cable route in the Mill Creek locale. These areas are enhanced with seed shellfish annually through the Town of Yarmouth's shellfish propagation program (Caia, 2002). The Town of Yarmouth's website indicates that current propagation efforts are directed toward restoration of the bay scallop fishery, maintenance of the quahog fishery, re-establishment of historic soft shell clam beds, and re-establishment of the oyster fishery.

The proposed submarine transmission cable route crosses approximately 600 ft (183 m) of the designated recreational shellfish area in Lewis Bay that is a summer relay area for depuration of contaminated shellfish. The contaminated shellfish come from Mount Hope Bay and Fall River and are usually relayed by mid-June and need to remain in the depuration areas for one year. Recreational harvesting is permitted in these areas every other year to correspond with the schedule and cycle of the relay activities (Caia, 2002).

Privately licensed shellfish areas or grants in Lewis Bay privately farmed or managed for shellfish species are located outside the area where the proposed submarine transmission cable is routed (see Figure 4.2.2-1, Benthic Habitat Map).

Classification information on designated shellfish growing areas provided by the Yarmouth Shellfish Constable (Caia, 2002) and on MassGIS data overlays shows that the submarine transmission cable route in Lewis Bay passes through approved shellfish growing areas. The designation shifts to a conditionally approved growing area as the submarine transmission cable route approaches the Yarmouth landfall. The change in classification occurs approximately 600 ft (183 m) from the landfall location. Approved shellfish areas are described as those that allow shellfish harvest for direct human consumption according to local rules and state regulations. Conditionally approved shellfish areas are described as those that allow shellfish harvest when the area is approved as determined by shellfish availability and water quality characteristics.

### *4.2.5.5 Meiofauna and Plankton*

#### 4.2.5.5.1 Meiofauna

Meiofauna are small benthic organisms that range in size from 0.02 to 0.002 inches (0.5 to 0.045 mm). They are found in freshwater and marine environments. The term "meiofauna" refers to the size class transition from micro- to macrofauna. The International Association of Meiobenthologists recognizes 20 phyla of organisms that can be meiofaunal representatives. Of these 20 phyla, five are exclusively meiofaunal. The five phyla include *Gnathostomulida* (jaw worms), *Kinorhyncha* (small marine pseudocoelomate invertebrates), *Loricifera* (small sediment dwelling animals), *Gastrotricha* (free-living acoelomate aquatic worms) and *Tardigrada* (small segmented animals similar to arthropods) (IAM, 2006). The 15 other phyla represented, but not exclusively found, within meiofauna include the following: *Porifera, Placozoa, Cnidaria, Ctenophora, Platyhelminthes, Orthonectida, Rhombozoa, Cycliophora, Acanthocephala, Nemertea, Nematomorpha, Nematoda, Rotifera, Entoprocta, Priapulida, Pogonophora, Echiura, Sipuncula, Annelida, Arthropoda, Onychophora, Mollusca, Phoronida, Bryozoa, Brachiopoda, Echinodermata, Chaetognatha, Hemichordata and Chordata* (IAM, 2006).

Given the small size of these organisms, they are seldom a part of general environmental surveys performed for environmental assessments of proposed actions and are seldom part of resource management activities. However, they can number in the ten to hundreds of thousands per $m^2$ in soft sediments, have reproductive mechanisms that allow them to survive in mobile sand sediments often found in shallow marine environments, and in certain instances, experience large seasonal fluctuations in abundance. For purposes of impact analysis (see discussion in Section 5.3.2.5), previous characterizations of the meiofauna (e.g., Theroux and Wigley, 1998) in the region that includes the area of the proposed action were taken into consideration.

#### 4.2.5.5.2 Plankton

Review of scientific literature suggests there is little existing information that describes plankton communities in Nantucket Sound. Plankton refers to plants (phytoplankton) and animals (zooplankton) that cannot maintain their distribution against movement of water masses and freely drift in the water column. These organisms are generally very small or microscopic, but organisms like jellyfish are sometime considered in the plankton community. Planktonic communities are generally variable in time and place, resulting in a patchy distribution. Zooplankton communities in Nantucket Sound are likely to contain copepods and euphausiids as well as other planktonic crustaceans such as amphipods and isopods. Many species of benthic invertebrates have planktonic egg and larval stages that are also considered within this community. Fish eggs and larvae from spawning of local fish populations would also be found in the Nantucket Sound plankton community, referred to as ichthyoplankton.

Red tide, a traditional but misleading name for a type of Harmful Algal Bloom (HAB), is a phenomenon that occurs when certain species of toxin-producing dinoflagellates become locally abundant. They are of concern because toxins tend to become concentrated in shellfish during HABs and may induce paralytic shellfish poisoning (PSP) in humans. In coastal New England, marine HABs are most often associated with *Alexandrium fundyense* (NOAA-CSCOR, 2006). However, the proposed Nantucket Sound site is unlikely to be the source of this type of HAB because *A. fundyense* cysts may not be retained well by relatively coarse sediments (WHOI, 2006). Dale (1976) reports that cysts from similar dinoflagellate species have settling velocities close to that of silt particles. Thus, they tend to be found in highest concentration in areas of weak currents and silt deposition. They are less likely to be found in shallow, sandy areas subject to strong tidal currents and wave action such as those found throughout the Nantucket Sound site.

### 4.2.6 Marine Mammals

#### *4.2.6.1 Introduction*

This section describes marine mammal species found in the area of the proposed action which are protected under the MMPA. Threatened or endangered marine mammals protected under the federal ESA are presented in Section 4.2.9 and in the Biological Assessment (BA) in Appendix G. The information contained in this section was obtained from literature review, agency consultations, and site investigations.

All marine mammals are protected under the MMPA (16 U.S.C. §§ 1361 *et seq.*). One duty of the MMPA is to monitor populations of marine mammals with the goal of keeping populations at optimum levels. This responsibility falls to NOAA Fisheries and FWS. If studies show a population falls below its optimum level, the population is designated as "depleted." In such case a conservation plan is developed to guide research and management actions to restore the population to healthy levels.

The MMPA also established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, and on the importing of marine mammals and marine mammal products into the United States.[13] The MMPA allows the incidental "taking" of marine mammals for certain specified activities provided the taking is of small numbers and would result in a negligible impact on marine mammals.[14] These "incidental take" authorizations, in the form of either a Letter of Authorization or an Incidental Harassment Authorization (IHA), require that either regulations or a proposed IHA be published in the Federal Register outlining the methods and geographical region of taking, the means of limiting adverse impacts on the species or stock and its habitat, and requirements for monitoring and reporting of any proposed activity. Public comments are then received on these proposed actions before NOAA Fisheries or FWS finalizes their regulations or IHA.

After initially reviewing the proposed action under consideration for the Cape Wind proposal, MMS determined that there would be a potential for the taking of marine mammals, most likely by incidental acoustic harassment, and therefore advised the applicant that the applicant should discuss seeking MMPA authorization with NOAA Fisheries. The applicant has since discussed the need for an MMPA authorization with NOAA Fisheries and has informed MMS that it intends to seek authorization under the MMPA. Therefore, MMS will require that the MMPA authorization be completed and a copy provided to MMS before activities are allowed to commence under any MMS issued lease or other authority that may result in the taking of marine mammals.

There is also a prohibition under the Endangered Species Act (ESA) for the taking of listed marine mammals without authorization known as an Incidental Take Statement (ITS). NOAA Fisheries will not issue this ESA ITS for listed marine mammal species without the applicant first obtaining authorization under the MMPA. Therefore, MMS will also require that the ESA ITS be in place before commencing any activities under MMS authorization which might result in the taking of a listed marine mammal.

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[13] The term "high seas" is defined under the U.N. Convention on the Law of the Sea to mean "…all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State."

[14] Under the MMPA, section 101(a) (5) allows the incidental, but not intentional, "taking" by U.S. citizens engaged in activities other than commercial fishing of small numbers of marine mammals if, after notice and opportunity for public comment, NOAA Fisheries Service determines that appropriate regulations have been met. The Incidental Take Authorization Office of Protected Resources – NOAA Fisheries webpage http://www.nmfs.noaa.gov/pr/permits/incidental.htm

Finally, both the MMPA authorization and the ESA ITS will include a suite of mitigation, monitoring and reporting measures meant to minimize or eliminate the potential for taking. MMS has also identified measures, as outlined in Section 9.3.5.6. These MMS measures may be similar or differ from those required under the ESA and MMPA. However, any measures contained within an MMPA or ESA authorization, if issued, that are more conservative than those measures built into this proposed action by MMS will take precedence.

**Studies Completed**

Review of scientific literature, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of protected whale species have been conducted within Nantucket Sound. A comprehensive literature search targeting protected whale, seal, and sea turtle species in Nantucket Sound and acoustical impacts to marine mammals and sea turtles was conducted to obtain information on protected marine species in Nantucket Sound and potential impacts of the proposed action to these resources. In addition, staff and researchers from the Protected Resources Branch at the NOAA Fisheries Northeast Fisheries Science Center, the Sea Turtle Stranding and Salvage Network, the Provincetown Center for Coastal Studies, and the University of Rhode Island, were contacted by the applicant to obtain additional stock assessment, sighting, stranding, and population studies information. The information gathered during this research is the best available scientific and commercial information and is used to determine the potential impacts of the proposed action in Section 5.3.2.6.

### *4.2.6.2 Resource Characterization*

Marine mammals that are protected under the MMPA (but not the ESA) and may occur in the waters of Nantucket Sound are described in the following Section 4.2.6.2.1 and 4.2.6.2.2. Threatened or endangered marine mammals protected under the federal ESA are presented in Section 4.2.9 and in the BA in Appendix G.

#### 4.2.6.2.1 Pinnipeds

A detailed evaluation was performed for two pinniped species that are most likely to occur in the vicinity of the area of the proposed action: the gray seal (*Halichoerus grypus*) and the harbor seal (*Phoca vitulina*) (Report No. 4.2.6-1). Both pinniped species are protected under the MMPA. The gray seal was previously listed as a species of special concern by the Commonwealth of Massachusetts. The Massachusetts ESA prohibits the "taking" of any rare plant or animal species listed as endangered, threatened, or of special concern by the Massachusetts Division of Fisheries & Wildlife (M.G.L c.131A and regulations 321 CMR 10.00). In addition, the harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) are discussed, as they may occur in the vicinity of the site of the proposed action and are also protected under the MMPA.

The population status and trends, seasonal distribution, food and feeding behaviors, and known disturbance and mortality factors are described below, and impacts are discussed in Section 5.3.2.6. Detailed discussions of the potential impacts of Project construction/decommissioning and operation/maintenance to gray and harbor seals can be found in the Pinniped Assessment (Report No. 4.2.6-1).

**Gray Seal (*Halichoerus grypus*)**

The Western population of the gray seal extends from New England to Labrador and is centered in the Sable Island area of Nova Scotia and breeds primarily at Sable Island and on pack ice in the Gulf of Saint Lawrence (NMFS, 2001). Gray seals inhabit temperate and sub-arctic waters, and, in the United States are found along the east coast from Maine to Long Island Sound, New York living on remote, exposed islands, shoals and unstable sandbars. They are relatively large, and may be gray, dark brown or even black in colorings with irregular spotting patterns. Gray seals can live as long as 30 to 40 years, with males reaching sexual maturity around six years and females at three years. While breeding, gray seals may live in loose colonies but generally are gregarious with no regular migratory seasons or patterns. Gray seals have an extensive fish diet, and forage at depths up to at least 230 ft (70 m) (Katona et al., 1993).

Gray seals have two known breeding and pupping grounds in Nantucket Sound at Monomoy and Muskeget Islands (approximately 12 miles [19.4 km] and 8 miles [13 km], respectively, from the proposed action area). Though Monomoy and Muskeget Islands have been identified as habitat for year-round breeding populations (Waring et al., 2006), winter and spring use of these areas is highest (NHESP, 2002). Gray seals presently use Muskeget Island and Monomoy National Wildlife Refuge within Nantucket Sound as an area to give birth and raise their pups. Since there is no defined migratory behavior for gray seals, a large portion of the population may be present in Nantucket Sound year-round, although the actual numbers are not as plentiful as harbor seals. Generally, there is some adult seal movement north during spring and summer out of Nantucket Sound to the waters of Maine and Canada for pupping, as seen with harbor seals (Waring et al., 2006).

The gray seal is protected under the MMPA but is not considered a strategic stock[15] (Waring et al., 2006). Available data are insufficient to estimate the size of the entire western North Atlantic gray seal population, but estimates are available for the Sable Island, Maine coast and Muskeget and Monomoy Island populations (NMFS, 2001). The Muskeget and Monomoy population was estimated at 2,010 in the spring of 1994 (Rough, 1995) and rose to 5,611 by the spring of 1999 (Barlas, 1999). Gray seal counts from winter/spring in 2002 at Monomoy, Muskeget, and Tuckernuck Islands in Nantucket Sound (approximately 14.6, 8.5, and 10.5 miles [23.5, 13.7, and 16.9 km] respectively from the proposed action site) showed 1,599, 16, and 1,192 individuals respectively (Wood, unpublished data). Incidental observations of seals were recorded during avian surveys which were conducted independently by both the proposed action team and the Massachusetts Audubon Society (MA Audubon). While these surveys are not direct observations of seals in the proposed action area and Nantucket Sound, they are used here to present a general overview of the presence of seals in the vicinity of the proposed action. Between May 2002 and February 2004 the proposed action team conducted approximately 47 aerial avian surveys in Nantucket Sound, with particular focus in the area of the proposed action. During the three years of surveys, approximately 26,873 seals were observed throughout Nantucket Sound; however the seals were not identified to the species level. Between June 2003 and April 2005, MA Audubon conducted 55 aerial avian surveys to observe tern breeding and migration patterns and winter waterfowl activities in Nantucket Sound, with specific attention paid to the proposed action area. A three-year total of approximately 396 seals were incidentally observed during these surveys throughout Nantucket Sound, with more heavy concentrations near the Muskeget and Monomoy Island breeding colonies, rather than concentrated in the approximate area of the proposed action.

While little is officially known about the natural causes of mortality for gray seals, major causes of human-induced mortality include marine pollution, habitat destruction, and commercial fishery-related drowning. For the period 2001 to 2004, the total estimated human caused mortality and serious injury to gray seals was 371 per year, of which 228 deaths are attributable to U.S. fisheries (specifically the Northeast multispecies sink gillnet fishery). Between 2001 and 2004, 279 gray seal strandings were recorded, extending from Maine to North Carolina (Waring et al., 2007). In 2004 alone there were 100

[15] Under the MMPA, the term “strategic stock” means a marine mammal stock - (A) for which the level of direct human-caused mortality exceeds the potential biological removal level; (B) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA of 1973 within the foreseeable future; or (C) which is listed as a threatened species or endangered species under the ESA of 1973 (16 U.S.C. 1531 et seq.), or is designated as depleted under this Act.

recorded strandings, ten of which showed signs of human interaction as a cause of mortality, (i.e., fishery interactions, power plant entrainments, oil spills, shooting, boat strikes, and other sources) (Waring et al., 2007). Of the total strandings, 154 were reported to occur in Massachusetts (Waring et al., 2007). During the period of September 2005 through August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 30 gray seal strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

**Harbor Seal (*Phoca vitulina*)**

Harbor seals (*Phoca vitulina*), or the common seal, are found in the northern Atlantic Ocean and adjoining seas above 30$^{o}$N (Waring et al., 2007), and is the most abundant pinnipeds on the east coast of the United States. Harbor seals commonly occur in coastal waters and coastal islands, ledges and sandbars. Harbor seals can be identified from its short, concave muzzle, which has a slightly upturned tip, and a broad V-shaped nostril. In addition, the eye of the harbor seal is equidistant between the nose and the ear opening. Harbor seals range in color from bluish gray with small dark spots to tan, brown, black or even reddish in color. Maturity is reached at five to six years for males and three to four years for females, and they have been known to live as long as from 30 to 40 years (Katona et al., 1993). Most of the harbor seal's diet consists of fish and invertebrates found within the Nantucket Sound area, but during late summer months they move offshore to deeper waters presumably for offshore fish migrations.

Harbor seals spend the late spring, summer, and early fall between New Hampshire and the Arctic where they breed and care for newly born pups. A general southward movement from the Bay of Fundy to southern New England waters occurs in fall and early winter, mostly consisting of juveniles and young adults. After overwintering in southern New England waters, including Nantucket Sound, the vast majority of the population migrates in the spring to northern waters for pupping season. No pupping areas have been identified in southern New England. While the greatest summer concentrations of harbor seals area long the coast of Main, harbor seals can occur year round in waters around Cape Cod and Nantucket Sound (Payne and Selzer, 1989).

The harbor seal is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2007). The best estimate of abundance for harbor seals is 99,340 based on surveys performed along the Maine Coast in May and June of 2001 (Waring et al., 2007).

While little is officially known about the natural causes of mortality for harbor seals, major causes of human-induced mortality include marine pollution, habitat destruction, and fishery-related drowning. For the period of 2001 to 2005, it is estimated that 893 harbor seals were killed or seriously injured each year in relation to human activities, mainly due to fishery practices, boat strikes, power plant entrainment, shooting, and loss of habitat (Waring et al., 2007). The total estimated average fishery-related mortality or serious injury in the by commercial fisheries, including the Northeast Sink Gillnet, Mid-Atlantic Gillnet and Northeast Bottom Trawl the period of 2001 to 2005 was 882 harbor seals (Waring et al., 2007). During the period 2001 to 2005 there were 1,717 recorded strandings of harbor seals along the U.S. Atlantic coast, with 503 strandings recorded in Massachusetts (Waring et al., 2007), the strandings may be attributed to vessel strikes, fishing gear entanglement, entrainment in power plant intakes, oils spills, storms, abandonment, and disease. Between 2002 and 2003, a total of 217 harbor seal strandings were reported in Massachusetts (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 45 harbor seal strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

**Harp Seal (*Phoca groenlandica*)**

Harp seals (*Phoca groenlandica*) occur throughout much of the north Atlantic and Arctic Oceans (Waring et al., 2007). Adult harp seals have a gray coat, and females are typically larger than males. Males may reach maturity between 4 and 5 years, while a female reaches sexual maturity at 6 to 7 years old. They can live to be 30 to 35 years old, feeding off of fish and crustaceans. They tend to be gregarious, living in dense groups during breeding season.

The harp seal has been sighted in winter and spring months at the extreme southernmost reaches of its range from mid-Atlantic waters through New England (Waring et al., 2007). The largest of three stocks of harp seals is the eastern Canadian stock, with breeding herds off the coasts of Newfoundland and Labrador, and in the Gulf of St. Lawrence. The other two stocks occur off the coasts of the former Soviet Union and Greenland.

The harp seal is protected under the MMPA but is not considered a strategic stock (Waring et al., 2007). A variety of methods are used to estimate harp seal population sizes including aerial surveys and mark-and-recapture surveys (Waring et al., 2007). The best estimate of the North Atlantic harp seal population based on modeling from the surveys is 5.9 million individuals (Waring et al., 2007).

The estimated annual human caused mortality rate for harp seals for the period 2001 to 2005 was 447,442 individuals (Waring et al., 2007). There were 447,365 recorded deaths from Canadian based fishery related incidental catch and 73 from U.S. observed fisheries (Waring et al., 2007). During the period 2001 to 2005 there was a total of 816 recorded standings along the U.S. Atlantic coast, with 396 strandings recorded in Massachusetts (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 25 harp seal strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

**Hooded Seal (*Cystophora cristata*)**

The hooded seal (*Cystophora cristata*) occurs throughout much of the north Atlantic and Arctic Oceans, in deeper water than other seals are typically found. Hooded seals have a black face and a bluish-grey coat, lighter on the sides and front, with irregular dark patches scattered over the body and the males have a distinguishable inflatable crest on their forehead. Males reach maturity at five to seven years and females reach maturity at three to six years, with life expectancies of 30 to 35 years of age. Hooded seals feed in deeper waters, and their diet consists of fish and larger invertebrates. Hooded seals are highly migratory, and have been occasionally sighted as far south as Puerto Rico. In recent years, they have been sighted with increasing frequency in waters from Maine to Florida, in the winter and spring months, especially from January to May (Waring et al., 2007).

The hooded seal is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2007). Two stocks occur in the northwest Atlantic; one stock has breeding grounds in the Davis Straight off of Newfoundland, and the second stock has breeding areas off the coast of Newfoundland and the Gulf of St. Lawrence. Surveys of these areas were conducted in 2005 to estimate the total population of hooded seals. Total pup production in the Northwest Atlantic was 116,900 (Waring et al., 2007). Using pup production estimates and making assumptions about the life histories of hooded seals, results in an estimated population size of 592,100 individuals in 2005 (Waring et al., 2007).

For the period 2001 to 2005 the total estimated human-caused mortality of hooded seals is 5,199 (Waring et al., 2007). The average annual estimated fishery-related mortality or serious injury to this stock in U.S. waters for the period of 2001 to 2005 is 25 hooded seals (Waring et al., 2007). Incidental bycatch of hooded seals has been observed in the Northeast multispecies sink gillnet fishery, and resulted in an estimated 25 deaths (Waring et al., 2007). Commercial harvest of hooded seals is not allowed in the Gulf of St. Lawrence (below 50°N) and in the Davis Strait (Waring et al., 2007). For the period 2001 to 2005 there was a total of 138 recorded strandings in U.S. waters, with 53 occurring in Massachusetts waters (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 10 hooded seal strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

#### 4.2.6.2.2 Cetaceans

The population status and trends, seasonal distribution, food and feeding behaviors, and known disturbance and mortality factors for those cetacean species that can be found in the vicinity of the area of the proposed action are summarized below.

**Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)**

The Atlantic white-sided dolphin (*Lagenorhynchus acutus*) occurs in temperate and polar waters in the North Atlantic, typically around the continental shelf to the 100 m (328 ft) isobath. These animals have black coloring on their dorsal side, with a yellow stripe on their lower dorsal area. Females reach sexual maturity at between 6 and 12 years, and males between 7 and 11 years. Individuals are known to live for up to 22 years (males) and 27 years (females). Their main diet consists of fish such as herring and mackerel and squid (Minasian and Balcomb, 1984; Leatherwood et al., 1982; Ellis, 1982).

In the western North Atlantic, Atlantic white-sided dolphins are believed to form three stocks, the Gulf of Maine stock, the Gulf of St. Lawrence stock, and the Labrador Sea stock. The Gulf of Maine stock ranges from Hudson Canyon to Georges Bank and in the Gulf of Maine to the Bay of Fundy (Waring et al., 2007). Atlantic white-sided dolphins of the Gulf of Maine Stock may occur in Nantucket Sound throughout the year but in higher numbers from June until September.

The Atlantic white-sided dolphin is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2007). The best available estimate for the abundance of the Gulf of Maine stock of white-sided dolphins is 17,594 individuals based on aerial surveys conducted in August 2006 from the Southern Gulf of Maine to the upper Bay of Fundy to the Gulf of St. Lawrence (Waring et al., 2007).

The total U.S. fisheries-related mortality estimate to the Gulf of Maine stock of the western Atlantic white-sided dolphin for the period of 2001 to 2005 was 350 dolphins (Waring et al., 2007). Incidental bycatch has been observed in the Northeast sink gillnet fishery, the mid-Atlantic coastal gillnet fishery, the pelagic drift gillnet fishery, the North Atlantic bottom trawl fishery, and the Atlantic squid, mackerel, and butterfish trawl fisheries (Waring et al., 2007). During the period 2001-2005, there were a total of 277 strandings recorded in U.S. waters, with a total of 222 strandings recorded in Massachusetts alone (Waring et al., 2007). Mass strandings of Atlantic white-sided dolphins are common and may involve over 100 animals (Waring et al., 2007). Several mass strandings have occurred in Massachusetts waters in April 2001 (6 animals), March 2002 (31 animals), January 2003 (4 animals), April 2003 (28 animals), November 2003 (4 animals), February 2005 (8 animals) April 2005 (6 animals), May 2005 (2 animals) and December 2005 (2 animals) (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 60 Atlantic white-sided dolphin strandings on the shores of Cape Cod and on the south coast of Massachusetts (CCSN Annual Report, 2006).

### Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin (*Stenella coeruleoalba*) is distributed worldwide in temperate, tropical, and subtropical seas. They are distinguishable with their pink underside, and bands that run down their dorsal side. Adults may grow to 8 ft (2.4 m) (females) or 8.5 ft (2.6 m) (males) and weigh 330 lbs (150 kg) (female) or 350 lbs (160 kg) (male). Striped dolphins reach maturity between 7 and 12 years, and may live to between 55 and 60 years. Their main diet is small pelagic fish and squid.

In the western North Atlantic, striped dolphins occur from Nova Scotia south into the Caribbean and the Gulf of Mexico, frequently in continental shelf waters along the 3, 281 ft isobaths (1,000 m) (Waring et al., 2007).

The striped dolphin is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2007). The best available estimate based on a June to August 2004 survey for the abundance of the North Atlantic striped dolphin is 94,462 for the entire eastern U.S. and Canadian coast, and 52,055 individuals from Maryland to the Bay of Fundy (Waring et al., 2007).

From 2001 to 2005 there were no reported fisheries-related mortalities of striped dolphins (Waring, et al., 2007). Incidental bycatch has been observed in the pelagic drift gillnet fishery and the North Atlantic bottom trawl fishery, but no mortalities or serious injuries have recently been documented in any U.S. fishery (Waring et al., 2007). From 2001 to 2005, 51 striped dolphins were found stranded in U.S. waters from Maine to Florida for unknown reasons (Waring et al., 2007).

### Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin (*Delphinus delphis*) is distributed worldwide in temperate, tropical, and subtropical seas. Their back is dark gray-to-black from the top of the head to the tail. Common dolphins can reach lengths from 7.5 to 8.5 ft (2.3 to 2.6 m) and weigh as much as 297 lbs (135 kg). They travel in small groups and frequently gather into large schools. Sexual maturity is reached at three to four years of age or when they reach 6 to 7 ft in length (1.8 to 2.1 m). The common dolphin feeds on squid and small schooling fish (Evans, 1994; Heyning and Perrin, 1994; Klinowska, 1991).

In waters off the northeastern United States., short-beaked common dolphins are associated with Gulf Stream features and are widespread from Cape Hatteras to Georges Bank over the 656 to 6,561 ft (200 to 2,000 m) isobaths (Waring et al., 2007). The short-beaked common dolphin migrates onto Georges Bank, the Scotian Shelf, and the continental shelf off Newfoundland in summer and autumn months.

The short-beaked common dolphin is protected under the MMPA and is considered a strategic stock (Waring et al., 2007). The best estimate from August 2006 for the abundance of the short-beaked common dolphin off the U.S. and Canadian Atlantic coasts is 84,000 (Waring et al., 2007).

The total annual fisheries-related mortality estimate for the period of 2001 to 2005 was 151 short-beaked common dolphins (Waring et al., 2007). Incidental bycatch was been observed in the pelagic drift gillnet fishery, the pelagic pair trawl, the pelagic longline fishery, the mid-Atlantic coastal gillnet fishery, the North Atlantic bottom trawl fishery, the Northeast multi-species sink gillnet fishery, and the Atlantic squid, mackerel, and butterfish trawl fisheries (Waring et al., 2007). During the period of 2001 to 2005, 323 short-beaked common dolphin strandings were reported in United States from Maine to Florida (Waring et al., 2007). Mass strandings waters occurred within Massachusetts in 2002 (9 dolphins) and 2005 (7, 5, 25 and 4 dolphins) (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 130 short-beaked common dolphin strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

### Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise (*Phocoena phocoena*) is primarily an inshore species. They are small rotund cetaceans, with grey coloring. They reach a maximum length of 6 ft (1.9 m) and do not weigh more than 130 lbs (60 kg). Harbor porpoises reach sexual maturity around three to four years. They can live alone, in pairs, or in larger groups. Their main diet is small spine-less fish (Minasian and Balcomb, 1984; Ellis, 1984; Leatherwood et al., 1982).

During the summer, harbor porpoises are concentrated in the northern Gulf of Maine and the southern Bay of Fundy region, generally in waters less than 492 ft (150 m). This stock of harbor porpoises, which migrates south into the mid-Atlantic region, is considered one population, separate from three other distinct populations in the Gulf of St. Lawrence, Newfoundland, and Greenland areas (Waring et al., 2007). During fall and spring months, harbor porpoises are widely distributed from New Jersey to Maine. Low densities of harbor porpoises are found in waters off New York and north to Canada in the winter. No specific migratory routes to the Gulf of Maine/Bay of Fundy region have been identified.

The harbor porpoise is protected under the MMPA, and is considered a strategic stock (Waring et al., 2007). The best estimate for the abundance of the Gulf of Maine/Bay of Fundy population is 89,504 harbor porpoises, based on surveys performed in August 2006 from the Southern Gulf of Maine to the upper Bay of Fundy to the Gulf of St. Lawrence (Waring et al., 2007).

The total annual estimated average human-caused mortality for harbor porpoises is 734 per year (Waring et al., 2007). The average annual mortality for the period of 2001 to 2005 was estimated at 652, attributable to U.S. fisheries (Waring et al., 2007). Mortality has occurred in the U.S. Northeast sink gillnet fishery, the mid-Atlantic coastal gillnet fishery, and in the Canadian Bay of Fundy groundfish sink gillnet and herring weir fisheries. Other human-induced mortality may occur from hunting in some areas of the western North Atlantic. During the period of 2001 to 2005, 604 harbor porpoise strandings were reported from Maine to North Carolina, 218 of which occurred in Massachusetts (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 20 harbor porpoise strandings on the shores of Cape Cod and on the south coast of Massachusetts (CCSN Annual Report, 2006).

### Long-finned Pilot Whale (*Globicephala melas*)

The long-finned pilot whale (*Globicephala melas*) occurs along the edge of the U.S. continental shelf in the winter and early spring. A second species of pilot whale, the short-finned pilot whale (*Globicelphala macrorhynchus*), also occurs in the western North Atlantic. Difficulty distinguishing the two species in the field prevents separate abundance and mortality estimates. They are generally dark colored, with a distinguishable rounded head. The males are larger than the females reaching 20 ft (6.1 m) while females typically measure 16 ft (4.9 m). Males may reach sexual maturity at about 12 years of age and females reach sexual maturity at about 6 to 7 years of age. Pilot whales typically feed on squid, but have been known to feed on fish (Bernard and Reilly, 1999; Olson and Reilly, 2002).

The long-finned pilot whale primarily occurs north of mid-Atlantic waters. Distribution of this species is widespread, ranging from North Carolina to Africa and north to Iceland, Greenland, and the Barents Sea (Waring et al., 2007). Further stock definition is under development.

The long-finned pilot whale is protected under the MMPA, and is currently considered a strategic stock (Waring et al., 2007). The best available estimate based on 2006 aerial surveys for the abundance of both pilot whale species in the Western North Atlantic is 26,535 individuals (Waring et al., 2007).

The average annual fisheries-related mortality estimate for the period of 2001 to 2005, including both species, is 7 pilot whales (Waring et al., 2007). Incidental bycatch has been observed in the pelagic drift gillnet fishery, the pelagic longline fishery, the pelagic pair trawl fishery, the North Atlantic bottom trawl fishery, the squid, mackerel, and butterfish trawl fisheries, and the Nova Scotia trawl fisheries. Mass strandings are common in pilot whales; during the period of 2001 to 2005, 139 long-finned pilot whales were stranded between Maine and Florida, including two mass strandings in Massachusetts waters of 11 and 57 animals in 2000 and 2002 respectively (Waring et al., 2007). While the causes for these strandings are uncertain, there are several hypothesized causes including changes in the earth's magnetic fields, exposure to pollution and toxins through bioaccumulation. During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 20 pilot whale strandings on the shores of Cape Cod and on the south coast of Massachusetts, (CCSN Annual Report, 2006).

**Minke Whale (*Balaenoptera acutorostrata*)**

Minke whales (*Balaenoptera acutorostrata*) occur throughout polar, temperate, and tropical waters. The minke is counter-shaded-black to dark gray on top, white below. They are a small species, males averaging 26 ft (8 m) and females measuring 27 ft (8.2 m). Sexual maturity is reached at 7 or 8 years. Minke whales feed on small schooling fish and some copepods (Minasian and Balcomb, 1984; Ellis, 1982; Leaterwood and Reeves, 1983).

The minke whale is the third most abundant great whale in the U.S. Atlantic Exclusive Economic Zone (EEZ) (CeTAP, 1982). Minke whales off the east coast of the U.S. are part of the Canadian east coast population, one of four minke populations recognized in the North Atlantic. The range of this population extends south from Canada to the Gulf of Mexico, but distribution is primarily concentrated in New England waters, with most sightings occurring during spring and summer months.

The minke whale is protected under the MMPA, but is not considered a strategic stock (Waring et al., 2007). The best available current abundance estimate for minke whales based on aerial surveys performed off the Canadian Coast from the Gulf of Maine to the Gulf of St. Lawrence in 2006 is 3,312 whales (Waring et al., 2007). This species is found in open seas primarily over continental shelf waters, but occasionally enters bays, inlets, and estuaries.

Minke whale incidental catches have been observed in U.S. waters in the mid-Atlantic coastal gillnet fishery, the Gulf of Maine and mid-Atlantic lobster trap/pot fishery, and the Atlantic tuna purse seine fishery. Not all incidental catches have resulted in mortality. The annual mortality estimate from these human interactions for the period of 2001 to 2005 is 2.6 minke whales per year, with 2.2 deaths attributable to U.S. fishery-related incidents (Waring et al., 2007). Other human-induced mortality occurs from hunting in some areas of the North Atlantic, and from collisions with vessels, although during the period of 1999 to 2003 no collisions were reported, however there was one report of vessel strike in each of the years 2004 and 2005 (Waring et al., 2007). During October 2003 an 'Unusual Mortality Event' was declared, when an abnormal increase in minke whale mortalities was reported; from September 11 to September 30, nine minke whales were found stranded with no known causes (Waring et al., 2007). Since then the number of minke whale mortalities has returned to previous levels. During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 1 minke whale stranding on the shores of Cape Cod and on the south coast of Massachusetts (CCSN Annual Report, 2006).

**Atlantic Spotted Dolphin (*Stenella frontalis*)**

Atlantic spotted dolphins (*Stenella frontalis*) are distributed in tropical and warm temperate waters of the western North Atlantic. There are two species of spotted dolphin in the Atlantic Ocean, the Atlantic spotted dolphin and the pantropical spotted dolphin (*S. attenuata*) (Waring et al., 2005). They are covered in spots, are typically dark colored with a darker dorsal then ventral side. They average 7 ft (2.1 m) in length, and reach maturity at 6 to 8 years. They are highly social and can be found in large herds numbering in the hundreds or sometimes thousands. Spotted dolphins feed on a variety of fish and squid found near the surface (Minasian and Balcomb, 1984; Leatherwood and Reeves, 1983).

The Atlantic spotted dolphin occurs in two forms, possibly two sub-species; the large, heavily spotted form inhabits the continental shelf and is usually found inside or near the 656 ft (200 m) isobath, and the smaller, less spotted island and offshore form (Waring et al., 2005). The Atlantic spotted dolphin is found from Southern New England to Venezuela, and is widely distributed on the continental shelf, along the continental shelf edge, and offshore over the deep ocean off the northeast U.S. coast (Waring et al., 2005).

The Atlantic spotted dolphin is protected under the MMPA but is not considered a strategic stock (Waring et al., 2005). The best available estimated population size for the Atlantic spotted dolphins from Maryland to the Bay of Fundy, including both forms, is 3,578 individuals, while the estimates of the population from Florida to the Bay of Fundy is 50,978 individuals (Waring et al., 2005). Given their distribution range, it is possible that Atlantic spotted dolphins may occur in Nantucket Sound.

There were no reports of fishery-related mortality or serious injury to the Atlantic spotted dolphin during 1999 and 2003 (Waring et al., 2005). Incidental bycatch has recently been observed in the pelagic drift gillnet fishery, the pelagic longline fishery, the pelagic pair trawl fishery, the North Atlantic bottom trawl fishery, the squid, mackerel, and butterfish trawl fisheries, and the Nova Scotia trawl fisheries. During the same period, 17 Atlantic spotted dolphins were stranded between Massachusetts and Florida (Waring et al., 2005). None of these strandings had evidence of human interaction.

**Risso's Dolphin (*Grampus griseus*)**

Risso's dolphin (*Grampus griseus*) has a worldwide distribution in tropical to warm temperate waters. They are robust with a rounded head, and typically have a light gray coloring. They typically grow to 10 ft (3 m) in length, and males tend to be a little smaller than females. Little is known regarding their life history traits, but maturity is assumed when the animal reaches 8.5 to 9.2 ft (2.6 to 2.8 m) in length. They tend to travel in groups, which may consist of related animals. Their main diet is squid, but they may feed on a variety of fish species (Ellis, 1982; Klinowska, 1991).

Risso's dolphin generally has an oceanic range, and occurs along the Atlantic coast of North America from Florida to eastern Newfoundland. Risso's dolphins are distributed along the continental shelf edge of the U.S. east shore from Cape Hatteras northward to Georges Bank during the spring, summer and autumn (Waring et al., 2007). In winter, their range begins at the Mid-Atlantic bight and extends further into oceanic waters. In general, the population occupies the mid-Atlantic continental shelf edge year-round, and is rarely seen in the Gulf of Maine (Waring et al., 2007).

Risso's dolphins is protected under the MMPA, but are not considered as strategic stocks (Waring et al., 2007). The best available estimate of Risso's dolphins, from Maryland to the Bay of Fundy, is 15,053 individuals, while the best available estimate for the entire eastern coast is 20,479 individuals (Waring et al., 2007). Given their distribution range, it is possible that Risso's dolphins may occur in Nantucket Sound.

During the period of 2001 through 2005 the total annual estimated average fishery-related mortality or serious injury was three Risso's dolphins (Waring et al., 2007). Incidental bycatch has been observed in the pelagic drift gillnet fishery, and the pelagic longline fishery both in and out of the Northeast Distant water (Waring et al., 2007). From 2001 to 2005, 65 Risso's dolphin strandings were reported, 18 of which were reported in Massachusetts (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 5 Risso's dolphin strandings on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

**Kogia species (*Kogia sima and K. breviceps*)**

The dwarf sperm whale (*Kogia sima*) and the pygmy sperm whale (*K. breviceps*) are distributed worldwide in temperate to tropical waters. They are very difficult to distinguish at sea, and are often categorized as *Kogia sp*., as in this report. Sightings of *Kogia sp.* occur in all oceanic waters, including the North Atlantic (Waring et al., 2007). They are stocky animals, reaching average lengths of 10 ft (3 m) and typically have grayish coloring. Males mature at 9 to 10 ft (2.7 to 3 m) while females mature at 8 to 9 ft (2.6 to 2.7 m). They typically form small groups, and are slow swimmers. Their diet consists of mainly squid and octopus, but may also include crab, fish, and shrimp (Katona 1993; Leatherwood and Reeves, 1983).

Both of the *Kogia sp*. are protected under the MMPA, and neither are considered a strategic stock in the Western North Atlantic (Waring et al., 2007). The best estimate for *Kogia sp*. from northern Western Atlantic is 358 individuals, while the entire U.S. Atlantic surveys showed 935 individuals (Waring et al., 2006).

During 2001 and 2005 the total annual estimated average fishery-related mortality and serious injury to the dwarf sperm whale and pygmy sperm whale were zero (Waring et al., 2007). Incidental bycatch has been observed in the pelagic longline fishery. From 2001 to 2005 there were 30 reported strandings of the dwarf sperm whale, only 1 of which occurred in waters of Massachusetts (Waring et al., 2007). There were 51 strandings reported of pygmy sperm whales from Maine to Puerto Rico, only 1 of which occurred in waters of Massachusetts (Waring et al., 2007). In addition, there were 11 strandings documented as *Kogia sp.* during the period of 2001-2005 (Waring et al., 2007). During the period of September 2005 to August 2006, the Cape Cod Stranding Network (CCSN) reported approximately 1 pygmy sperm whale stranding on the shores of Cape Cod and on the south coast of Massachusetts, with the major cause attributed to entanglement in marine debris and boat strike (CCSN Annual Report, 2006).

### 4.2.7 Fish and Fisheries

In the Nantucket Sound area, managing or monitoring of fishery resources is conducted by both Federal and state agencies. NOAA Fisheries manages recreational and commercial fishing activities in coastal states in the United States. The New England Fisheries Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC), established by the Magnuson-Stevens Act, manage various fishery resources within the Federal fishery conservation zone in the Nantucket Sound area. The Atlantic States Marine Fisheries Council coordinates the management actions of many coastal states for species that occur in near-coastal waters, including striped bass, American lobster, and others. The Commonwealth of Massachusetts monitors fishery resources in its coastal waters mainly through the activities of MassDMF.

The following section describes existing fisheries resources that occur within the area of the proposed action. Information was obtained from agency monitoring programs, consultations, literature reviews, and site investigations. While shellfish are considered under fisheries because of their linkage with commercial and recreational harvesting of seafood, their life histories, habitat occurrences, and potential impacts are closely aligned with benthic species habitats and are discussed also in Section 4.2.5.

### 4.2.7.1 Demersal and Pelagic Fish

This section presents a description of fish species including expected seasonal occurrence in Nantucket Sound and the area of the proposed action. Review of the scientific literature indicates that few studies related to fishery resources have been conducted specifically in the proposed action locale in Nantucket Sound and Lewis Bay. Data available from studies conducted by NOAA Fisheries, MassDMF, and others were reviewed and evaluated regarding their applicability to the proposed action.

NOAA Fisheries collects data that are "fishery independent" with a bi-annual bottom research trawl survey program; however, the surveys occur offshore of Nantucket Sound and are therefore not useful in characterizing the fishery resources for the area of the proposed action. (As described below, however, MassDMF conducts research trawl surveys in waters under state jurisdiction, including Nantucket Sound, and these surveys are integrated with the NOAA Fisheries bottom research trawl survey database.) In addition, NOAA Fisheries collects information on commercial fish catches, as defined by discrete statistical reporting zones. NOAA Fisheries also identifies and designates EFH for marine species in the United States as part of their responsibility to manage the fish resources of coastal waters. In the Northeast region, NOAA Fisheries works with the New England Fishery Management Council (NEFMC) and also the Mid-Atlantic Fishery Management Council (MAFMC) in defining essential fish habitat for key species that occur in the coastal New England waters, including Nantucket Sound. Detailed source documents were used to describe life history stages for each species and habitat that is necessary for survival of each life history stage. The source documents also provide information on ecology, basic biology, and species behavior such as spawning, migratory behavior and food preference. This information was used with literature and field data collected by the applicant in preparing the EFH Assessment that is found in Appendix H of this document.

MassDMF is involved in studying the basic biology and ecology of anadromous fish species, tautog, northern shrimp, lobster, and recreational fish species, including big game species, sharks, bluefin tuna, and striped bass in state waters. MassDMF performs bi-annual research trawl surveys for the collection of fishery-independent information related to the distribution and abundance of fish and invertebrates in Massachusetts' waters (including both state and Federal waters in Nantucket Sound). These trawl surveys have been on-going in May (spring) and September (fall) each year since 1978. The results of the trawl surveys are compiled with the results of offshore NOAA Fisheries research trawl surveys. State and federal research trawl data is analyzed to understand population structure, stock status, and the geographic distribution of fish and shellfish along the Eastern Seaboard of the United States.

The MassDMF research trawl survey dataset was used to provide an overview of the occurrence of fishery resources in the area of the proposed action, including the identity of species and their frequencies of occurrence in research trawls during a 30-year period. The research trawl program was not designed for the statistical testing of similarities or differences in fish abundance or distribution between specific sites, however. Further, survey timing does not permit the surveys to adequately represent fish distribution and abundance over an entire year. Survey timing coincides with the seasons when juveniles or adults are present in inshore areas. The survey's gear type (otter trawl) and methods are more effective for collecting semi-pelagic and demersal fish species; thus, analyses evaluating species occurrence may not represent accurate distribution and abundance for pelagic species.

Research trawl data during 1978 to 2007 were obtained from MassDMF for all of Nantucket Sound. In Nantucket Sound, trawl data typically is collected for 10 randomly sampled tows for "strata 15" (0 to 30 foot depths) and 11 randomly sampled tows for "strata 16" (31 to 60 foot depths). Data fields include species, pounds, and catch number. Size composition data were not requested. Both juvenile and adult lifestages are collected using this method.

This analysis provides information for a general assessment of species occurring in Nantucket Sound and on Horseshoe Shoal in the months of May and September based on data collected over a period of 30 years. The actual number of randomly sampled tows varies from year to year depending upon weather conditions and other factors, so it is not straightforward to use measures of weight or catch number as an index of catch per unit effort. After correcting for factors affecting research trawl effort, estimates of catch per unit effort from 1990 through 2002 were calculated for the site of the proposed action at Horseshoe Shoal (Report No. 4.2.7-1).

Between 1978 and 2007, 120 species were recorded in the bi-annual resource trawl data set for Nantucket Sound. Over the 27-year period, surveys conducted in the spring collected 74 species, and surveys conducted in the fall collected 103 species. For each species sampled in both the fall and the spring, fall catch numbers tend to be higher than spring catch numbers (see the individual entries in Tables 4.2.7-1 and 4.2.7-2). For each species sampled in both the fall and the spring, fall catch weights tend to be lower than spring catch weight numbers (see the individual entries in Tables 4.2.7-3 and 4.2.7-4).

Nantucket Sound supports a diverse fish community. Off the east coast of Cape Cod, a temperature gradient forms during summer months, setting a boundary so that colder water fish occur to the north and warmer water fish occur to the south (Freeman and Walford, 1974). This temperature gradient fluctuates north and south over an area of 20 to 40 miles (32 to 64 km) along the Cape Cod shoreline. Due to the presence of the temperature gradient along Cape Cod and its geographic location, Nantucket Sound serves as a migratory pathway for some warm-water species as they move into Cape Cod Bay and Massachusetts Bay. The Nantucket Sound area also is a northern border for some summer migrant species, including black sea bass, northern fluke, and scup.

Some fish species that have been observed in Nantucket Sound exhibit migratory behavior and are known to move in and out of areas when there are changes in water temperature. In winter and early spring, some fish species are known to concentrate on shoal areas in Nantucket Sound for spawning or feeding, and some move from the shoal areas to deeper water or channel areas. The winter flounder is a species that is known to move from shoal areas to deeper water and channel areas in summer months when shallower water in the shoal areas has warmer water temperatures. In fall, when the water temperatures start to cool, winter flounder are known to move back to shoal areas. Thus, in spring when water temperatures are cool, winter flounder are likely to be more common than in September when water temperatures remain warmer.

Tables 4.2.7-5 and 4.2.7-6 present for each species the percent occurrence, mean weight (pounds) per tow, mean numbers of fish per tow, and the number of annual cruises (maximum of 30) in which a species was observed. The species are arranged in descending order by percent occurrence. (Percent occurrence is defined as the proportion of all tows during the 30-year period in which a particular species is observed.) As observed in the fall tows (Table 4.2.7-5), longfin squid, scup, butterfish, black sea bass, spider crab, smooth dogfish, lady crab, northern searobin, summer flounder, little skate, and knobbed whelk exhibit the highest percent occurrences (above 50 percent), mean numbers per tow, and weights per tow. Bay and striped anchovies also exhibit high numbers per tow. As observed in the spring tows (Table 4.2.7-6), longfin squid, spider crab, winter flounder, windowpane flounder, little skate, Atlantic rock crab, Northern searobin, winter skate, summer flounder, channeled whelk, Atlantic cod, and knobbed whelk exhibit the highest percent occurrences (above 50 percent), mean numbers per tow, and weights per tow. Scup, butterfish, and Atlantic herring also exhibit high numbers per tow.

### 4.2.7.2 Commercial and Recreational Fish and Shellfish

Review of the scientific literature indicates that few studies related to commercial and recreational fishery resources have been conducted specifically at the proposed action locale in Nantucket Sound. Data on commercial fishing are available from monitoring conducted by NOAA Fisheries and MassDMF. Data on recreational fishing is available from surveys and monitoring conducted by NOAA Fisheries. Examination of these survey and monitoring data help to understand the scale, species mix, and geographic distribution of commercial and recreational fishing in Nantucket Sound. The data are not fully descriptive of all commercial and recreational fishing activity, however, as some fisheries are not monitored, either in whole or in part. Further, there are overlaps in the monitoring efforts conducted by NOAA Fisheries and MassDMF. Recent changes in data collection implemented by MassDMF using both fishermen's catch reports (striped bass and fluke) and an electronic dealer reporting system (shellfish) are likely to resolve some of these overlaps and data gaps. These changes provide information for only two years, however. This section presents an assessment of the best available data on commercial and recreational fisheries for Nantucket Sound.

Additional information about commercial and recreational fishing in Nantucket Sound has been produced by the project proponent and stakeholders. Two independent surveys were sponsored by the project proponent to obtain additional information about commercial and recreational fishing activities in Nantucket Sound. The sample sizes and sample selection processes limit the statistical significance of the conclusions of these surveys. Nevertheless, these surveys yield useful, albeit anecdotal, information on target species, fishing locations, and the seasonality of fishing in Nantucket Sound. Additional information provided through a study of the commercial squid and fluke fishery sponsored by the Massachusetts Fishermen's Partnership also is reviewed, and its conclusions are critiqued.

Report No. 4.2.7-2 provides life history descriptions for additional species occurring in Nantucket Sound that have not been addressed in the EFH Assessment (Section 4.2.8). These species include 22 species (including the horseshoe crab) managed by the Atlantic States Marine Fisheries Commission (ASMFC); other commercially or recreationally important species; and forage species. The other commercially or recreationally important species were identified from reviews of MassDMF Nantucket Sound commercial catch data, NOAA Fisheries commercial vessel trip report (VTR) data pertaining to Nantucket Sound, NOAA Fisheries charter and party boat (CPB) VTR data pertaining to Nantucket Sound, and the results of the recreational intercept surveys and interviews sponsored by the project proponent (mentioned above). Report No. 4.2.7-2 provides summary information including life history descriptions on the prey of EFH species, ASMFC managed species, and additional commercial and recreational fish species.

#### 4.2.7.2.1 Commercial Fisheries

Nantucket Sound supports commercial fisheries for diverse species of fish and invertebrates such as squid, conch, quahogs, fluke, black sea bass, bluefish, striped bass, Atlantic mackerel, and lobster. Both Federal and State agencies monitor certain commercial fishing activities in Nantucket Sound. NOAA Fisheries monitors federally-permitted commercial fishing activities in the northeast United States, including fishing activity in Massachusetts and specifically in Nantucket Sound. The Commonwealth of Massachusetts monitors state-permitted commercial fishing activities for certain fisheries and gear types in its coastal waters. NOAA Fisheries also collects price information for fisheries that are federally-permitted on a county-wide basis through a dealer database. Information from these programs has been used to describe the commercial fisheries in Nantucket Sound.

NOAA Fisheries and MassDMF collect both independent and overlapping data. Mechanisms for collecting the data vary. NOAA Fisheries compiles trip-based reports to monitor catches, species types, gear types, and fishing locations for Federal permit holders only. MassDMF compiles data through both a dealer reporting system, called the Standard Atlantic Fisheries Information System (SAFIS), and commercial fisherman reporting for certain gears (fish pots, fish weirs, and gillnets) and for certain quota-managed fisheries. In addition, municipalities report shellfish catches and production from shellfish leases on tidelands and state submerged lands.

In order to understand the gaps and overlaps in the monitoring of commercial fisheries in Nantucket Sound, it is critical first to understand how the state-level monitoring system works. MassDMF compiles data on finfish and shellfish catches from fishermen's catch reports, seafood dealer reports, and municipal shellfish reports. Fishermen file catch reports with MassDMF on an annual basis, identifying the species caught, catch levels, and, in the case of shellfish, the location of harvest. The reporting of shellfish harvest location is required for public health purposes. Fishermen are not required to identify the location of finfish catches, other than for certain gear types, fish weirs, fish pots, and gillnets, for handline catches and releases of striped bass, and for fluke by MassDMF statistical area (within the last two years). The NOAA Fisheries VTR system requires that fishermen identify the location of both finfish and shellfish harvests. A significant number of state-permitted fishermen do not hold federal permits, however, and this leads to a gap in the collection of data on finfish catches from these vessels. While the overall level of catch is known as fishermen land their catches and sell them to seafood dealers (explained below), it is not feasible to tie the catches to specific locations such as Nantucket Sound.

In order to sell marine species in Massachusetts, a fisherman must have a state permit and, if relevant, any required endorsements (i.e., coastal access permits [CAPs] with endorsements) for quota-managed species. A fisherman may have a federal permit as well. In theory, some fish may be harvested in Nantucket Sound by fishermen with federal permits only or with permits from other states (such as Rhode Island or Maine), but, absent a Massachusetts permit, these fish cannot be landed and sold in Massachusetts. It is thought that the level of catch in Nantucket Sound by non-Massachusetts permit holders is small, but the actual level is unknown.

Beginning in 2005, all "primary buyers" (seafood dealers or fishermen that are also dealers) in Massachusetts are required to report their purchases of marine species from fishermen. These dealers must check to make sure that fishermen hold valid state fishing permits. The dealers report into the SAFIS dealer reporting database, and Massachusetts landings of quota-managed species, including *Loligo* and *Illex* squid, black sea bass, bluefish, striped bass, dogfish, fluke, scup, and tautog, are accounted for through this system. The SAFIS system is used to keep track of the catches in relation to an annual state quota, and any fisheries that exceed the quota are closed.

The Federal VTR reporting system collects data on fishing location, as well as catch weight, gear type used, and species caught. The federal VTR data may overlap the state data for species that are sold in Massachusetts. In general, for finfish catches, it is not feasible to determine the degree of overlap for an area such as Nantucket Sound, because the proportion of annual catches of finfish caught by state permit holders in Nantucket Sound is not recorded. Although the SAFIS system requires that seafood dealers collect both state permit ID and federal VTR numbers, again, there is no requirement to report the geographic location for state permitted finfish catches. In the case of shellfish, the SAFIS system can be used in the future to distinguish between state and federal permitted catches in the designated SAFIS shellfish growing areas.

Because of the incompleteness of the data and the unknown extent of overlap between the state and federal data monitoring systems, it is not possible to completely characterize the scale of commercial fishing for finfish in Nantucket Sound. The data have been arranged into a unified format in tables that allow close comparison between the NOAA Fisheries and MassDMF data. In order to enhance the comparison, catches of certain related species are tabulated together (this matches the MassDMF approach to compiling data). For example, conch includes the knobbed, channeled, and lightning whelks.

Similarly, squid include both *Loligo* and *Illex* squids; dogfish include both the smooth and spiny dogfish. (Technically a mollusk, squid are included in the finfish data because of their physical behavioral characteristics.) The data can be used to identify the types of commercial fishing in Nantucket Sound and the proportions of different fish catches in each dataset. The data are roughly representative of the scale of commercial fishing in Nantucket Sound, subject to the caveat on incompleteness and overlaps discussed above.

NOAA Fisheries and MassDMF commercial fisheries data are presented in the following sections. This discussion is supplemented with additional information from a recent study sponsored by the Massachusetts Fishermen's Partnership and a study sponsored by the project proponent.

**NOAA Fisheries Commercial Fisheries Data**

NOAA Fisheries divides the U.S. coastal ocean into statistical sampling areas. Waters near Cape Cod and the Islands have been designated as NOAA Fisheries Statistical Area 538, and Nantucket Sound is designated as Subarea 075. Fishermen report catches by statistical area or subarea and by specific latitude-longitude (lat-lon) coordinates or LORAN coordinates. (In the tables and figures below, lat-lon coordinates were used to sort the data to identify catches occurring specifically in Nantucket Sound.) Prior to 1994, landings information was collected through a system of voluntary reporting. NOAA Fisheries port agents collected fish landings and price information at the locus of initial sale through dealer reports or "weigh-out receipts." A mandatory reporting system replaced the voluntary weigh-out reporting method in June 1994. The new reporting system requires fishermen to submit vessel trip report (VTR) logbooks that characterize their catches, including the location where the majority of fishing occurred during a specific trip. Seafood dealers report fish received at the point of sale to the SAFIS program. Because the VTR system was initiated in 1994, there are no data from 1990-1993 to compare with MassDMF data, which have been collected since 1990.

Table 4.2.7-7 presents the VTR finfish catches in pounds by species in each year from 1994 through 2007. Table 4.2.7-8 presents the VTR shellfish catches in pounds by species in each year from 1994 through 2007. Catches of the most common species appear to have increased significantly in the VTR database beginning in 1998. This observation may be the result of increased compliance with the VTR system or a shift from offshore fishing grounds to near coastal waters or both. The last ten years of data (1998-2007) are probably most representative for Nantucket Sound.

From 1998 through 2007, based on the VTR data, an average of 762,650 lbs (346,659 kg) of commercial finfish catches and an average of 251,808 pounds (114,458 kg) of commercial shellfish catches were harvested from Nantucket Sound. Finfish catches, which are heavily influenced by squid and fluke, peaked during 2006. Shellfish catches, which are heavily influenced by conch (whelk species), peaked also in 2006. Report No. 4.2.5-5 presents more detailed analyses of commercial fisheries data from 1994 to 2004.

Commercial fishermen use a variety of gear types for harvesting commercial finfish and shellfish species, including otter trawls, dredges, fish weirs, seines, a variety of traps/pots, and hand lines. Federal VTR data reveal that largest catches during 1994 to 2007 were made from otter trawls for squid and groundfish. Table 4.2.7-9 shows the proportion of total finfish catches by gear type in the VTR data for Nantucket Sound during 1998 to 2007. Sixty percent of catches were made with otter trawls for bottom fish. Eighteen percent of catches were made with fish weirs, and 14 percent were made with fish pots.

As measured by average annual catches, the top 10 species of finfish caught in Nantucket Sound by commercial fishermen with federal permits include squid, fluke, Atlantic mackerel, black sea bass, scup, bluefish, menhaden, butterfish, winter flounder, and king whiting (Table 4.2.7-10). Catches of these fish represent 99 percent of average annual total VTR catches during 1998-2007. Catches of squid represent 50 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of these finfish catches are on the order of $800,000. As explained above, a significant, but unknown, amount of finfish are caught by state-permitted fishing vessels in Nantucket Sound. These catches would significantly increase the total gross sales value, but there is currently no way of attributing state-permitted catches to Nantucket Sound (other than for fluke since 2006).

Some insight is gained on the geographic distribution of fish catches by plotting the NOAA Fisheries VTR lat-lon position data. Figures 4.2.7-1 through 4.2.7-3 display the location of finfish catches in Nantucket Sound from 1998 to 2007. Figure 4.2.7-1 depicts total finfish (including squid) catches. Most catches are located around but not inside of the proposed project area. Figure 4.2.7-2 breaks-out squid catches separately. Note the change in scale. Squid catches are located to the north and south of the project area; only a few are located within the area. Figure 4.2.7-3 breaks-out fluke catches separately. These tend to occur to the east and southeast of the project area. It is important to note that there is one location given for each VTR trip, but trips, especially trawls, can occur over a substantial distance, covering large areas. Consequently, it is possible that trawling across Horseshoe Shoal goes unrecorded in the data. This seems unlikely to occur on a consistent basis over a period as long as 1998 to 2007, however.

As measured by average annual catches, the top five species of shellfish caught in Nantucket Sound by commercial fishermen with federal permits include conch, ocean quahog, surf clam, hard clam, and horseshoe crab (Table 4.2.7-11). Catches of these shellfish represent 99 percent of average annual total VTR shellfish catches during 1998-2007. Catches of conch represent 88 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of these shellfish catches are on the order of $646,000.

Table 4.2.7-12 shows the proportion of total shellfish catches by gear type in the VTR data for Nantucket Sound during 1998 to 2007. Seventy-eight percent of total catches were made with conch pots and 21 percent with clam dredges.

Figure 4.2.7-4 displays the location of total shellfish catches in Nantucket Sound from 1998 to 2007. A large number of catches are made just at the bottom of the project area. Most catches are located to the east and southeast of the proposed project area, however.

**MassDMF Commercial Fisheries Data**

MassDMF studies and monitors marine fishery resources that fall under its jurisdiction. This effort includes the commercial harvests of both finfish and shellfish. MassDMF administers several programs to manage marine fishery resources. The Fisheries Dependent Investigation Project involves monitoring the catch and by-catch composition of some of the state's fisheries. The Management Information Systems and Fisheries Statistics Project maintains a commercial database for shellfish, lobster, and other regulated fisheries. MassDMF has divided Massachusetts coastal waters into statistical areas. Nantucket Sound is has been designated Area 10, which is apparently equivalent to the NOAA Fisheries Subarea 075. Commercial fishermen are required to submit catch reports for hook and line (striped bass), fish weirs, gillnets, shellfish (compiled by municipalities), lobster pots, and fish pots (black sea bass, scup, and conch). Report No. 4.2.5-5 presents detailed information regarding these data during 1990-2004.

The state-permitted gillnet fishery does not make up a large component of state-reported catches in Nantucket Sound. From 1990 to 2003, gillnet catches were reported during only five years including 1992, 1993, 1995, 1999, and 2002. Only one commercial gillnet license was issued for the area in 1992, 1995, and 1999. Only three fishermen reported using gillnets in the area in 1993. There were no fishermen reporting the use of gillnets in the remaining years. From 2004 to 2007, however, a gillnet fishery targeting bluefish has yielded significant catches (averaging 24,000 pounds) in Nantucket Sound.

Both scup and black sea bass are important fisheries in Nantucket Sound. Many commercial fishermen have licenses for the harvesting of these species using fish pots. Numbers of fishermen using fish pots for black sea bass in Nantucket Sound varied over the years with a high of 38 in 1991 and a low of 18 in 1998. Black sea bass catches peaked in 2002 at 419,077 pounds and have averaged about 200,000 pounds annually since that year. Reporting of catch for harvesting of scup from fish pots has been required only since 1994. For 1994 there were 49 fishermen fishing pots for scup in MassDMF Area 10. This number decreased to 28 by 2004. This number has declined during the years to a low of 21 fishermen fishing pots for scup in Nantucket Sound. Scup catches are now only about ten percent of the large pot catches in the 1990s.

The striped bass fishery is another important fishery in Nantucket Sound. This species is harvested both commercially and recreationally in Nantucket Sound. The striped bass commercial fishery is a hook and line fishery only with the season going from mid-July until the quota is filled (MassDMF 2005). MassDMF monitors striped bass that are landed and sold to the Nantucket Sound seafood dealers, in addition to those caught and released, or kept by fishermen. The striped bass hook and line fishery has consistently yielded landings of under 100,000 pounds until 2006-2007. In these recent two years, the fishery averaged more than 200,000 pounds (this figure does not include fish that were caught and released). Note that some unknown proportion of striped bass caught in Nantucket Sound may be marketed to seafood dealers outside of the region.

From 1998 through 2007, based on MassDMF data, an average of 1,149,488 pounds (522,495 kg) of commercial finfish catches (including squid) and an average of 1,650,129 pounds (750,059 kg) of commercial shellfish catches were harvested from Nantucket Sound (Tables 4.2.7-13 and 4.2.7-14). Both finfish catches, which are heavily influenced by squid, scup, Atlantic mackerel, black sea bass, and fluke, and shellfish catches, which are heavily influenced by conch (whelk species), peaked in 2006. Report No. 4.2.5-5 presents more detailed analyses of commercial fisheries data from 1994 to 2004.

As measured by average annual catches, the top ten species of finfish caught in Nantucket Sound by commercial fishermen with state permits include black sea bass, Atlantic mackerel, squid, fluke, scup, striped bass, menhaden, bluefish, butterfish, and bonito (Table 4.2.7-10). Catches of these fish represent 99 percent of average annual total MassDMF catches during 1998-2007. Catches of black sea bass represent 20 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of these finfish catches are on the order of $1,710,000.

As measured by average annual catches, the top three species of shellfish caught in Nantucket Sound by commercial fishermen with state permits include conch, hard clam, and lobster (Table 4.2.7-11). Catches of these shellfish represent 99 percent of average annual total MassDMF catches during 1998-2007. Catches of conch represent 72 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of these shellfish catches are on the order of $6,200,000.

During 2006-2007, the SAFIS database records landings from Designated Shellfish Growing Areas (DSGAs) in Nantucket Sound. Figure 4.2.7-5 shows that the majority of Horseshoe Shoal lies within Area NS-4. This database is believed to be comprehensive for shellfish, but it comprises only two years of landings thus far. Table 4.2.7-15 presents the SAFIS shellfish landings during this period and the two-year average. Average annual landings of all shellfish equal 16,543,299 pounds. Of the four DSGAs in Nantucket Sound, Area NS-4 produces the lowest amounts (only whelk are produced in that area). Table 4.2.7-16 presents the leading shellfish products in order of average pounds landed. Again, reaffirming the other databases, the leading shellfish is conch, comprising 77 percent of total landings. Using average annual price for each species over the two year period, the average annual gross sales value of these shellfish catches are on the order of $50,226,000. This is the best estimate of shellfish production and value in Nantucket Sound.

Table 4.2.7-17 shows the proportion of total finfish catches by gear type in the MassDMF data for Nantucket Sound during 1998 to 2007. (Striped bass data represent landings reported by Nantucket Sound seafood dealers.) Fifty-nine percent of catches and landings were made with fish weirs and 27 percent with fish pots. Again, there has been no reporting for finfish, other than fluke during 2006 to 2007, specifically for Nantucket Sound. Table 4.2.7-18 shows the proportion of total shellfish landings by gear type in the MassDMF data for Nantucket Sound during 1998 to 2007. Seventy-five percent of total catches were made with conch pots and 22 percent with clam dredges.

**Massachusetts Fishermen's Partnership Study**

In an unpublished study sponsored by the Massachusetts Fishermen's Partnership, Wiersma (2008) examines the potential economic impacts of the construction and operation of the WTGs on the squid and fluke fisheries in Nantucket Sound. The author notes the lack of data on catches of vessels holding Massachusetts coastal access permits (CAPs) with endorsements for squid and fluke. Although the state data are incomplete, the author finds that two-thirds of squid and fluke CAP holders also hold federal permits. The catch and location of catch for these vessels is accounted for in the NOAA Fisheries VTR database. The author suggests that "VTR data can provide a general idea of mobile gear landings" for squid and fluke.

The author provides important details about the characteristics of the squid and fluke fisheries in Nantucket Sound. The average size of small mesh squid season otter trawlers is 50 feet (in order to obtain a squid endorsement, these vessels cannot exceed 72 feet). Fishermen who hold CAP endorsements for squid and fluke fish for squid mainly from April to June and for fluke mainly from July through September. These vessels are able to switch gear (to comply with mesh size regulations) readily in order to prosecute both fisheries. Massachusetts CAP permits with endorsements for squid and fluke are held by fishermen from Massachusetts, Rhode Island, New Hampshire, and Maine. Massachusetts CAP holders fish Nantucket Sound the most frequently, followed by vessels from Rhode Island. Many vessels from Rhode Island, New Hampshire, and Maine are limited in their use of CAP endorsements because of the distances required to travel to Nantucket Sound.

Citing a study conducted by scientists at MassDMF (McKiernan and Pierce, 1995), the author finds that nearly all squid taken in Massachusetts waters are from Martha's Vineyard Sound and Nantucket Sound. Further, Nantucket Sound near Horseshoe Shoal is the second-most trawled area for squid. Citing a presentation by another MassDMF scientist (Malkowski, 2001), the author reports that, in the 2000 fishing season, 34 trawlers landed 637,522 pounds of squid and 58 trawlers landed 508,785 pounds of fluke in Nantucket Sound. Based on a survey of fishermen (discussed below), the author finds it likely that many of these vessels were fishing around Horseshoe Shoal.

The author realizes that navigation of Horseshoe Shoal by fishing vessels may not be regulated or constrained even after the construction of the WTGs. Even in the absence of regulation, the author identifies a number of potential external effects ("social costs") of the construction and operation of the WTGs on Horseshoe Shoal. These potential effects comprise increased steaming time; heightened risks of collisions; loss of access to traditional tow patterns; reductions in the number of tows; reductions in days fished; and increased transactions costs.

The author surveys a sample of the squid and fluke endorsement CAP holders (it is unclear from the study whether the sample is random or not). The author finds that 34 fishermen (out of 48 who were contacted) fish in the Horseshoe Shoal area for squid and fluke. (This number is the same as that identified in 2000 by MassDMF (Malkowski, 2001). During the survey, it is discovered that only 22 out of the 34 fishermen use their permits in Nantucket Sound. (In questions to respondents the author estimates that between 30 to 50 Massachusetts vessels and between 15 to 20 out-of-state vessels use Nantucket Sound. The frequency of use by these vessels is not further characterized.)

The survey is used to develop estimates of the proportion of total fishing income that can be attributed to fishing in the Horseshoe Shoal area. Further, respondents are asked to characterize what they would accept for compensation (willingness to accept a lawsuit settlement) if either (i) they become excluded from Horseshoe Shoal or (ii) they are not excluded but inconvenienced by the construction and operation of WTGs on Horseshoe Shoal.

Per fisherman, the author finds a mean fishing income in the area of Horseshoe Shoal of $14,590, and willingness to accept compensation for exclusion of $31,471 or inconvenience of $19,370. The difference between income loss and willingness to accept compensation are attributed to a fisherman's "satisfaction bonus," or the amount required to leave fishing and assume another occupation. Assuming that the average number of vessels prosecuting the fishery is 45, the author estimates a net present value over 25 years (using a discount rate of 10 percent) of $6 million for mean fishing income in the area of Horseshoe Shoal, and willingness to accept compensation for exclusion of $13 million or inconvenience of $8 million. The $8-13 million range was widely cited, without elaboration of the underlying assumptions or methodologies, by commenters on the DEIS.

The Wiersma (2008) analysis brings a focus to two of the leading fisheries in Nantucket Sound. It's conclusions must be tempered, however, by several points. First, there has been no suggestion that Horseshoe Shoal will be closed to fishing. If it is not closed, the upper bound of $13 million is not relevant. Second, it is not clear that the social costs identified by the author are actual and not potential costs. The incidence of these costs cannot be demonstrated conclusively in the absence of the construction and operation of the WTGs. Even if the social costs are actual, it is unclear that fishermen would require a satisfaction bonus. The distribution of squid and fluke fishing activity in the VTR database (Figures 4.2.7-2 and 4.2.7-3), which, according to the author, provides a general idea of mobile gear landings, indicates that this fishing activity rarely occurs on Horseshoe Shoal proper. It is reasonable to assume that squid fishermen will continue to fish unhindered in Nantucket Sound mainly to the east of and along the margins of Horseshoe Shoal and mainly to the east of and southeast of Horseshoe Shoal (off Nantucket) for fluke. If this is true, then the difference between mean income on Horseshoe Shoal and the lower bound of $2 million ($8m - $6m = $2m) required for a satisfaction bonus is not relevant.

Given their historical use of the area, fishermen might be compensated on the basis of equity (fairness) if there would be losses to income. Precedents for such a policy may be found in the cases of the siting of deepwater ports for liquefied natural gas established recently off Boston. Absent data on the number of CAP holders fishing on Horseshoe Shoal, it is unclear what should be the level of aggregate mean lost income. If there is only limited fishing occurring on Horseshoe Shoal, as suggested by the VTR data, then the economic impact may be insignificant. Whether there will be impacts or not is an empirical question that cannot be answered without knowing the actual extent of commercial finfish harvesting that occurs within the proposed project area. Answering this question is made problematic by the gaps in data collection for state-permitted vessels fishing for finfish that have been described in the previous sections.

An important finding of this study is that between 40 and 50 vessels were unaccounted for in the FEIR or the DEIS. This suggests that there is a need for the Commonwealth of Massachusetts to begin the compilation of data on the location of fishing activity in Nantucket Sound. With such data available, the MassDMF proposal for post construction analysis of the effects of the construction and operation of the WTGs becomes much more viable, because it would enable the comparison of fishing activity with and without the construction of the wind power facility.

**Survey of Commercial and Recreational Fishing Activities – 2005**

In 2005, a survey of recreational and commercial fishermen, shellfish officers, harbor masters, bait and tackle shop employees, and a commercial fish dealer was sponsored by the project proponent. Several commercial fishermen and one fish dealer were contacted by mail and were asked to participate voluntarily in the survey. Some of the respondents were interviewed in person, but most were interviewed by phone in the late summer and early fall of 2005. Information on categories and numbers of respondents, selection methodologies, survey methodologies, and summary information on the respondents is presented in detail in the *Survey of Commercial and Recreational Fishing Activities* (Report No. 4.2.5-6).

In the overall survey group, there were 18 commercial and fixed gear fishermen who averaged 32 years of commercial fishing (Report No. 4.2.5-6). This is a small group of respondents, and the selection process for the survey cannot be described as random. Nevertheless, the results of the survey are reported here as information useful for a description of the types of fishing activities in Nantucket Sound and specifically on Horseshoe Shoal.

A summary of the survey selection methodology for the commercial and fixed gear fisherman is presented here. To select the fishermen, license and address information for commercial fishermen who reported landings in Nantucket Sound on federal vessel trip reports (VTRs) or state catch reports was obtained from MassDMF. This database included a list of 399 state- or federally-licensed vessels. Federally-licensed vessel information provided by MassDMF included vessels that both reported landings from NMFS Area 075 (Nantucket Sound) on a VTR from 2000 to 2004 and for which there was matching contact information in the MassDMF database. State licensed vessel information included those vessels that reported landings in MassDMF Area 10 (Nantucket Sound) on a Massachusetts catch report from 2000 to 2004. The commercial vessel license database provided by MassDMF included 82 federally-licensed fishermen and 332 state-licensed fishermen. Fifteen fishermen reported landings from Nantucket Sound via federal VTRs and state catch reports and 317 fishermen reported Nantucket Sound landings via state catch reports only.

Based on discussions with NOAA Fisheries and MassDMF staff, survey letter requests were sent to 50 of the identified fishermen in hopes of receiving at least 12 responses. The method for selecting fishermen to receive a survey letter was deemed acceptable by MassDMF staff. A survey request letter was sent also to one commercial fish dealer on Cape Cod at the request of the USACE. Of the 50 commercial fishermen contacted, 21 replied by mail. Nineteen of the 21 offered to participate in the survey and two declined. Every effort was made to include those who wished to participate. A total of 18 respondents were reached and surveyed by phone.

The 18 surveyed commercial fishermen reported that their boats fished in Nantucket Sound for the following species, which are presented in order of diminishing frequency: scup, squid, and fluke (summer flounder), sea bass, conch, tautog, stripers, and bluefish.

Commercial mobile gear fishermen reported that squid is an important fishery in Nantucket Sound in the spring. Trawlers harvest this species. Twelve of 13 trawlers in the sample survey of 21 boats (57 percent) fish for squid in April and May. Ten boats were active in June. Areas heavily fished included nearshore Falmouth to Hyannis to Horseshoe Shoal and Half Moon/Cross Rip Shoals. Out of 12 commercial trawlers targeting squid that were surveyed, approximately 27 percent reported fishing in the Horseshoe Shoal area and 73 percent reported fishing outside of the Horseshoe Shoal area.

Of 21 boats owned or managed by surveyed commercial fishermen, 11 (52 percent) trawled for fluke with mobile gear some time during the season in Nantucket Sound. Active areas for fluke targeted by trawlers included Horseshoe Shoal and Half Moon/Cross Rip Shoals. Medium activity was reported for these areas from April through September. In fall, activity for fluke, especially hook and line fishermen, was reported in Eastern Sound. Of 11 surveyed commercial trawlers targeting fluke, approximately 24 percent reported fishing in the Horseshoe Shoal area and 76 percent reported fishing outside the Horseshoe Shoal area.

In Nantucket Sound, scup fishing with mobile gear was reported to have two active periods. The first was in April through June reported in the nearshore Falmouth to Hyannis, Horseshoe Shoal and Half Moon/Cross Rip Shoals areas. The second was in the fall reported in Tuckernuck Shoals followed by Horseshoe Shoal and Big Flat. Eight of 21 boats (38 percent) under management of surveyed respondents were noted as trawling for scup using mobile gear some time during the season in Nantucket Sound. Of the eight surveyed commercial trawlers that were targeting scup, approximately 28 percent reported fishing in the Horseshoe Shoal area and 72 percent reported fishing outside the Horseshoe Shoal area.

For sea bass the most active fishing was reported to occur in May to June in the Horseshoe Shoal and Half Moon/Cross Rip Shoals areas. In July and August activity diminished but then increased in these areas during September through November. Of the 21 boats owned or managed by the surveyed commercial fishermen, 4 (19 percent) trawl for sea bass some time during the year in Nantucket Sound. Of these 4 surveyed commercial trawlers that target sea bass, approximately 41 percent reported fishing in and 59 percent reported fishing outside the Horseshoe Shoal locale.

Conch fishing was reported to have medium activity levels in summer across much of Nantucket Sound. Areas where medium activity occurred included Horseshoe Shoal, Half Moon/Cross Rip Shoals, Tuckernuck Shoals, and Eastern Sound. Of the 21 boats in the survey sample, two trawlers reported harvesting conch in the Nantucket Sound area. Of the 2 surveyed commercial trawlers that targeted conch, approximately 19 percent reported fishing in and 81 percent reported fishing outside the Horseshoe Shoal locale.

Hook and line commercial fishermen reported fishing activity information. Three of 21 boats (14 percent) fish with hook and line in the Nantucket Sound area some time during the season. Fish species that are targeted include bluefish, fluke, scup, sea bass, striped bass, and tautog. Bluefish were caught by one such fisherman from May to July in various areas of Nantucket Sound including Horseshoe Shoal. Approximately 17 percent of his fishing reported was in the Horseshoe Shoal locale and approximately 83 percent occurred outside the Horseshoe Shoal locale. Two such fishermen caught striped bass. One reported fishing just in July in the Eastern Sound area and the other targeted bluefish and tautog concurrently.

Out of the two commercial hook and line boats that were surveyed, approximately 12.5 percent of reported fishing for striped bass took place in the Horseshoe Shoal locale and approximately 87.5 percent took place outside the Horseshoe Shoal locale. Two of 21 boats owned/managed by surveyed commercial fishermen reported fishing for tautog in Nantucket Sound using hook and line. These fishermen fished commercially for tautog in April to May and in September to October. Of these boats, approximately 30 percent of reported fishing occurred in the Horseshoe Shoal locale and approximately 70 percent occurred outside the Horseshoe Shoal locale. Of three commercial hook and line boats surveyed that targeted scup and fluke, approximately 22 percent of scup fishing and 14 percent of fluke fishing was reported to take place in the Horseshoe Shoal locale. The rest of the fishing effort was reported taking place outside the

Horseshoe Shoal locale. For commercial sea bass fishing using hook and line, Eastern Sound was noted as the most active area during the season. Of three commercial hook and line boats surveyed, approximately 20 percent of sea bass fishing occurred in the Horseshoe Shoal locale and 80 percent occurred outside the Horseshoe Shoal locale.

Commercial fixed gear fishermen reported that most active areas for scup were in the areas that include nearshore Falmouth to Hyannis and Horseshoe Shoal in April and May. Central and eastern Sound areas had medium activity levels in the remainder of the season. Activity levels for sea bass by trap and pot fisherman were the same as those described for scup. Three of 21 boats owned/managed by the commercial fishermen who were surveyed target scup and sea bass with the use of pots and traps. Of the surveyed boats, approximately 27 percent of fishing was noted to occur in the Horseshoe Shoal locale and approximately 73 percent of fishing was noted to occur outside the Horseshoe Shoal locale.

Conch was reported as caught in pots and traps at varying depths in Nantucket Sound. Information about boats targeting conch indicated that Horseshoe Shoal has most activity during the spring through June and in December. In summer, Big Flat and Eastern Sound were reported to have the most conch fishing. Two of 21 boats owned/managed by the commercial fishermen who were surveyed fish for conch with the use of pots and traps. Of these two boats, approximately 27 percent of fishing was noted to take place in the Horseshoe Shoal locale and approximately 73 percent of fishing was noted to occur outside the Horseshoe Shoal locale.

For tautog, the fixed gear boat was reported as most active in April and May in the Horseshoe Shoal and nearshore Falmouth to Hyannis areas. Central and eastern Sound areas had medium activity levels in the remainder of the season. The one boat that targets tautog with pots/traps noted that approximately 31 percent of the tautog fishing took place in the Horseshoe Shoal locale with approximately 69 percent taking place outside the Horseshoe Shoal locale.

Bluefish are commercially caught by one fixed gear gill-netter in Nantucket Sound. It was reported that only bluefish were fished for on Horseshoe Shoal from May through July employing this method (see Report No. 4.2.5-6).

**Horseshoe Crab Fishery Information**

Along the U.S. Atlantic coast, horseshoe crabs are most abundant between Virginia and New Jersey (ASMFC, 2005). This species is common on the shores of Cape Cod as evidenced by one study that tagged over 7,800 horseshoe crabs on Cape Cod between 2000 and 2002 (Pirri et al., 2005). On the shores of Nantucket Sound, they have been observed in Barnstable Harbor (O'Connell et al., 2003) and Monomoy Islands (Pirri et al., 2005; USFWS, 2005a). They are also are observed in Nantucket Sound on a regular basis (ERDG, 2005).

Horseshoe crabs are collected mainly for use as bait in conch and eel pots (Fraser, 2008). Live animals also are collected for research purposes and are returned to the water and not counted towards the state's quota (Fraser, 2008). Massachusetts landings have increased in the past few years leading to a recently reduced number of this species that can be harvested each year to 165,000 (ASMFC, 2008; Daley, 2008). Adults of this species are exclusively subtidal except during spawning; however, their specific habitat requirements are unknown (ASMFC, 1998). Since this species occurs in Barnstable Harbor, there is also a good chance that horseshoe crabs may occur within Lewis Bay in the nearshore proposed action area.

Spring and fall trawl survey data from the Massachusetts MassDMF indicates that horseshoe crabs are present in Nantucket Sound in greater numbers in the fall than in the spring (MDMF, 2005a). In

Massachusetts, studies have been conducted on isolated spawning populations of this species; however there has not been a comprehensive study conducted (Daley, 2008).

**Commercial Fisheries Summary**

Nantucket Sound supports commercial fisheries for many species of fish and shellfish. NOAA Fisheries and MassDMF monitor commercial fishing activities in the Sound, but they collect both independent and overlapping data. A critical gap in data collection is that the annual catches of finfish caught by state permit holders in Nantucket Sound are not tied specifically to Nantucket Sound. (In the last two years, however, catches of fluke only have been monitored and accounted for in Nantucket Sound.) Because of the incompleteness of the data and the unknown extent of overlap between the state and federal data monitoring systems, it is not possible to fully characterize the scale of commercial fishing in Nantucket Sound. The best available data from both federal and state sources must be reported separately, and it can be used only to get a sense of the commercial fish species and their approximate scales relative to catches of other species as reported within each catch monitoring system. Recently MassDMF landings data for shellfish have been linked to designated shellfish growing areas in Nantucket Sound. Further, MassDMF is now keeping track of fluke landings for Area 10.

As measured by average annual catches of vessels holding federal permits, the top 10 species of finfish caught in Nantucket Sound include squid, fluke, Atlantic mackerel, black sea bass, scup, bluefish, menhaden, butterfish, winter flounder, and king whiting. These catches occur primarily in otter trawls, but other gears are used as well. Catches of squid represent 50 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of federally-reported finfish catches are on the order of $800,000. As measured by average annual catches, the top five species of shellfish caught in Nantucket Sound by commercial fishermen with federal permits include conch, ocean quahog, surf clam, hard clam, and horseshoe crab. Catches of conch represent 88 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of federally-reported shellfish catches are on the order of $646,000.

As measured by average annual catches, the top ten species of finfish caught in Nantucket Sound by commercial fishermen with state permits include black sea bass, Atlantic mackerel, squid, fluke, scup, striped bass, menhaden, bluefish, butterfish, and bonito. These catches occur primarily in fish weirs, fish pots, and gillnets. Catches of black sea bass represent 20 percent of average annual catches. Using average annual price for each species over the ten year period, the average annual gross sales value of state reported finfish catches are on the order of $1,710,000. As measured by average annual landings in the SAFIS database, the top five species of shellfish caught in Nantucket Sound by commercial fishermen with state permits include conch, hard clam, horseshoe crab, sea clams, and bay scallops. Catches of conch represent 77 percent of average annual catches. Using average annual price for each species over a two year period, the average annual gross sales value of state reported shellfish catches is on the order of $50 million.

The geographic distribution of fish catches using the federal VTR data show that most catches are located around but not inside of the proposed project area. Squid catches are located to the north and south of the project area. Fluke catches tend to occur to the east and southeast of the project area. Shellfish catches occur primarily in DSGAs to the east and south of Horseshoe Shoal.

A study sponsored by the Massachusetts Fishermen's Partnership examines the potential economic impacts of the construction and operation of the WTGs on the squid and fluke fisheries in Nantucket Sound. The study reaffirms the lack of data on catches of vessels holding Massachusetts coastal access permits (CAPs) with endorsements for squid and fluke. This finding suggests that there is a need for

Massachusetts to compile data on the location of all fishing activity in Nantucket Sound. With such data, analysis of the effects of the construction and operation of the WTGs becomes possible.

#### 4.2.7.2.2 Recreational Fisheries

Nantucket Sound is located near several world class vacation destinations (i.e., Cape Cod, Nantucket, and Martha's Vineyard). These areas offer numerous opportunities for recreational fishing. Review of the scientific literature indicates that few studies related to recreational fishery resources have been conducted specifically in Nantucket Sound. Although the best available data are not fully descriptive of the spatial distribution of recreational fishing in Nantucket Sound, little evidence has been found or brought forward by commenters to date to suggest that marine recreational fishing will be adversely affected by the construction and operation of the WTGs.

Few studies exist on the economic value of recreational fishing in Nantucket Sound. Norton et al. (1983) estimate the net value (consumer surplus) to recreational anglers of fishing for striped bass in Massachusetts at $207.26 per day (2005 dollars). Pendelton (2008) reports a range of values from $15 to $100 per visit for coastal and estuary recreational fishing in Massachusetts. Using estimates developed by NOAA Fisheries of recreational fishing effort in Nantucket Sound (reported below), this range suggests that the annual net value of recreational fishing in Nantucket Sound ranges from $10 to $63 million. Valuing shore-based fishing with the lower value and party/charter boat and private/rental boat fishing with the higher value suggests a best estimate of an annual value approximately $25 million for marine recreational fishing in Nantucket Sound. Although it is difficult to make comparisons with incomplete data, given the inefficient regulation of the commercial fisheries, this scale of economic value for recreational fishing may well exceed the net economic value for commercial finfish fishing in Nantucket Sound. (Note that these are net value estimates, unlike the gross value estimates reported above for commercial fisheries.).

The best available data on recreational fishing comprise surveys and monitoring conducted by NOAA Fisheries. NOAA Fisheries uses two methods to monitor recreational fishing activity: a Marine Recreational Fisheries Statistics Survey (MRFSS) and Charter and Party Boat (CPB) vessel trip report (VTR) data. The MRFSS data provide the best estimates of recreational fishing effort and catch, but they include only limited broad-based information on the spatial distribution of recreational fishing. The CPB/VTR data provide information about the spatial distribution of recreational fishing, but they are limited only to CPB fishing on vessels that hold federal licenses (a subset of party/charter boats working in Nantucket Sound). Although MassDMF does not conduct its own surveys of recreational fishing, it provides NOAA Fisheries with financial assistance for carrying out the MRFSS program in Massachusetts' counties.

In addition to NOAA Fisheries recreational fishing surveys and monitoring, the applicant undertook two data collection efforts: an intercept survey was conducted from August 2002 through November 2002, and a survey of commercial and recreational fishing activities was conducted in 2005. These two surveys provide some limited additional information about recreational fishing activity in Nantucket Sound.

**NOAA Marine Recreational Fisheries Statistics Survey (MRFSS)**

The MRFSS methods include both face-to-face and telephone interviews held with recreational anglers in several local seaports. These surveys do not collect information on the specific spatial distribution of recreational fishing, for example by using a statistical sampling grid of coastal waters. During the face-to-face interviews, the county where the survey was held is recorded. During the telephone interviews, the county where anglers indicate participation in recreational fishing is recorded.

The surveys collect information on the general location of fishing activity, the length of time fished, the type of gear used, and the description of species and numbers of fish that were caught and released.

The raw MRFSS data are compiled at the county level and aggregated to state, regional, and national levels. The state, regional, and national-level compilations are available from NOAA online at http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. The county level data have been posted on an file transfer protocol site maintained by NOAA: ftp://cusk.nmfs.noaa,gov/mrfss/intercept/ag/. Massachusetts is identified as state number 25; the counties surrounding Nantucket Sound are identified as follows: Barnstable (CNTY=1); Dukes (CNTY=7); and Nantucket (CNTY=19). Report No. 4.2.5-5 provides a compilation and summary of the raw data from 1990 to 2004.

The raw MRFSS data are not measures of total fishing effort or total catch, however. The raw data are a sample of the population of recreational anglers, and the sample must be extrapolated to the population to estimate total recreational fishing effort and total recreational fish catch. Because of limited sample sizes, raw data typically is aggregated to the larger geographic scales (state, region, or nation) to reduce sources of error when making extrapolations. Data analyzed by NOAA for Nantucket Sound utilizing the three relevant Massachusetts counties, although presented at a less aggregated scale, is nevertheless useful in presenting a description of the scale of recreational fishing effort and the nature of fish catches.

The data describing recreational fishing effort and catch are compiled along a number of different dimensions. We present data on fishing mode and fishing area by bimonthly intervals (waves). Fishing modes comprise shore-based fishing, party/charter and private/rental boat fishing. Recreational fishers are surveyed on their geographic fishing areas, including ocean, sound, river, bay, and all other locations. We present data on sound-based fishing only for Barnstable, Dukes, and Nantucket Counties as the data that best characterize recreational fishing in Nantucket Sound. Data are presented for the period 2005 to 2007 (2007 data are unavailable for party/charter boat fishing). Although this is a short time series, these recent years best depict both current and likely near future levels of recreational fishing activity.

Recreational fishing is sampled in bimonthly “waves” as follows: wave 1: January/February; wave 2: March/April; wave 3: May/June; wave 4: July/August; wave 5: September/October; and wave 6: November/December (NOAA Fisheries, 2001). Recreational fishing may take place in Nantucket Sound during the entire year; however, NOAA Fisheries does not survey the New England region during the wave 1 timeframe. Only about five percent of the annual recreational catch along the Atlantic and Gulf coasts occurs during wave 1. The costs of sampling during these months are high due to the low levels of fishing activity, especially in the North- and Mid-Atlantic subregions. Data collection for wave 1 has been continued along the Gulf and Pacific coasts and along the Atlantic Coast of Florida. With the exceptions of Georgia from 1985 to 1989, South Carolina in 1988, and North Carolina from 1988 to 1992, the MRFSS has not been conducted during wave 1 along the Atlantic Coast north of Florida since 1980 (NOAA Fisheries, 2004).

Table 4.2.7-19 presents the NOAA Fisheries estimate of MRFSS recreational fish catches in Nantucket Sound. The catches are measured in pounds, and the top eight species represent 99 percent of the total recreational catch. The leading species include bluefish, scup, striped bass, fluke, black sea bass, little tunny, bonito, and tautog. The estimated recreational catches exceed recorded levels of commercial catches for many of these species (see the tables referenced in Section 4.2.7.2.1 above), although it is understood that the commercial fishing data for Nantucket Sound are incomplete.

Table 4.2.7-20 presents the NOAA Fisheries estimate of MRFSS recreational fishing effort (trips) in Nantucket Sound. The data are presented by bimonthly survey wave (2-6) and by fishing mode (shore, party/charter boat, and private/rental boat). The highest recreational fishing pressure occurs in Nantucket

Sound during the summer months (i.e., June through September) when tourists are vacationing in this region. During 2005-07, the average annual total recreational fishing effort in Nantucket Sound is estimated to be 635,047 trips. Recreational fishing effort peaks during the July-August wave with an annual average of 272,655 trips across all three modes. Average annual shore-based fishing accounts for over 73 percent of average annual effort. Shore-based fishing occurs during all five waves. Average annual party/charter boat fishing effort accounts for only about three percent of the total, although it represents 11 percent of the non-shore average annual effort. Average annual private/rental boat fishing effort represents about 25 percent of the total. Average annual private/rental boat fishing effort accounts for 89 percent of the non-shore total. Clearly private/rental boat fishing it is the most important mode of recreational fishing in Nantucket Sound proper.

**NOAA Fisheries Recreational Vessel Trip Report (VTR) Data: Charter and Party Boats (CPB)**

Table 4.2.7-21 presents the recreational Charter and Party Boat Vessel Trip Report (CPB/VTR) data from NOAA Fisheries for Nantucket Sound (Area 075) during 1994-2007. These data comprise recreational catches for federally-permitted charter or party boats, which are subject to VTR reporting requirements. Federal CPB permits are issued by NOAA Fisheries to vessels involved in recreational catches of black sea bass, bluefish, squid/mackerel/butterfish, scup, summer flounder, and New England multi-species fisheries (groundfish). Federal vessel permits for bluefish were not implemented until 2000 for CPB fisheries (NOAA Fisheries, 2005). Report No. 4.2.5-5 presents additional descriptions of these data from 1994 to 2004.

CPB/VTR recreational catches include finfish, shellfish, and squid. Recreational CPB/VTR catches were reported for federally-permitted vessels during 1994-2007 primarily during the months of April to October. During the ten year period from 1998-2007, federally-reported CPB/VTR recreational catches averaged 40,992 pounds. Reported catches have been increasing over the same period (Table 4.2.7-21). The top ten species include: scup (74 percent of catches), *Loligo* squid, black sea bass, summer flounder, bluefish, tautog, striped bass, and sea robin, (Table 4.2.7-22). These species made up nearly 100 percent of the total federally-reportable recreational species caught during the ten-year period.

Gear types that were used for harvesting recreational species were reported to include both hand line/rod and reel and fish pots, Hand line/rod and reel landings accounted for nearly 100 percent of total federally-reportable recreational CPB landings during 1994 to 2007.

A unique aspect of the CPB/VTR data is that catches are reported by geographic location. The CPB/VTR data are the best available data on the spatial distribution of recreational fishing in Nantucket Sound. Recreational fishing vessels may move around during a trip, but the reported location is representative of where the majority of fishing took place during a trip. Figure 4.2.7-6 depicts the location of catches (in pounds) for the reporting CPB vessels during 1998-2007. The figure shows that most of the CPB/VTR recreational fishing activity is distributed along the northern edge of Nantucket Sound, near the municipalities on Cape Cod that border the sound, and few catches were reported on or near Horseshoe Shoal.

It is possible that the spatial distribution of the federally-permitted charter and party boats could be interpreted as an approximation of the spatial distribution of all recreational fishing activity in Nantucket Sound. Fishing guides who run charter and party boat fishing businesses are regarded as among the most knowledgeable individuals with respect to identifying and utilizing recreational fishing locations with the highest catch rates. In fact, their livelihoods depend upon identifying the most productive locations.

Notwithstanding this interpretation of the potential representativeness of the CPB/VTR data for the geographic distribution of recreational fishing activity in general, some serious limitations to the use of the data for this purpose exist. The CPB/VTR data do not include the location of state-permitted charter and party boats. (MassDMF does not compile data on the spatial distribution of recreational fishing by charter or party boats that hold permits only from Massachusetts.) Further, the CPB/VTR data do not include information on the spatial distribution of party/rental boats, which, according to the MRFSS data represent the great majority (89 percent) of recreational fishing effort in Nantucket Sound.

These limitations to the representativeness of the CPB/VTR data on recreational fishing should be conditioned on at least two points. First, it is known to be hazardous for small craft to fish on Horseshoe Shoal because of the strong currents, waves, and rips (see Section 4.4.3.5 for Report No. 4.4.3-1). These hazards certainly constrain the recreational fishing effort exerted by private/rental boats on Horseshoe Shoal. Second, no comments have been received suggesting that Horseshoe Shoal would be less productive as a consequence of the construction of the WTGs. To the contrary, it is commonly assumed that the scour mats and riprap, either as fish aggregating devices or as enhanced habitat, will lead to increased productivity for recreational fishing. Consequently, those recreational fishing boats (party/charter or private/rental) that are able to safely navigate Horseshoe Shoal may experience increased success and higher catch rates from the construction of the WTGs. This hypothesis would be important to test with a program of research. Both the MRFSS and the CPB/VTR datasets, as well as information from stock assessments, could be very useful for testing this hypothesis.

**Recreational Intercept Survey**

An intercept survey was performed from August 2002 through November 2002 to estimate of fishing by party/charter boats in Nantucket Sound. These types of boats are common platforms for recreational fishing activities, especially for those without access to personal boats. Party boats are those that accept individual passengers on a first-come, first-served basis, taking such individuals fishing for either a half or a full day for a fee. A charter boat is one that is reserved in advance by a small number of anglers who pay a set price for the charter.

One purpose of the 2002 intercept survey was to collect information on existing recreational fishing efforts by party/charter boats in Nantucket Sound for evaluation of the potential impacts of the proposed action on this type of recreational fishing activity. Further, the survey collected information on the species targeted by recreational anglers in Nantucket Sound. The survey was designed to be answered by captains or crew of party/charter boats. Charter boat and registered party boat captains expected to fish in the area were identified, contacted by phone, and questioned. A map indicating the locations of the WTGs and other areas in Nantucket Sound was sent to captains so that they might identify specific fishing locations in the Sound. Report No. 4.2.7-3 presents detailed information on these data.

Thirty charter and party boat captains were contacted and then questioned. Of the 30 respondents, 27 were charter boat operators and three were party boat operators. When party/charter boat operators were asked to estimate the number of days fished during a year, they reported fishing an average of 150 days per year. Some operators indicated that several trips were made each day, thus numbers of days fished may not correspond with total numbers of trips. Party/charter boat captains surveyed reported totals of 430 full-day trips and 1,752 half-day trips. Vessel size determines the number of anglers that can fish from charter or party boats. Charter vessels usually can take five to six anglers whereas party boats were may take as many as 20 to 30 anglers each trip.

Captains of both the charter and party boats indicated that the most sought after species for both types of fishing excursions include scup, striped bass, and various tunas. Other common target species include bluefish, bonito, cod, sea bass, and various sharks. It was reported that most species are caught during trips taken from May through September, months when more people participate in fishing activities on charter and party boats.

Charter and party boat captains were asked about the specific areas where they take anglers for fishing. Most charter and party boat captains reported that for short (half-day) trips they did not take their anglers to Horseshoe Shoal. Areas reported by captains as being frequently fished included the following: the Elizabeth Islands, Squibnocket Beach (Martha's Vineyard), Vineyard Sound, South Beach (Martha's Vineyard), Nauset, Stage Harbor, Buzzards Bay, Old Man, shoreline areas near the Dennis/Harwich, Canyons, regions south of Martha's Vineyard, Muskeget Channel, Nantucket Shoals, and Great Point. Other areas fished on half-day trips, but fished less frequently than the above noted areas include areas around Tuckernuck Island and Monomoy Island.

Survey results showed that charter and party boat captains reported they fish shoal areas around Horseshoe Shoal, Tuckernuck Island, and Monomoy Island on the full day trips. Approximately 56 percent of the 430 full-day trips that were reported in the most recent 12 months were to shoal areas around Monomoy Island, 21 percent were to the Horseshoe Shoal area, and 9 percent were to shoal areas around Tuckernuck Island. The remaining full-day trips were reported to be to regions southeast of Nantucket, to areas east of Monomoy Island, and south of Martha's Vineyard. Report No. 4.2.7-3 presents additional detailed information on the recreational intercept survey.

**Survey of Commercial and Recreational Fishing Activities – 2005**

Information was gathered by survey from recreational and commercial fishermen, shellfish officers, harbormasters, bait and tackle shop employees, and a commercial fish dealer. Recreational fishermen were approached in person and interviewed at several types of boat access locations. Harbormasters, shellfish and coastal officers, and bait and tackle shops were identified using town web sites or through a review of MassDMF's January Massachusetts Saltwater Recreational Fishing Guide. Twenty-three individuals were surveyed in late summer and early fall of 2005. Some of these individuals were interviewed in person, but most were interviewed by phone. Information on categories and numbers of interviewees, selection methodologies, survey methodologies, and summary information on the respondents is presented in detail in Report No. 4.2.5-6.

Information obtained from interviews with eight individuals who described themselves as recreational fishermen gave some information on areas that are fished and species of fish sought. Twenty-five percent (two out of eight fishermen interviewed) reported that they fish some portion of the time on Horseshoe Shoal. Other individuals reported that they only fish areas that are closer to shore (25 percent), they fish near Monomoy (25 percent), they fish only off the Elizabeth Islands and in Vineyard Sound (12.5 percent), and they fish in Nantucket Sound and offshore areas but not on Horseshoe Shoal (12.5 percent). The primary target species were reported to include bluefish and striped bass. Other species reported as targeted include fluke and bonito.

Harbor masters and shellfish wardens who were interviewed reported there were more recreational fishermen than commercial fishermen in their areas of jurisdiction. Edgartown and Yarmouth did, however, report a 50/50 split. Fishing areas preferred for most of the users were in proximity to home port areas. Species reported to be targeted included the following: bluefish, striped bass, scup, mackerel, bottom fish such as fluke, squid and lobster, conch (technically a shellfish), and summer and fall transient species that include false albacore, bonito, shark, and tuna. Details on the findings of this survey are presented in Report No. 4.2.5-6.

**Recreational Fisheries Summary**

Nantucket Sound offers excellent opportunities for recreational fishing, leading to an estimated $25 million in annual net economic value. During 2005-07, the average annual total recreational fishing effort in Nantucket Sound is estimated to be 635,047 trips. Average annual shore-based fishing accounts for over 73 percent of average annual effort. Average annual party/charter boat fishing effort accounts for 11 percent of the non-shore average annual effort. Average annual private/rental boat fishing effort accounts for 89 percent of the non-shore total. Clearly private/rental boat fishing is the most important mode of recreational fishing in Nantucket Sound proper.

The best available data on recreational fishing comprise surveys and monitoring conducted by NOAA Fisheries. The MRFSS data provide the best estimates of recreational fishing effort and catch, but they include only limited broad-based information on the spatial distribution of recreational fishing. The CPB/VTR data provide information about the spatial distribution of recreational fishing, but they are restricted only to CPB fishing on vessels that hold federal licenses (a subset of party/charter boats working in Nantucket Sound). Two additional data collection efforts initiated by the project proponent, a 2002 intercept survey and a 2005 telephone survey, provide some limited anecdotal information about recreational fishing activity in Nantucket Sound. These surveys reveal that Horseshoe Shoal is one of several locations utilized by party/charter boats and private/rental boats for targeting the primary recreational species, including bluefish, scup, striped bass, fluke, black sea bass, little tunny, bonito, tautog, and others.

Clearly the best available data are not fully descriptive of the spatial distribution of recreational fishing in Nantucket Sound. These data include government surveys and monitoring as well as intercept and telephone surveys conducted by project proponent. The latter involve small sample sizes that raise questions about the statistical reliability of their conclusions. Little evidence has been found or brought forward by commenters to date, however, to suggest that marine recreational fishing will be adversely affected by the construction and operation of the WTGs. Both the MRFSS and the CPB/VTR datasets, as well as information from stock assessments, could be very useful for testing a null hypothesis that there will be no affect of the construction and operation of WTGs on marine recreational fishing activity in Nantucket Sound.

### 4.2.8 Essential Fish Habitat (EFH)

#### *4.2.8.1 Introduction*

A requirement of the 1996 amendments to the Magnuson-Stevens Act is that an EFH consultation and assessment be conducted for activities that may adversely affect important habitats of federally-managed marine and anadromous fish species. The following is a summary of the EFH assessment (the full EFH assessment is provided in Appendix H). The definition of EFH is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. 1802(10). In the definition the term “waters” refers to the physical, chemical, and biological properties of aquatic areas that are currently being used or have historically been used by fish and certain designated invertebrates. In the definition the term “substrate” refers to sediment, hard bottom, or other underwater structures and their biological communities. In the definition the term “necessary” indicates the habitat is required to sustain the fishery and support the fish species’ contribution to a healthy ecosystem. Nantucket Sound has been designated as EFH for twenty fish and invertebrate species that are introduced in the EFH Assessment description below. In addition, the EFH process involves the designation of habitat areas of particular concern (HAPC) for those habitat areas determined to be of particular importance to the survival and growth of a particular species. An EFH Assessment was conducted for these species as they relate to proposed action activities.

Habitat in the proposed action locale has been designated EFH for 17 federally-managed fish and three federally-managed invertebrates. The Magnuson-Stevens Act requires assessment of the potential impacts to the 17 federally-managed fish and three federally-managed invertebrates. These species include the following: Atlantic cod (*Gadus morhua*), scup (*Stenotomus chrysops*), black sea bass (*Centropristis striata*), winter flounder (*Pseudopleuronectes americanus*), windowpane (*Scophthalmus* *aquosus*), summer flounder (*Paralichthys dentatus*), yellowtail flounder (*Limanda ferruginea*), Atlantic butterfish (*Peprilus triacanthus*), Atlantic mackerel (*Scomber scombrus*), blue shark (*Prionace glauca*), shortfin mako shark (*Isurus oxyrhinchus*), bluefin tuna (*Thunnus thynnus*), king mackerel (S*comberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), cobia (*Rachycentron canadum*), little skate (*Leucoraja erinacea*), winter skate (*Leucoraja ocellata*), long-finned squid (*Loligo pealei*), short-finned squid (*Illex illecebrosus*), and the surf clam (*Spisula solidissima*). A summary of specific life stage EFH designations for these species is provided in Table 4.2.8-1. One EFH HAPC has been identified in the proposed action locale. Eelgrass beds, when located within summer flounder EFH, have been designated as an HAPC by MAFMC. Descriptions of potential direct and indirect impacts of the proposed action to these species and their associated habitat are discussed in Section 5.3.2.8 and are further detailed in the EFH Assessment.

### *4.2.8.2 Life History Characteristics of Species with EFH Designation*

In addition to the life history characteristics of the species with designated EFH in the proposed action area, information is also provided on the occurrence of these species based on several available databases. Although the species presented in Section 4.2.8.1 are reported by NOAA Fisheries to have designated EFH in the four 10 x 10 minute grid squares that encompass the proposed action area, NOAA Fisheries and MassDMF databases were analyzed to determine the occurrence and relative reported landings of these species in Nantucket Sound. While it is understood that the EFH designations are partially based on abundance data from NOAA's Estuarine Living Marine Resources (ELMR) program and other sources and that EFH can be designated based on the habitat that support species and lifestages and not the actual presence of certain species, however, to tie EFH designations to actual occurrence and relative abundance as documented in landings and other available resource data, results from these databases were reviewed. These are summarized in Section 4.2.8.3 below and in Appendix A of the EFH Assessment. Report No. 4.2.7-2 provides more extensive and detailed information on the forage characteristics of the EFH species. Life history characteristics for each EFH species are presented below.

#### 4.2.8.2.1 Demersal Species

**Atlantic cod *(Gadus morhua)***

*Adults*. EFH for adult Atlantic cod is designated as those bottom habitats with substrates of rocks, pebbles, or gravel in the Gulf of Maine, Georges Bank, southern New England, and the middle Atlantic south to Delaware Bay. Nantucket Shoals exists as a migration point for adults in the Mid-Atlantic Bight during summer and fall as southern water temperatures exceed 68 °F (20 $^{o}$C) (Heyerdahl and Livingstone, 1982). MassDMF trawl surveys (Fahay et al., 1999) in Massachusetts found adults occur more frequently in spring than in fall, but are rare for both seasons in Nantucket Sound. Consequently, the ELMR database indicates that adult cod are common in the Sound during the colder months, from October to April. In the spring, adult cod occur abundantly around Cape Ann, the tip of Cape Cod, and the western part of Cape Cod Bay. Few were found during fall, and those were restricted to the Cape Ann and Cape Cod tip areas. Adult cod are typically found on or near bottom along rocky slopes and ledges, preferring depths between 131 and 427 ft (40 to 130 m), but are sometimes found at mid-water depths (Fahay et al., 1999). NMFS has designated all of Nantucket Sound as EFH for this life stage.

*Forage Species*. Juvenile cod are bottom-dwelling and feed mainly upon small crustaceans such as shrimp and amphipods (Marine Fisheries, 2005). However, although studies have shown that the most frequently consumed food items by adult cod are invertebrates (Fahay et al., 1999), they will in fact eat almost anything small enough to fit into their mouths, including clams, cockles, mussels, and other mollusks, as well as crabs, lobsters, and sea urchins (Marine Fisheries, 2005). Adults also pursue schooling fish, eating substantial numbers of herring, shad (*Alosa spp*.), mackerel, and silver hake (*Merluccius bilinearis*) (Marine Fisheries, 2005).

**Scup *(Stenotomus chrysops)***

*Juveniles*. For juvenile scup, EFH is designated as the demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all estuaries and bays where juvenile scup were identified as being common, abundant or highly abundant in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones between Massachusetts and Virginia, in association with various sands, mud, mussel, and eelgrass bed type substrates. Juveniles are common and highly abundant in Nantucket Sound from May to October as indicated in the ELMR database. As inshore water temperatures decline to less than 46 to 48°F (8 to 9°C) in winter, scup leave inshore waters and move to warmer waters in the Mid-Atlantic Bight, returning inshore with rising temperatures in the spring (Steimle et al., 1999b). Juveniles will often use biogenic depressions, sand wave troughs, and possibly mollusk shell fields for shelter in winter (Steimle et al., 1999b).

*Adults*. EFH for adult scup is designated as those demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all estuaries where adult scup were identified as being common, abundant or highly abundant in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Adults are highly abundant in Nantucket Sound from May to September and common in October as indicated in the ELMR database. The distribution and abundance of adult scup off New England is temperature dependent (Mayo, 1982; Gabriel, 1992). As inshore water temperatures decline to less than 46 to 48 °F (8 to 9 °C) in winter, scup leave inshore waters and move to warmer waters in the Mid-Atlantic Bight (Steimle et al., 1999b). Thus, wintering adults (November through April) are primarily offshore, south of New York to North Carolina relative to the location of the 45 °F (7 °C) bottom isotherm, their lower preferred limit (Neville and Talbot, 1964). With rising temperatures in the spring, scup return inshore (Steimle et al., 1999b).

*Forage species*. Scup are benthic feeders, adult scup forage upon a variety of prey including zooplankton, small crabs, amphipods, cnidarians, squid, polychaetes, clams, mussels, snails, sand dollars, insect larvae, and vegetative detritus (Ross, 1991; Steimle et al., 1999b; Marine Fisheries, 2005). Smaller scup eat a larger proportion of cnidarians, polychaetes, amphipods, and mysid shrimp, whereas larger scup consume more squids and fishes (Collette and Klein-MacPhee, 2002).

**Black sea bass *(Centropristis striata)***

*Larvae*. For larval black sea bass, EFH is designated as the pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all the estuaries where larval black sea bass were identified as being common, abundant or highly abundant in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Larval black sea bass are not yet compiled in the ELMR database. Based on New England Fisheries Science Center (NEFSC) Marine Resources Monitoring Assessment and Prediction Program (MARMAP) ichthyoplankton surveys (Steimle et al., 1999a), larvae are generally found at water temperatures of 52 to 79 °F (11 to 26 °C) (55 to 70 °F [13 to 21 °C] preferred range). They were also collected at depths less than 328 ft (100 m), but several collections during May-July and October occurred over deeper (>656 ft [>200 m]) waters. The habitats for transforming (to juveniles) larvae are near the coastal areas and into marine parts of estuaries between New York and Virginia. When larvae become demersal, they are generally found on structured inshore habitat.

*Juveniles*. The demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras, are designated as EFH for juvenile black sea bass. EFH in inshore waters includes all estuaries where juvenile black sea bass were identified as being common, abundant or highly abundant in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Juveniles are common in Nantucket Sound from May to October as indicated in the ELMR database. Most juvenile settlement does not occur in estuaries, but in coastal areas (Steimle et al., 1999a). Recently settled juveniles then find their way into estuarine nurseries, where they will co-exist with other fish species in and around oyster beds (Steimle et al., 1999a). Older juveniles return to estuaries in late spring and early summer, and may follow the migration routes of adults into coastal waters (Steimle et al., 1999a). However, all juveniles seem to winter offshore, from New Jersey southward. Juvenile black sea bass are associated with rough and hardbottom substrate, shellfish and eelgrass beds, and man-made structures in sandy/shelly areas, as well as offshore clam beds and shell patches during the wintering. Some individuals may spend the warmer months along the coast in accumulations of surf clam and ocean quahog shells (Able et al., 1995).

Adults. EFH for adult black sea bass is also designated as those demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all estuaries where adult black sea bass were identified as being common, abundant or highly abundant in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Adults are common in Nantucket Sound from May to October as indicated in the ELMR database. They are heavily associated with man-made structures, rough and hardbottom substrate along the sides of navigational channels (Steimle et al., 1999a), shellfish and eelgrass beds, and sandy/shelly areas. Studies (Mercer, 1989) have found adult black sea bass to prefer depths of 66 to 197 ft (20 to 60 m).

*Forage species.* Juveniles feed upon a variety of benthic organisms such as shrimp, isopods and amphipods with mysid shrimp constituting more than half their food intake (Ross, 1991). Adults commonly feed upon rock crabs (*Cancer spp*.) and hermit crabs (*Pagurus spp*.) as well as other crustaceans (Ross, 1991) including juvenile American lobster (*Homarus americanus*) (Steimle et al., 1999a), mollusks and squid (Ross, 1991). Adults also occasionally graze upon attached organisms such as barnacles and colonial tunicates (Ross, 1991) as well as razor clams (*Siliqua patula*) (Marine Fisheries, 2005). Fishes including herring and anchovies (*Anchoa spp*.) are also a major component of the adult diet as well as other species such as, scup, sand lance and windowpane (Collette and Klein-MacPhee, 2002).

#### 4.2.8.2.2 Demersal Groundfish Species

**Winter flounder *(Pseudopleuronectes americanus)***

Eggs. EFH for winter flounder eggs consists of bottom habitat with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay. However, sand appears to be the most common associated substrate (Pereira et al., 1999). Winter flounder eggs are not yet compiled in the ELMR database.

Larvae. EFH for larval winter flounder is designated as pelagic and bottom waters of Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay. Winter flounder larvae are not yet compiled in the ELMR database.

"*Young-of-the-Year" Juveniles.* Winter flounder less than one year old (Young-of-the-Year, or YOY) are treated separately for this species because their habitat requirements are different from that of larger juveniles (>1 year) (Pereira et al., 1999). EFH includes bottom habitat with a substrate of mud or sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to Delaware Bay. Many studies reviewed in Pereira et al. (1999) confirm young winter flounder are plentiful along the east coast, especially in Massachusetts. In southern New England, newly metamorphosed YOY juveniles take up residence in shallow water where they may grow to larger juvenile sizes within the first year (Bigelow and Schroeder, 1953). Sandy coves appear to be the preferred habitat in the very shallow waters of estuaries and bays where they were spawned (Hildebrand and Schroeder, 1928). However, recent comparisons of habitat-specific patterns of abundance and distribution of YOY winter flounder in many Mid-Atlantic estuaries support the conclusion that habitat utilization by YOY winter flounder is not consistent across habitat types and is highly variable among systems and from year to year (Pereira et al., 1999; Goldberg et al., in prep).

Age 1+ Juveniles. Winter flounder juveniles older than one year have EFH in bottom habitats with a substrate of mud or fine-grained sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay. Juveniles are common, abundant, and highly abundant throughout the year in Nantucket Sound as indicated in the ELMR database. Older juveniles inhabiting estuaries gradually move seaward as they grow larger (Mulkana, 1966).

Adults. EFH for adult winter flounder consists of bottom habitat, including estuaries, with a substrate of mud, sand, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay. Adults are common, abundant, and highly abundant throughout the year in Nantucket Sound as indicated in the ELMR database. Traditionally, New England and the New York Metropolitan area have contained the most abundant populations (NUSC, 1989). MassDMF (2001b) survey trawls on Horseshoe Shoal have found winter flounder are relatively common during spring and rare during fall within the proposed action area.

Spawning Adults. For spawning winter flounder, EFH consists of bottom habitat, including estuaries, with a substrate of sand, mud, muddy sand, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay. Winter flounder adults undertake small-scale migrations into estuaries, embayments, and saltwater ponds from winter through spring to spawn. Winter flounder are most often observed spawning during the months of February to June with the peak spawning occurring during February and March south of Cape Cod (Goldberg et al., in prep). Typically, eggs are deposited over a sandy substrate at depths of 6.6 to 262.5 ft (2 to 80 m) (Bigelow and Schroeder, 1953), although most spawning takes place at depths less than 16.4 ft (5 m). Major egg production occurs in New England waters before temperatures go below 37.9 °F (3.3 °C) (Bigelow and Schroeder, 1953). After spawning, adults may remain in the spawning areas before moving to deeper waters when water temperatures reach 59 °F (15 $^{o}$C) (McCracken, 1963).

Forage species. Winter flounder have been described as omnivorous or opportunistic feeders, consuming a wide variety of prey; polychaetes and crustaceans (mostly amphipods) generally make up the bulk of the diet (Pereira et al., 1999). Juveniles feed heavily upon copepods, nemerteans, ostracods, amphipods, and polychaetes (Ross, 1991; Buckley, 1989). Adults feed primarily upon polychaetes, anthozoans (e.g., anemones) and amphipods (Bowman et al., 2000) however they also feed upon a great variety of other organisms including shrimp, small crabs, mollusks, squids, fish eggs, fish fry, vegetation, (Bowman et al., 2000; Ross, 1991) and rarely they will also eat fishes such as sand lance (Collette and Klein-MacPhee, 2002).

**Summer flounder or fluke *(Paralichthys dentatus)***

Eggs. EFH for summer flounder eggs is designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. Summer flounder eggs are not yet compiled in the ELMR database. Generally, summer flounder eggs are found between October and May, being most abundant between Cape Cod and Cape Hatteras, with the heaviest concentrations within 9 miles (14.5 km) offshore of New Jersey and New York. Able et al. (1990) found the highest frequencies of occurrence and greatest abundances of eggs in the northwest Atlantic occur in October and November. However, due to limited sampling in areas of southern New England in the month of December, this lifestage could be under represented.

Larvae. The pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras, are designated as EFH for summer flounder larvae. EFH in inshore waters includes all the estuaries where larval summer flounder were identified as being present (rare, common, abundant or highly abundant) in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Larvae are not yet compiled in the ELMR database. They are most frequently found in the northern part of the Mid-Atlantic Bight from September to February.

Juveniles. EFH for juvenile summer flounder consists of the demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all estuaries where juvenile summer flounder were identified as being present (rare, common, abundant or highly abundant) in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Juveniles are rare in Nantucket Sound from May to October as indicated by the ELMR database. In estuaries north of Chesapeake Bay, some juveniles remain in their estuarine habitat for 10 to 12 months before migrating offshore their second fall and winter (Packer et al., 1999). Generally, juvenile summer flounder use several different estuarine habitats as nursery areas, including salt marsh creeks, seagrass beds, mudflats, and open bay areas in a salinity range of 10 to 30 ppt.

Adults. Like juveniles, EFH for adult summer flounder also consists of the demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes all estuaries where adult summer flounder were identified as being present (rare, common, abundant or highly abundant) in the ELMR database for the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) salinity zones. Adults are common in Nantucket Sound from May to October as indicated by the ELMR database. The preferred substrate is sand, which is used to conceal themselves from predators and thus avoid predation. Summer flounder in Massachusetts migrate inshore in early May and occur along the entire shoal area south of Cape Cod and Buzzards Bay, Vineyard Sound, Nantucket Sound, and the coastal waters around Martha's Vineyard (Howe et al., 1997). MassDMF considers the shoal waters of Cape Cod Bay and the region east and south of Cape Cod, including all estuaries, bays, and harbors thereof, as critically important habitat (Packer et al., 1999). All of these designated areas are outside of the proposed action area and alternative sites in Nantucket Sound.

Studies by Burke (1991) and Burke et al. (1991) have made it clear that the summer flounder's distribution is due to substrate preference and is not affected by salinity. Summer flounder occupy a variety of habitats over sand, mud, and vegetated substrate including marsh creeks (Able and Fahay, 1998). Generally, adult summer flounder inhabit shallow coastal and estuarine waters during spring and summer, then move offshore during late summer and fall to the OCS to depths of 558 ft (170 m). Some evidence suggests that older adults may remain offshore all year (Festa, 1977).

HAPC for summer flounder is defined as all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH.

Forage species. Juveniles and smaller adults feed mostly upon mysid shrimp and other crustaceans (Ross, 1991; Collette and Klein-MacPhee, 2002), adults eat a variety of fishes, including small winter flounder, menhaden, sand lances, red hakes, silver hakes, anchovies, silversides, bluefish, weakfish, and mummichogs, as well as invertebrates such as blue crabs, squid, sand shrimp (*Crangon septemspinosa*), and mollusks (Ross, 1991; Collette and Klein-MacPhee, 2002). Weakfish, winter flounder and sand lance have been found to constitute the greatest volume of food eaten by summer flounder, although sand shrimp are also a major food for both juveniles and adults (Ross, 1991; Collette and Klein-MacPhee, 2002).

**Windowpane *(Scophthalmus aquosus)***

Adults. For adult windowpane, EFH exists in bottom habitats with a substrate of sand, fine-grained sand, or mud around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to the Virginia-North Carolina border. Adults are common and abundant in Nantucket Sound throughout the year as indicated by the ELMR database. Adults occur primarily on sand substrates off southern New England (Chang et al., 1999). MassDMF (2001b) survey trawls on Horseshoe Shoal have found windowpane are relatively common during spring and rare during fall within the proposed action area.

Spawning Adults. Spawning windowpane have designated EFH in bottom habitats with a substrate of mud or fine-grained sand in the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras. Aggregations of adults south of Cape Cod in spring suggest spawning activities may occur in the proposed action area (Chang et al., 1999). The seabed sediment composition of Nantucket Sound primarily consists of sand. Since the preference for spawning adults is fine-grained sand or mud, spawning activities may occur in the proposed action area. However, NMFS has not designated EFH in the proposed action area for eggs.

Forage species. The three major components of the windowpane diet are mysid shrimp, fishes and decapods (Bowman et al., 2000). Other prey items include chaetognaths, squids, mollusks, ascidians (sea squirts), polychaetes, cumaceans, isopods, amphipods, sand shrimp, and euphausiids (Bowman et al., 2000; Collette and Klein-MacPhee, 2002; Ross, 1991). Windowpane over 7.9 inches (20 cm) also feed on the aforementioned items but in addition prey on juvenile fishes such as anchovies, silver hake, tomcod, killifishes (i.e., mummichog and striped killifish), pipefish, longhorn sculpin, striped bass, sand lance, pollock, herring, and flatfishes (Bowman et al., 2000; Collette and Klein-MacPhee, 2002; Ross, 1991) as well as their own species (Chang et al., 1999).

**Yellowtail flounder *(Limanda ferruginea)***

Juveniles. EFH for juvenile yellowtail flounder is not present in Nantucket Sound but is within other areas of the designated EFH squares overlapping with Nantucket Sound. NMFS has not appointed specific regions of EFH in Nantucket Sound for this life stage (NEFMC, 1998).

#### 4.2.8.2.3 Coastal Pelagic Species

**Atlantic butterfish *(Peprilus triacanthus)***

Eggs. EFH for butterfish eggs is designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all estuaries where Atlantic butterfish eggs were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Atlantic butterfish eggs are not yet compiled in the ELMR database, but are considered common in Massachusetts Bay, Cape Cod Bay, Waquoit Bay, and Buzzards Bay (Cross et al., 1999).

Larvae. EFH for Atlantic butterfish larvae consists of those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH for inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where Atlantic butterfish larvae were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Atlantic butterfish eggs are not yet compiled in the ELMR database, but are considered common in Buzzards Bay and Waquoit Bay (Cross et al., 1999).

*Juveniles*. EFH for juvenile butterfish is designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where juvenile Atlantic butterfish were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Juveniles are abundant in Nantucket Sound from June to October, and common in November as indicated by the ELMR database.

*Adults*. EFH for adult butterfish also consists of the pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where adult Atlantic butterfish were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Adults are abundant in Nantucket Sound from June to October, and common in May and November as indicated by the ELMR database. Several studies in Cross et al. (1999) reveal adults will inhabit high salinity and mixed salinity zones of most estuaries from the Gulf of Maine to Florida. MassDMF (2001b) survey trawls on Horseshoe Shoal have found butterfish are rare during spring and more common during fall within the proposed action area.

*Forage Species*. In general butterfish predominantly prey upon urochordates (tunicates), but also are known to feed upon cnidarians (i.e., jellyfish, hydroids, anemones) and a wide variety of planktonic organisms (Bowman et al., 2000). Some other common prey items include mollusks (primarily squids), crustaceans (copepods, amphipods, and decapods), polychaetes, and small fishes (Cross et al., 1999). In addition, a ctenophore (comb jelly) (*Mnemiopsis leidyi*) has been shown to be an important component of the diet of butterfish juveniles in Narragansett Bay, R.I. (Collette and Klein-MacPhee, 2002).

**Atlantic mackerel *(Scomber scombrus)***

*Eggs*. EFH for Atlantic mackerel eggs is designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where Atlantic mackerel eggs were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Based on a Massachusetts coastal zone survey in Studholme et al. (1999), eggs in Nantucket Sound occur only randomly.

*Larvae*. EFH for Atlantic mackerel larvae is also designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where larval Atlantic mackerel were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Atlantic mackerel larvae are not yet compiled in the ELMR database. Based on a Massachusetts coastal zone survey in Studholme et al. (1999), larvae in Nantucket Sound occur only randomly.

*Juveniles*. EFH for juvenile Atlantic mackerel is designated as those pelagic waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing" (0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where juvenile Atlantic mackerel were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Juveniles are common in Nantucket Sound from August to November as indicated by the ELMR database. Based on a Massachusetts coastal zone survey in Studholme et al. (1999), juveniles in Nantucket Sound occur only randomly.

*Adults*. For adult Atlantic mackerel, EFH is also designated as those pelagic waters found over the continental shelf, from the Gulf of Maine to Cape Hatteras. EFH in inshore waters includes the "mixing"

(0.5 to 25.0 ppt) and "seawater" (>25 ppt) portions of all the estuaries where adult Atlantic mackerel were identified as being common, abundant or highly abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia. Adults are common in Nantucket Sound in March, April, and from October to December as indicated by the ELMR database. Based on a Massachusetts coastal zone survey in Studholme et al. (1999), adults in Nantucket Sound occur only randomly.

Forage species. These fish are opportunistic feeders that swallow prey whole. Food is acquired either through filter feeding or pursuit of individuals (Studholme et al., 1999). Juveniles will eat mostly small crustaceans such as copepods, amphipods, mysid shrimp (*Mysis spp*.), and decapod larvae (Studholme, 1999). Adults feed on the same foods as juveniles but their diet will additionally include larger prey items such as squid, silver hake, sand lance (*Ammodytes spp*.), and small herring (Collette and Klein-MacPhee, 2002) as well as young mackerel (Ross, 1991).

#### 4.2.8.2.4 Coastal Migratory Pelagic Species

The general NMFS EFH designation (NOAA Fisheries Service, 2006) for all the Coastal Migratory Pelagic Species listed below, except the bluefin tuna, includes the sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf Stream shoreward (including *Sargassum*), coastal inlets, and tidal estuaries. In addition, all coastal inlets in the South and Mid-Atlantic Bight are state-designated nursery habitats of particular importance to these species as well. However, the following species do not have a management plan in the North Atlantic, and are currently managed within the jurisdiction of the South Atlantic Fisheries Management Council. All are considered rare in Nantucket Sound, as their preference lies in warmer waters south of Chesapeake Bay. Therefore, no specific EFH designations exist within the proposed action area. More specific habitat characteristics taken from literature review and desktop analyses are described below.

**Bluefin tuna *(Thunnus thynnus)***

EFH is not present for the designated lifestages of bluefin tuna in the proposed action area within Nantucket Sound but is located further offshore within the designated EFH blocks that overlap with Nantucket Sound.

**King mackerel *(Scomberomorus cavalla)***

*Eggs*. Studies in Godcharles and Murphy (1986) reveal that king mackerel spawn in the coastal waters of the northern Gulf of Mexico, and off the southern Atlantic coast. There does not appear to be a well-defined area for spawning, but warm waters are preferred. There is no documentation found of king mackerel eggs occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics.

*Larvae*. King mackerel larvae have been collected near the surface on the Atlantic coast from May through October in surface water temperatures of 78.8 to 87.8 °F (26 to 31 $^{o}$C) and in a salinity range of 26 to 37 ppt (Godcharles and Murphy, 1986). Larval distribution indicates that spawning occurs in the western Atlantic off the Carolinas, Cape Canaveral and Miami, Florida. There does not appear to be a well-defined area for spawning. There is no documentation found of king mackerel larvae occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics.

*Juveniles*. There is no documentation found of juvenile king mackerel occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics. However, a small amount of landings have been reported from state-reportable fish weirs in Nantucket Sound according to the MassDMF commercial database.

Adults. King mackerel adults range from the Gulf of Maine to Rio de Janeiro, Brazil. However, they are most commonly found from the Chesapeake Bay southward (Chesapeake Bay Program, 2006). Migratory patterns are driven heavily by water temperature, preferring those greater than 68 °F (20 $^{o}$C). There is no documentation found of adults occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics. However, a small amount of landings have been reported from state-reportable fish weirs in Nantucket Sound according to the MassDMF commercial database.

Forage species. King mackerel are primarily pelagic carnivores, principally piscivorous but also showing a preference for invertebrates (Godcharles and Murphy, 1986). They feed primarily on fishes and in smaller quantities on squid (Collette and Klein-MacPhee, 2002). Menhaden are also an important prey species as well as other mackerel (Bowman et al., 2000).

**Spanish mackerel *(Scomberomorus maculatus)***

All life stages of Spanish mackerel are primarily seen in waters above 63.9 °F (17.7 $^{o}$C) and within a salinity range of 32 to 36 ppt (Godcharles and Murphy, 1986). There is no documentation found of Spanish mackerel lifestages occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics.

**Cobia *(Rachycentron canadum)***

There is no documentation found of cobia eggs, larvae, or juveniles occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics. Cobia adults range from Cape Cod to Argentina. They undergo extensive migrations from overwintering grounds near the Florida Keys to more northerly spawning/feeding grounds in spring and summer months (Richards, 1967). Cobia can be found in high salinity bays, estuaries, and seagrass habitat in a variety of locations over mud, gravel, or sand bottoms, coral reefs, and man-made sloughs. They often congregate along reefs and around buoys, pilings, wrecks, anchored boats, and other stationary or floating objects. There is no documentation found of adult cobia occurring at any regularity within the proposed action area, which has physical properties that are inconsistent with its preferred habitat characteristics.

#### 4.2.8.2.5 Sharks

The following shark species would most likely be rare around the proposed action area due to their preference for deeper waters outside of Nantucket Sound. Personal communications with the NMFS office in Gloucester, Massachusetts indicated that shark species EFH is located more offshore on the OCS, outside of Nantucket Sound.

**Blue shark *(Prionace glauca)***

Adults. Blue shark adults inhabit the pelagic, surface waters of tropical, subtropical, and temperate oceans worldwide. They are commonly found in the Cape Cod area during the summer months (New England Sharks, 2006), moving out to deeper water in late fall and winter (DFO, 2006). Blue sharks are not expected to occur within the proposed action area and were not documented in any of the agency databases for Nantucket Sound (see Appendix A of the EFH Assessment).

Forage species. A large proportion of the diet of the adult blue sharks in western Atlantic waters is made up of squid and octopods (Bowman et al., 2000). Fishes also constitute an important part of the blue sharks diet, with bluefish and red and silver hakes the most important, and mackerel, menhaden, Atlantic herring, and blueback herring also being common forage items (Ross, 1991).

**Shortfin mako shark *(Isurus oxyrhinchus)***

Late Juveniles/Subadults. EFH exists for juvenile shortfin mako sharks in the offshore waters between Cape Cod and Onslow Bay, NC, between the 82 and 6,652 foot (25 and 2000 m) isobaths; and extending west between 38°N and 41.5°N to the EEZ boundary. It is most commonly seen in offshore waters from Cape Cod to Cape Hatteras (Passarelli et al., 2006). Shortfin mako sharks are not expected to occur within the proposed action area.

Forage species. The mako feeds heavily upon a variety of fish species; one of the most important of these is the bluefish although mako will also eat small bodied schooling species such as mackerel and herring and larger fishes such as swordfish, bonito and tuna (Ross, 1991). Other fish species found in shortfin mako stomachs include blue shark, eel, menhaden, and butterfish (Bowman et al., 2000). In addition, squid are also commonly eaten but generally only in offshore areas (Collette and Klein-MacPhee, 2002).

#### 4.2.8.2.6 Skates

**Little skate *(Leucoraja erinacea)***

Juveniles. EFH for juvenile little skate has been designated for the areas of highest relative abundance for this species based on NMFS trawl survey (1963 to 1999) and ELMR data. Only habitats with sandy, gravelly, or mud substrates that occur within these areas of high abundance are designated as EFH (NOAA, 2006).

NEFSC bottom trawl surveys conducted between 1963 and 2002 (Reid et al., 1999) captured juvenile little skate year-round and showed that in the winter, juveniles were found from Georges Bank to Cape Hatteras, out to the 200 m (656 ft) depth contour, but were almost entirely absent from the Gulf of Maine. In spring they were also found from Georges Bank to Cape Hatteras, but were also heavily concentrated nearshore throughout the Mid-Atlantic Bight and southern New England as well as in Cape Cod and Massachusetts Bays. Both the spring and fall 1978-2002 Massachusetts inshore trawl surveys (Reid et al., 1999) show nearly identical abundances and distributions of juveniles around Nantucket and in Nantucket Sound, in Cape Cod Bay, along the Massachusetts coast and Broad Sound, and north of Cape Ann, with higher concentrations west and south of Martha's Vineyard. Along the inshore edge of its range, little skate moves onshore and offshore seasonally. They generally move into shallow water during the spring and into deeper water in the winter and may leave some estuaries for deeper water during warmer months.

Adults. EFH for adult little skate has been designated for the areas of highest relative abundance for this species based on NMFS trawl survey (1963-1999) and ELMR data. Only habitats with sandy, gravelly, or mud substrates that occur within these areas of high abundance are designated as EFH (Packer et al., 2003b).

NEFSC bottom trawl surveys (Reid et al., 1999) captured adult little skate during all seasons. The numbers of adults in spring and fall were much lower than for juveniles of the same two seasons. In winter, they were caught from Georges Bank to North Carolina, with very few in the Gulf of Maine. In spring they were also found from Georges Bank to North Carolina and, as with the juveniles, were also distributed nearshore throughout the Mid-Atlantic Bight and along Long Island as well as in Cape Cod and Massachusetts Bays. They had a limited distribution in the summer, being found mostly in southern New England, Georges Bank, Cape Cod Bay, in the Gulf of Maine near Penobscot Bay, and near Browns

Bank and the Northeast Channel. The distributions of adult little skate from both the spring and fall Massachusetts inshore trawl surveys (Reid et al., 1999) were similar to that of the juveniles, but with fewer numbers collected in all areas (including west and south of Martha's Vineyard).

*Forage species*. In general, little skate feed on benthic fishes and invertebrates (i.e., associated with the bottom) (Collette and Klein-MacPhee, 2002). Little skate from the Woods Hole region were found to contain mostly crabs, followed by sand shrimp (*Crangon septemspinosa*) and squid (Packer et al., 2003a), although overall the most important prey items for the species are decapod crustaceans (crabs) and amphipods followed by polychaetes (Bowman et al., 2000). Razor clams are also frequently taken (Ross, 1991). Fish prey include sand lance, alewives, herring, cunners, silversides, tomcod, and silver hake (Packer et al., 2003a), as well as sculpins and yellowtail flounder (Collette and Klein-MacPhee, 2002).

**Winter skate *(Leucoraja ocellata)***

*Juveniles*. EFH for juvenile winter skate has been designated for the areas of highest relative abundance for this species based on NMFS trawl survey (1963 to 1999) and ELMR data. Only habitats with a substrate of sand and gravel or mud that occur within these areas of high abundance are designated as EFH (Packer et al., 2003b).

NEFSC bottom trawl surveys conducted between 1963 and 2002 (Reid et al., 1999) captured juvenile winter skate year-round. In winter, juveniles were found from Georges Bank to Cape Hatteras, out to the 200 m (656 ft) depth contour, but were almost entirely absent from the Gulf of Maine. In spring they were also found from Georges Bank to Cape Hatteras, and were concentrated nearshore throughout the Mid-Atlantic Bight and southern New England as well as in Cape Cod and Massachusetts Bays. Comparatively few were present in summer, with concentrations on Georges Bank and around Cape Cod. Winter skate abundances in the fall were not as high as in the spring. In the fall they were collected from Georges Bank to the Delmarva Peninsula and were again concentrated along Long Island, southern New England, around Cape Cod, and on Georges Bank. Both the spring and fall 1978-2002 Massachusetts inshore trawl surveys (Reid et al., 1999) show similar abundances and distributions of juveniles. The highest concentrations were found on the Atlantic side of Cape Cod and south and west of Martha's Vineyard (especially in spring) and south and northeast of Nantucket (also in spring). Large numbers were also found near Monomoy Point in the fall. Other notable occurrences of winter skate were around Plum Island, Ipswich Bay, north of Cape Ann, near Nahant Bay (especially in the fall), in Cape Cod Bay, and in Nantucket Sound.

*Adults*. EFH for adult winter skate has been designated for the areas of highest relative abundance for this species based on NMFS trawl survey (1963 to 1999) and ELMR data. Only habitats with a substrate of sand and gravel or mud that occur within these areas of high abundance are designated as EFH (Packer et al., 2003b).

NEFSC bottom trawl surveys (Reid et al., 1999) captured adult winter skate during all seasons. The numbers of adults in spring and fall were much lower than for juveniles of the same two seasons. In winter, adult winter skate were scattered from Georges Bank to North Carolina; very few occurred in the Gulf of Maine. In the spring, they were also found from Georges Bank to North Carolina but, as with the juveniles, were also distributed nearshore throughout the Mid-Atlantic Bight and along Long Island as well as around Cape Cod and Massachusetts Bays. Few occurred in summer, being found mostly on Georges Bank, Nantucket Shoals, and near Cape Cod. In the fall, they were mostly confined to Georges Bank, near Nantucket shoals, and near Cape Cod, with very few found south of those areas. Adult little skate were collected in much fewer numbers than juveniles during the spring and fall Massachusetts inshore trawl surveys. The greatest numbers were found on the Atlantic side of Cape Cod and, in spring, south of Nantucket.

Forage species. In general, winter skate prey on fishes and invertebrates that are associated with the bottom. Prey include hydrozoans, gastropods, bivalves, squids, polychaetes, cumaceans, isopods, amphipods, mysids, euphausiids, pandalid shrimps, crangon shrimps, hermit crabs, cancer crabs, portunid crabs, rock crabs, razor clams, echinoderms, and fishes (Bowman et al., 2000; Ross, 1991). Out of the above prey mentioned, amphipods and polychaetes are the most common forage but fishes, decapod crustaceans, isopods, bivalves, and hydroids are also important (Packer et al., 2003b). Studies show that smaller individuals consume relatively more amphipods and cumaceans and larger specimens consume relatively more decapods, polychaetes and fishes (Collette and Klein-MacPhee, 2002). In general, fishes make up the majority of the diet of individuals larger than 7.8 inches (20 cm) (Bowman et al., 2000). Fish prey include skates, herring, alewife, blueback herring, menhaden, silver hake, red hake, tomcod, cod, smelts, sculpins, sand lance, cunner, butterfish, and summer and yellowtail flounders (Collette and Klein-MacPhee, 2002).

### 4.2.8.2.7 Invertebrates

**Long-finned squid *(Loligo pealei)***

Juveniles, or "Pre-recruits." EFH for long-finned squid pre-recruits consists of those pelagic waters over the continental shelf from the Gulf of Maine to Cape Hatteras. Older juveniles (sub-adults) are thought to overwinter in deeper waters along the edge of the continental shelf (Black et al., 1987). They were also collected in greater abundance during the fall than in spring, with concentrations in Buzzards Bay, around Martha's Vineyard and Nantucket Island, throughout Cape Cod Bay, in Massachusetts Bay, and north and south of Cape Ann. The spring concentrations occurred in Buzzards Bay and around Martha's Vineyard and Nantucket Island (Jacobson, 2005). Lower numbers of the pre-recruits in the inshore waters in spring was likely due to surveys taking place before the main part of the inshore migration (Jacobson, 2005).

Adults, or "Recruits." Adult long-finned squid also have EFH designated as the pelagic waters over the continental shelf from the Gulf of Maine to Cape Hatteras. Adults will migrate offshore during late fall and overwinter in warmer waters along the edge of the continental shelf, returning inshore during the spring and early summer (MAFMC, 1996b). Off Massachusetts, larger individuals migrate inshore in April-May to begin spawning, while smaller individuals move inshore during the summer (Lange, 1982). MassDMF (2001b) survey trawls on Horseshoe Shoal have found long-finned squid are abundant year round within the proposed action area.

Forage species. In general the diet of the long-finned squid changes with size; small immature individuals feed on planktonic organisms and polychaete worms, whereas larger individuals feed on small fish and crustaceans such as euphausiids (krill), small crabs and shrimp. (Cargnelli et al., 1999b). In addition, studies (Cargnelli et al., 1999b) stated that cannibalism is observed in individuals larger than 5 cm. Fish species preyed on by long-finned squid include silver hake, mackerel, herring, menhaden, sand lance, bay anchovy, menhaden, weakfish, and silversides (Cargnelli et al., 1999b).

**Short-finned squid *(Illex illecebrosus)***

Juveniles, or "Pre-recruits." EFH for juvenile short-finned squid is designated as those pelagic waters over the continental shelf from the Gulf of Maine to Cape Hatteras. Studies in Cargnelli et al. (1999a) state short-finned squid are highly migratory, moving offshore in the fall and not returning to the continental shelf until the following spring. The migratory paths during this time have not been thoroughly researched. In NEFSC Massachusetts surveys (Cargnelli et al., 1999a), very few juveniles were taken during the spring north of Nantucket, while only few were taken in the fall west of Nantucket and east of Cape Cod. Short-finned squid exist mainly in deeper waters, and are not particularly common within the proposed action area.

Adults, or "Recruits." For adult short-finned squid, EFH also exists in the pelagic waters over the continental shelf from the Gulf of Maine to Cape Hatteras. Studies in (Cargnelli et al., 1999a) state short-finned squid are highly migratory, moving offshore in the fall and not returning to the continental shelf until the following spring. The migratory paths during this time have not been thoroughly researched. In NEFSC Massachusetts surveys (Cargnelli et al., 1999a), as with the juvenile population, very few adults were taken during the spring in the coastal waters of Massachusetts, while more were taken in the fall west of Nantucket and east of Cape Cod. The distribution was found to correlate well with the species' inshore-offshore migrations (Cargnelli et al., 1999a). In general, there are more adults present in the spring than juveniles due to size-related differences in the timing of migration (i.e., larger individuals migrate inshore earlier in the spring) (Cargnelli et al., 1999a). Short-finned squid exist mainly in deeper waters and are not particularly common within the proposed action area.

Forage species. Northern shortfin squid feed primarily on fish, squid and crustaceans. Fish prey include the early life history stages of Atlantic cod, sand lance, mackerel, Atlantic herring, sculpin, and mummichogs as well as longfin inshore squid, cannibalism is also significant among this species (Hendrickson and Holmes, 2004). Studies in (Hendrickson and Holmes, 2004) also state that when the shortfin squid are inshore in the summer and fall they primarily consume fish and squid.

**Surf clam *(Spisula solidissima)***

Juveniles and Adults. Because of the wide variability in age at maturity, juvenile and adult surf clams are discussed together (Cargnelli et al., 1999c). EFH for both life stages exists within the substrate to a depth of 3.3 ft (1 m) below the water/sediment interface, from the Gulf of Maine and eastern Georges Bank throughout the Atlantic EEZ. Studies reviewed in Cargnelli et al. (1999c) have shown the greatest concentration of surf clams are usually found in well-sorted, medium-grained sand, and are most common at depths of 26.2 to 216.5 ft (8 to 66 m) in the turbulent areas beyond the breaker zone.

Forage species. In general, Atlantic surf clams are planktivorous siphon feeders (Cargnelli et al., 1999c). Studies in (Cargnelli et al., 1999c) noted the presence of many genera and species of diatoms (a unicellular organism) in the guts of Atlantic surf clams although ciliates (unicellular free-living protists) were also found to be a common component of their diet (Cargnelli et al., 1999c).

### *4.2.8.3 Landings Data for EFH Species*

Both NOAA Fisheries and MassDMF monitor certain commercial and recreational fishing activities within Nantucket Sound. NOAA Fisheries monitors federally-permitted commercial and recreational fishing activities in all coastal states throughout the United States. The Commonwealth of Massachusetts monitors state-permitted commercial fishing activities in its coastal waters for certain fisheries and gear types. In addition, a valuable source of resource data available for Nantucket Sound is the MassDMF independent fisheries monitoring program. For more details on these datasets, please see Report No. 4.2.7-1 and Report No. 4.2.5-5. Using these agency database sources, the following were reviewed to determine the occurrence and relative reported landings of species with designated EFH in Nantucket Sound:

- Commercial catch data monitored by NOAA Fisheries and reported on NOAA VTRs by federally-permitted vessels fishing in Nantucket Sound
- Commercial catch data monitored by MassDMF and reported by state-permitted vessels fishing in Nantucket Sound
- Recreational fishery information obtained from the NOAA Fisheries MRFSS for three counties surrounding Nantucket Sound (Dukes, Nantucket, and Barnstable)

- Recreational catch data reported by federally-permitted charter or party boats fishing in Nantucket Sound
- MassDMF bi-annual resource trawls for Nantucket Sound (information gathered is for state resource assessment and management purposes and is independent of commercial fisheries activities)

A summary table listing which databases reported the presence of the EFH designated species is provided in Table 4.2.8-2. The detailed reported landings and catch data for these species according to the NOAA and MassDMF databases are summarized below.

**Atlantic cod**

This species was documented by the NOAA VTR commercial landings database, NOAA Fisheries MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), cod was reported in six of the years with a total of 2,865 lb (1,299.5 kg) harvested from Nantucket Sound.
- The numbers of Atlantic cod observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 278 from party/charter boats and 38 from private/rental boats.
- During the eleven years of MassDMF commercial data landings (1994-2004), gill nets were fished in Nantucket Sound only five of the years. Cod was reported in three of five of the years with a total of 3,346 lb (1,517.7 kg) harvested from the Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, Atlantic cod was reported in one year in the fall with a total of 6 individuals caught and in every year in the spring with a total of 4,768 individuals caught.

**Scup**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), scup was reported every year with a total of 564,380 lb (564,380 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), scup was reported every year with a total of 508,129 individuals harvested from Nantucket Sound.
- The numbers of scup observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 192 from shore, 2,472 from party/charter boats and 566 from private/rental boats.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), scup was reported every year with a total of 1,583,567 lb (718,293.9 kg) harvested from Nantucket Sound. Scup was also reported in the eleven years of fish

pots landings (1994-2004) with a total of 1,307,897 lb (593,250 kg) harvested from Nantucket Sound.

- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, scup was reported in every year in the fall with a total of 1,559,537 individuals caught and in every year in the spring with a total of 27,616 individuals caught.

**Black sea bass**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), black sea bass was reported every year with a total of 736,861 lb (334,235.5 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), black sea bass was reported every year with a total of 58,871 individuals harvested from Nantucket Sound.
- The numbers of black sea bass observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 10 from shore, 186 from party/charter boats and 102 from private/rental boats.
- During the fifteen years of MassDMF commercial data landings for fish weirs and fish pots (1990-2004), black sea bass was reported in four of the years with a total of 63,929 lb (28,997.7 kg) harvested from Nantucket Sound and in every year with a total of 2,837,308 lb (1,286,981.3 kg) harvested from Nantucket Sound, respectfully.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, black sea bass was reported in every year in the fall with a total of 64,950 individuals caught and in 25 of the years in the spring with a total of 891 individuals caught.

**Winter flounder**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), winter flounder was reported every year with a total of 77,961 lb (35,362.5 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), winter flounder was reported in eight of the years with a total of 169 individuals harvested from Nantucket Sound. An additional 5 lb of unspecified flounder was harvested in 1995.
- The numbers of winter flounder observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 87 from shore, 38 from party/charter boats and 415 from private/rental boats.

- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), winter flounder was reported in four of the years with a total of 2,093 lb (949.4 kg) harvested from Nantucket Sound. An additional 376 lb (170.5 kg) of unclassified flounder was harvested from the Sound using fish weirs. Gill nets were fished in only five out of eleven years (1994-2004) according to MassDMF commercial data landings. Winter flounder was reported in three of the five years with a total of 2,549 lb (1156.2 kg) harvested and an additional 43 lb (19.5 kg) of unclassified flounder harvested from gill nets in Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, Atlantic cod was reported in 26 of the years in the fall with a total of 1,094 individuals caught and in every year in the spring with a total of 13,451 individuals caught.

**Summer flounder**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), summer flounder was reported every year with a total of 912,017 lb (413,683.9 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), summer flounder was reported every year with a total of 6,036 individuals harvested from Nantucket Sound.
- The numbers of summer flounder observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 63 from shore, 60 from party/charter boats and 664 from private/rental boats.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), summer flounder was reported in every year with a total of 54,311 lb (24,635 kg) harvested from Nantucket Sound. Gill nets were fished in only five out of eleven years (1994-2004) according to MassDMF commercial data landings. Summer flounder was reported in three of the five years with a total of only 112 lb (50.8 kg) harvested from gill nets in Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, summer flounder was reported in every year in the fall and spring with a total of 1,509 individuals and 846 individuals caught, respectively.

**Windowpane**

This species was documented by the NOAA VTR commercial landings database, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), windowpane was reported in seven of the years with a total of 2,981 lb (1,352.2 kg) harvested from Nantucket Sound.

- The numbers of windowpane observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 31 from shore and three from private/rental boats.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, windowpane was reported in every year in the fall and spring with a total of 655 individuals and 18,768 individuals caught, respectively.

**Yellowtail flounder**

This species was documented by the NOAA VTR commercial landings database, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), yellowtail flounder was reported in four of the years with a total of 2,981 lb (1,352.2 kg) harvested from Nantucket Sound.
- The numbers of yellowtail flounder observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 1 from shore and 2 from private/rental boats.
- During the eleven years of MassDMF commercial data landings (1994-2004), gill nets were fished in only five of the years. Yellowtail flounder was reported in three of the five years with a total of 3,862 lb (1751.8 kg) harvested from gill nets in the Sound.
- During the 26 years of MassDMF spring data in Nantucket Sound, yellowtail flounder was reported in nine of the years with a total of only 14 individuals caught. Yellowtail founder was not reported in any of MassDMF fall resource trawl data in Nantucket Sound over the 27 year period.

**Atlantic butterfish**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), Atlantic butterfish was reported in nine of the years with a total of 70,034 lb (31,766.9 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), Atlantic butterfish was reported in two of the years with a total of 2 individuals harvested from Nantucket Sound.
- The numbers of Atlantic butterfish observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 9 from shore.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), Atlantic butterfish were reported in every year with a total of 191,814 lb (87,005.4 kg) harvested from Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, Atlantic butterfish was reported in every year in the fall with a total of

217,038 individuals caught and in 24 of the years in the spring with a total of 6,579 individuals caught.

**Atlantic mackerel**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, MassDMF commercial database, and the MassDMF resource trawl spring survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), Atlantic mackerel was reported in eight of the years with a total of 1,269,104 lb (575,655.9 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), Atlantic mackerel was reported in two of the years with a total of 2 individuals harvested from Nantucket Sound.
- The numbers of Atlantic mackerel observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 453 from shore, 25 from party/charter boats and 1 from private/rental boats.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), Atlantic mackerel were reported in every year with a total of 5,785,313 lb (2,624,173.8 kg) harvested from Nantucket Sound. Gill nets were fished in only five out of eleven years (1994-2004) according to MassDMF commercial data landings. Atlantic mackerel was reported in three of the five years with a total of 6,305 lb (2,859.9 kg) harvested from Nantucket Sound.
- During the 26 years of MassDMF spring data in Nantucket Sound, Atlantic mackerel was reported in 10 of the years in the spring with a total of 68 individuals caught. Atlantic mackerel was not reported in any of MassDMF fall resource trawl data in Nantucket Sound over the 27 year period.

**King mackerel**

This species was documented by the MassDMF commercial database only.

- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), king mackerel was reported in twelve of the years with a total of 4,910 lb (2,227.1 kg) harvested from Nantucket Sound. King mackerel was not reported in MassDMF commercial data landings for any other fishery or gear type in Nantucket Sound.

**Spanish mackerel**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, NOAA MRFSS database, and the MassDMF commercial database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), Spanish mackerel was reported in one of the years with a total of only 4 lb (1.8 kg) harvested in Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), Spanish mackerel was reported in one of the years with a total of only 1 individual harvested in Nantucket Sound.

- The numbers of Spanish mackerel observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 5 from shore and 1 from private/rental boats.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), Spanish mackerel was reported in fourteen of the years with a total of 67,687 lb (30,702.3 kg) harvested from Nantucket Sound.

**Cobia**

This species was not reported in any of the five databases.

**Blue shark**

This species was not reported in any of the five databases. The MFRSS survey reported shark, but it was not classified to the species level.

**Shortfin mako shark**

This species was documented by the NOAA MRFSS database only.

- The numbers of shortfin mako shark observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 1 from party/charter boats and 1 from private/rental boats.

**Bluefin tuna**

This species was documented by the NOAA VTR commercial landings database and the NOAA MRFSS database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), bluefin tuna was reported in only one of the years with a total of 375 lb (170 kg) harvested from Nantucket Sound.
- The numbers of bluefin tuna observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 16 from private/rental boats.

**Little skate**

The NOAA VTR commercial and recreational charter landings databases and the MassDMF commercial database reported landings for unspecified skate species. The NOAA MRFSS database and the MassDMF resource trawl spring and fall survey database reported landings specifically for little skate.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), unspecified skate species was reported in ten of the years with a total of 12,792 lb (5,802.3 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), unspecified skate species was reported in ten of the years with a total of 174 individuals harvested from Nantucket Sound.
- The numbers of little skates observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 4 from private/rental boats. In addition, one unspecified skate was observed from private/rental boats.

- During the eleven years of MassDMF commercial data landings (1994-2004), gill nets were fished in only five of the years. Unclassified skates were reported in one of the five years with a total of 371 lb (168.3 kg) harvested from Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, little skate was reported in every year in the fall and spring with a total of 6,534 individuals and 6,794 individuals caught, respectively.

**Winter skate**

The NOAA VTR commercial and recreational charter landings databases and the MassDMF commercial database reported landings for unspecified skate species. The NOAA MRFSS database and the MassDMF resource trawl spring and fall survey database reported landings specifically for winter skate.

- For NOAA commercial VTR data and recreational charter VTR data landings, see above.
- The numbers of winter skate observed by MRFSS survey interviewers from 1990-2004 in three counties surrounding Nantucket Sound were: 1 from private/rental boats.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, winter skate was reported in every year in the fall and spring with a total of 4,205 individuals and 5,481 individuals caught, respectively.

**Long-finned squid**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, MassDMF commercial database (not specific to species), and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), long-finned squid was reported in every year with a total of 3,583,134 lb (1,625,282.2 kg) harvested from Nantucket Sound. An additional 169,825 lb (77,031.3 kg) of unspecified squid was harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), long-finned squid was reported in seven of the years with a total of 19,680 individuals harvested from Nantucket Sound. An additional 1,031 lb (467.7 kg) of unspecified squid was harvested from Nantucket Sound.
- During the fifteen years of MassDMF commercial data landings for fish weirs (1990-2004), unclassified squid were reported in every year with a total of 4,726,815 lb (2,144,047.2 kg) harvested from Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, long-finned squid was reported in every year in the fall and spring with a total of 228,817 individuals and 54,408 individuals caught, respectively.

**Short-finned squid**

This species was documented by the NOAA VTR commercial and recreational charter landings databases, MassDMF commercial database (not specific to species), and the MassDMF resource trawl spring survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), short-finned squid was reported in six of the years with a total of 79,152 lb (35,902.7 kg) harvested from Nantucket Sound.
- During the eleven years of NOAA recreational charter VTR data landings (1994-2004), short-finned squid was reported in one of the years with a total of 500 individuals harvested from Nantucket Sound.
- During the 26 years of MassDMF spring data in Nantucket Sound, short-finned squid was reported in one of the years with a total of 1 caught in the spring. Short-finned squid was not reported in any of MassDMF fall resource trawl data in Nantucket Sound over the 27 year period.

**Surf clam**

This species was documented by the NOAA VTR commercial landings database (not specific to species), MassDMF commercial database, and the MassDMF resource trawl spring and fall survey database.

- During the eleven years of NOAA commercial VTR data landings (1994-2004), an unspecified clam species was reported in two of the years with a total of 137,936 lb (62,566.7 kg) harvested from Nantucket Sound.
- During the fifteen years of MassDMF commercial data landings for fish pots (1990-2004), surf clam was reported in six of the years with a total of 12,816,980 lb (5,813,684.3 kg) harvested from Nantucket Sound.
- During the 27 years of MassDMF fall data and 26 years of spring data in Nantucket Sound, surf clam was reported in thirteen of the years in the fall with a total of 61 individuals caught and in eight of the years in the spring with a total of 17 individuals caught.

## 4.2.9 Threatened and Endangered (T&E) Species

### *4.2.9.1 Introduction*

This section provides an overview of the species in the area of the proposed action that are protected under the Endangered Species Act (ESA). More detailed information on the presence of federally-listed species in the area of the proposed action and potential impacts to these species from the proposed action is included in the Biological Assessment (BA) in Appendix G. The MMS, as the lead federal NEPA agency for the proposed action, is mandated by Section 7 of the ESA to consult with the Department of Commerce (via NOAA Fisheries Service) and the Secretary of the Interior (via U.S. Fish & Wildlife Service [FWS]) to determine if any species protected under the ESA may be affected by the proposed action. MMS submitted a BA to these agencies in May 2008 to initiate formal consultation which includes the evaluation of potential impacts from the proposed action on listed species and designated critical habitat. The outcome of these consultations and reviews, in the form of a Biological Opinion, assesses whether the action is likely to "...jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species" (50 CFR Part 402). Where possible, requirements and recommendations would be provided within these

Biological Opinions as to how the potential for impacts from the proposed action can be minimized or eliminated. Further, an Incidental Take Statement (ITS) may be given, allowing the unintentional "taking' of listed species based on certain conditions.

### 4.2.9.2 Studies Completed

Review of scientific literature, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of marine mammal and turtle species have been conducted within Nantucket Sound. A literature search targeting threatened and endangered whale, and reptile species in Nantucket Sound and acoustical impacts to marine mammals and reptiles was conducted to obtain information on marine species in Nantucket Sound and potential impacts of the proposed action to these resources. In addition, researchers from the Protected Resources Branch at the NMFS Northeast Fisheries Science Center, the Sea Turtle Stranding and Salvage Network, the Provincetown Center for Coastal Studies, and the University of Rhode Island, were contacted by the applicant to obtain additional stock assessment, sighting, stranding, and population studies information. MMS has also worked with the staff at NOAA Fisheries during development of this EIS and the associated BA.

In addition, a similar approach to gathering data was followed in order to characterize those protected species under the jurisdiction of the FWS, including three bird species, a beetle, and a rabbit species. Of these five species, three are listed as threatened or endangered under the ESA (roseate tern [*Sterna dougallii*], piping plover [*Charadrius melodus*] and northeastern beach tiger beetle [*Cicindela dorsalis dorsalis*]) and two as candidate species (red knot [*Calidris canutus rufa*] and New England cottontail [*Sylvilagus transitionalis*]). In its formal consultation request to the USFWS, MMS requested consultation for the roseate tern and piping plover since they are species listed as threatened or endangered with the potential to occur in the project area. In addition, as part of the formal consultation process, the FWS updated its list of threatened or endangered species that may occur in the area of the proposed action. In a FWS letter to MMS, dated September 30, 2008 (in Appendix B), the northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) was identified as being on the periphery of the project area with the potential to be adversely affected in the event of an oil spill attributable to the proposed action. MMS was requested to amend its BA to include an independent analysis and effects determination. The MMS BA amendment letter is included in Appendix G, and information on this beetle has been added to the FEIS. This EIS also contains an analysis on the two candidate species in order to assess the potential for impacts and, where appropriate, determine if measures are needed to minimize or eliminate such impacts.

The applicant also conducted extensive studies of the avifauna, and Massachusetts Audubon Society also performed studies, only some of which relate to listed bird species. The information gathered during this research is the best available scientific and commercial information and is used to determine the potential impacts of the proposed action in Section 5.3.2.6.

### 4.2.9.3 Resource Characterization

While initial FWS letters indicated there are no federally-listed or proposed threatened or endangered species located within the proposed onshore transmission cable system route to the Barnstable Switching Station, with the exception of the occasional transient bald eagle (*Haliaeetus leucocephalus*) (Appendix G), their September 30, 2008 letter (Appendix B) identified the threatened northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) as potentially occurring on beaches in the project area, therefore this species has been added to this analysis. Since the applicant filed its application for the proposed action the bald eagle has been de-listed, and is therefore not discussed in this document. There are two listed birds, the roseate tern **(***Sterna dougallii)* and the piping plover (*Charadrius melodus*) that have the potential to occur in the area of the proposed action, as well as the candidate species, the red knot

(*Calidris canutus rufa*). An additional candidate species in the proposed action area is the New England Cottontail (*Sylvilagus transitionalis*).

The proposed transmission cable landfall for the proposed action is located approximately 0.8 miles (1.3 km) from the nearest known nesting sites of piping plover on Great Island and 1.5 miles (2.4 km) from nesting sites at Kalmus Beach/Dunbar Point, Hyannis and the north-western corner of Great Island. The proposed action's buried cables (at their closest point to nesting sites) would pass within approximately 820 ft (250 m) of Kalmus Beach/Dunbar Point and approximately 1,210 ft (369 m) of Great Island. Support vessels associated with the proposed action's cable installation would pass within approximately 670 ft (204 m) of Kalmus Beach/Dunbar Point and 1,060 ft (323 m) of Great Island (Report No. 4.2.9-1).

The NOAA Fisheries consultation has led to the identification of three whales and four sea turtles as having the potential to occur in the area of the proposed action. The whale species include the humpback whale (*Megaptera novaeangliae*), the fin whale (*Balaenoptera physalus*), and the North Atlantic right whale (*Eubalaena glacialis*). Three other listed whale species, the sperm (*Physeter macrocephalus*), sei (*Balaenoptera borealis*), and blue (*Balaenoptera musculus*) do not occur in the project area, as all of these species occur in deep offshore waters. The sea turtle species include the loggerhead sea turtle (*Caretta caretta*), the Kemp's ridley sea turtle (*Lepidochelys kempi*), the leatherback sea turtle (*Dermochelys coriacea*), and the green sea turtle (*Chelonia mydas*).

A brief overview of the life history characteristics for these species is provided below, and a summary overview of the potential impacts is provided in Section 5.3.2.9. For a detailed presentation of the characteristics of the T&E species that have been identified as potentially occurring in the area of the proposed action and potential impacts associated with the project (see the BA in Appendix G). Detailed presentation of information on the red knot and the New England cottontail are provided below, and in Section 5.3.2.9, but not in the BA in Appendix G, since these are candidate species under the ESA.

**Humpback Whale (*Megaptera novaeangliae*)**

Humpback whales (*Megaptera novaeangliae*) occur throughout the world. Humpback whales are opportunistic feeders, and prey on a variety of pelagic crustaceans and small fish (Nemoto, 1970; Kreiger and Wing, 1984). There are three primary feeding aggregations in the Western Atlantic: the U.S. east coast (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, and Western Greenland (Waring et al., 2006). Humpback whales are a migratory species, feeding in the northern latitudes during the summer months and migrating to the West Indies during winter months to mate and calve (Waring et al., 2006). Humpback whales regularly visit the area of southern New England, where they are present in greatest abundance between June and September (Payne and Heinemann, 1990; Sadove and Cardinale, 1993). Located offshore from Nantucket Sound are primary feeding grounds for humpback whales, mainly supplying whales from the Gulf of Maine feeding aggregation. Few humpback whales are sighted within Nantucket Sound since they favor locations further north for feeding grounds, as prey species are not plentiful within the Sound (Kenney and Winn, 1986).

Humpback whales were first listed as an endangered species in the U.S. in 1970. The best estimate for humpback whales in the Gulf of Maine is 847 individuals based on surveys conducted in August 2006 from the southern Gulf of Maine to the upper Bay of Fundy to the Gulf of St. Lawrence (Waring et al., 2007). Current data suggests that the Gulf of Maine stock is increasing in size.

Between 2001 and 2005, the minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine humpback whale stock averaged 4.2 animals per year (Waring et al., 2007). This is based on three causes: (1) incidental fishery interactions; (2) vessel collisions; and (3) direct takes (this occurred during winter breeding periods in the south) (Waring et al., 2006). The most common source of mortality for humpback whales in the western North Atlantic is entanglement in commercial fishing gear, particularly off Newfoundland (O'Hara et al., 1986; Lien et al., 1989 a, b; Hofman, 1990; Volgenau and Kraus, 1990; NMFS, 1991). The second major anthropogenic source of mortality for humpback whales in the New England is collisions with vessels. In NMFS records from 1999 to 2003, 15 humpback whales were recorded as been struck by a vessel, 6 of which resulted in mortalities.

**Fin Whale (*Balaenoptera physalus*)**

Fin whales (*Balaenoptera physalus*) are large whales found in the temperate waters of the western North Atlantic. Fin whales feed on a wide variety of small schooling fish and crustaceans, primarily capelin (Piatt et al., 1989). Fin whales range along the continental shelf between Cape Hatteras and southeastern Canada (Hain et al., 1992). Stocks of fin whales from the Gulf of Maine, Nova Scotia and Labrador are believed to be of one or a few closely related populations (Waring et al., 2006). Fin whales occur in Massachusetts waters from mid March to the end of November, in important feeding grounds of New England waters, specifically the areas around Jeffrey's Ledge, Stellwagen Bank, and Cape Cod Bay with few sightings within Nantucket Sound (NOAA Fisheries Service, 2005).

Fin whales were listed as endangered throughout their range in 1970. The best available estimates of the western North Atlantic fin whale stock is 2,269 based on surveys conducted in August 2006 from the southern Gulf of Maine to the upper Bay of Fundy to the Gulf of St. Lawrence (Waring et al., 2007).

While there is little published information about natural and anthropogenic causes of mortality in fin whales, it can be assumed that the hazards that affect humpback whales would also affect fin whales. According to NMFS records from 2001 through 2005, the minimum annual rate of human-caused mortality and serious injury to finwhales was 2.4 per year, 0.8 resulted from incidental fishing interaction and 1.6 resulted from vessel strikes (Waring et al., 2007).

**North Atlantic Right Whale (*Eubalaena glacialis*)**

The North Atlantic right whale (*Eubalaena glacialis*) is the rarest of the larger whales. The primary food of right whales in the western North Atlantic is calanoid copepods, *Calanus finmarchicus*, and juvenile euphausiids (Nemoto, 1970; Murison and Gaskin, 1989). Right whales are migratory animals, with seasonal movements including "high use" of areas from spring to fall within Cape Cod Bay, Massachusetts Bay, Georges Bank and the Gulf of Maine (Waring et al., 2006). The Great South Channel and Cape Cod Bay have been designated as critical habitat for the North Atlantic right whale, and considered to be essential for the recovery of the population (Report No. 4.2.9-2). North Atlantic right whales may occasionally occur in Nantucket Sound; however, as the waters are too shallow and not productive enough for the whale's prey, their occurrence would be considered "rare and transient."

The North Atlantic right whale has been listed as endangered under the ESA since 1973. The western North Atlantic population size was estimated to be at least 313 individuals in 2002 based on a census of individual whales identified using photo-identification techniques (Waring et al., 2007). This value is a minimum and does not include animals that were alive prior to 2002, but not recorded in the individual sightings database as seen from January 1, 2002 to June 15, 2005. It also does not include any calves known to be born during 2002, but not yet entered as new animals in the catalog.

For the period 2001 through 2005, the minimum rate of annual human-caused mortality and serious injury to right whales averaged 3.2 per year (U.S. waters, 2.0; Canadian waters, 1.2). This is derived from two components: 1) non-observed fishery entanglement records at 1.4 per year (U.S. waters, 0.4; Canadian waters, 1.0), and 2) ship strike records at 1.8 per year (U.S. waters, 1.6; Canadian waters, 0.2) (Waring et al. 2007). Researchers believe that North Atlantic right whales are more susceptible to strikes due to the characteristics of slow swimming, feeding at the surface, and preferring nearshore waters. Entanglement in fishing gear is the second leading cause of mortality in North Atlantic right whales; over half of the photographed population has some scaring from fishing gear entanglements (Waring et al., 2006).

**Loggerhead Turtle (*Caretta caretta*)**

The loggerhead sea turtle (*Caretta caretta*) is a turtle that seasonably inhabits the inshore coastal waters of the North Atlantic. Adult loggerheads are primarily bottom feeders, foraging in coastal waters for benthic mollusks and crustaceans (Bjorndal, 1985). The range of the loggerhead sea turtle extends from Newfoundland to Argentina. Loggerhead turtles are abundant in the northeast from May 1 through November 15 when water temperatures are favorable (NOAA, 2005). During the spring and summer months, loggerhead turtles are commonly found in the waters off New York, with a small number of individuals, mostly comprised of juveniles, reaching as far north as New England (NOAA, 2005). There have been no direct surveys of loggerhead turtles along the North Atlantic Coast, the best available estimates for the proposed action area can be obtained through incidental observation of sea turtles made by the MAS from 2002 through 2004 during boat tern surveys. During this survey in the waters of Nantucket Sound, 115 individuals were recorded, identified as leatherback, non-leatherback and unidentifiable, of which only 14 were located within the proposed action area and 10 identified as non-leatherback or unidentifiable (MAS, 2005). The loggerhead sea turtle was listed as threatened under the ESA throughout its range in 1978, and its status has not changed.

While the causes of loggerhead sea turtle strandings, whether human-caused or natural, are not well understood, between four and seven strandings per year have been recorded in the waters Massachusetts and Rhode Island from 1990 to 2000, and 11 loggerhead strandings were recorded on the shorelines of Nantucket and Martha's Vineyard from 1980 through 1997 (NMFS, 2002 unpublished data). Strandings occur most frequently in the fall and winter, presumably caused by cold stunning due to prolonged exposure to lower water temperatures (Morreale et al., 1992; Matassa et al., 1994). Human-caused mortality of loggerhead turtles includes incidental take, fishing gear and marine debris entanglement and ingestion, and loss of nesting habitat (NOAA, 2005).

**Kemp's Ridley Turtle (*Lepidochelys kempii*)**

The Kemp's ridley sea turtle (*Lepidochelys kempii*) is distributed through coastal areas of the Gulf of Mexico and northwestern Atlantic Ocean. Juveniles, representing the greatest proportion of Kemp's ridley sea turtles in the North Atlantic forage in shallow coastal waters, usually in waters less than 3 ft (1 m) deep (Ogren, 1989), but tend to move into deeper water as they grow. Young Kimp's ridley sea turtles consume several species of crabs, and crustaceans represent more than 80 percent of their diet (Burke et al., 1994). Adult Kemp's ridley sea turtles are found mainly in the Gulf of Mexico, while juveniles use northeast and mid-Atlantic coastal waters during the summer months as primary developmental habitat. Kemp's ridley turtles feed in the shallow nearshore waters of Vineyard Sound and Buzzards Bay in summer months, and may be present in the vicinity of Nantucket Sound through the fall (Burke et al., 1989; Morreale and Standora, 1989; Keniath et al., 1987; Musick and Limpus, 1997). The Kemp's ridley sea turtle was listed as endangered under the ESA in 1970.

For the period of 1990 to 2000, between nine and 216 Kemp's ridley sea turtle strandings were reported in Massachusetts waters, and one Kemp's ridley sea turtle stranding was reported in Rhode Island waters (Sea Turtle Stranding and Salvage Network, unpublished data). Each year between November and January when ocean water temperatures are falling, small numbers of Kemp's ridley sea turtles become stranded and die on beaches of the north and east shores of Long Island and Cape Cod Bay, due to cold stunning (NOAA, 1991; Morreale and Standora, 1992). Other human-caused mortality of Kemp's ridley sea turtles include incidental take, fishing gear and marine debris entanglement and ingestion, chemical pollution, and loss of nesting habitat (NOAA, 2005).

### Leatherback Turtle (*Dermochelys coriacea*)

Leatherback sea turtles (*Dermochelys coriacea*) are found in temperate and tropical waters. They are common turtle along the eastern United States and the most common north of 42° N latitude. They are pelagic feeders preying on zooplankton; they can dive to considerable depths of at least 1000 m (Eckert et al., 1989). The seasonable distribution of leatherback sea turtles in the North Atlantic waters range from Cape Sable, Nova Scotia south to Puerto Rico and the U.S. Virgin Islands. Leatherback sea turtles can be expected to be present in Nantucket Sound when water temperatures are favorable, from early summer through late fall. Leatherback sea turtles are more commonly reported in Massachusetts waters than other sea turtle species, and densities are likely associated with inshore concentrations of jellyfish. The leatherback sea turtle was listed as endangered throughout its range in 1970 under the ESA.

Incidental observation of sea turtles made by the MAS from 2002 to 2004 during tern surveys recorded 115 individuals in the waters of Nantucket Sound, of which only 14 were located within the proposed action area and 12 were identified as leatherback sea turtles or unidentifiable (MAS, 2005). Leatherbacks sea turtles are highly vulnerable to entanglement in fishing gear; 6,363 individual turtles were caught by U.S. Atlantic tuna and swordfish longlines from 1992 to 1999; 88 of those turtles died (NMFS-SEFSC, 2001). Human-caused mortality of leatherback sea turtles includes incidental take, fishing gear and marine debris entanglement and ingestion, and loss of habitat nesting (NOAA, 2005).

### Green Turtle (*Chelonia mydas*)

The green sea turtle (*Chelonia mydas*) range in the continental U.S. extends from Massachusetts to Texas, the occurrence of this species north of Virginia during any month of the year is considered unusual (NOAA Fisheries, 2002; Thompson, 1988). Adult green sea turtles forage on shallow-growing algae and seagrasses (Crite, 2000). The green sea turtle was originally protected under the ESA in 1978.

Documented accounts of green sea turtles in New England are most commonly instances of reported strandings; between 1999 and 2001, nine strandings of green sea turtles were reported within Massachusetts and Rhode Island (STSSN, 2005). Strandings occur most frequently in the fall and winter, presumably caused by cold stunning due to prolonged exposure to low water temperatures below 50°F (10°C) (Morreale et al., 1992; Matassa et al., 1994). Human-caused mortality of green sea turtles include incidental bycatch by various fishing practices, fishing gear and marine debris entanglement and ingestion, oil spills, PCBs, and the loss of nesting habitat (Thompson, 1988; NMFS & USFWS, 1991; NOAA, 2005).

### Roseate Tern (*Sterna dougallii*)

Federally-endangered roseate terns (*Sterna dougallii*) breed at limited colony locations within Buzzards Bay including Bird, Ram, and Penikese Islands; and South Monomoy and Minimoy Island in Nantucket Sound. Roseate terns return to breeding grounds in the Northeast and Atlantic Canada from late-April to mid-May. Roseate terns depart the region for their wintering grounds by September. Cape Cod, Massachusetts supports the largest pre-migratory staging habitat for roseate terns in North America and any individual from the northeastern population could occur in the area of Nantucket Sound during migration.

The majority of tern observations in Nantucket Sound during the applicant and MAS's surveys from 2002 to 2006 occurred outside of HSS. Terns were generally concentrated around the mainland and island coasts of the Sound, particularly Monomoy Island during the late-August and early-September staging period. Terns were observed traveling through the area of the proposed action, and few were observed actively foraging. During this period HSS likely had the lowest level of activity out of any similar habitat surveyed in the Sound.

**Piping Plover (*Charadrius melodus*)**

Federally-threatened piping plover (*Charadrius melodus*) breed along the mainland and island shores of Nantucket Sound. Piping plover spring arrival in the region peaks in late April to early May. In the fall in Massachusetts, the birds depart breeding sites by late-August. During migration periods, any individual from the Atlantic Canada or New England populations could occur in the area. Migration corridors along the coast are not well known. South Beach, Chatham and locations on Nantucket and Martha's Vineyard may provide stop-over habitat.

No piping plover were observed during either the applicant or MAS's aerial and boat surveys conducted over areas of Nantucket Sound. However, these surveys were conducted only during the day, and therefore do not account for the potential of plover crossings of the Sound at night during migration.

Beach habitat at the cable landing location is not optimal for piping plover, and the nearest known nesting beach is 1.5 miles (2.4 km) from the landfall. For the offshore portion of the proposed action area, piping plover occurrence, while not well known, is most likely less than that associated with their use of coastal beaches and shoreline areas, rather than open water areas like Horseshoe Shoal. Few crossings of Nantucket Sound are expected during the breeding season as plovers are mainly sedentary and make small scale movements between nesting and foraging locations along the beach. Regular daily movements would not result in crossings of Nantucket Sound. The exception would be occasional crossings of Nantucket Sound as individuals access alternate nesting or foraging areas. Other unusual crossings could be conducted by failed nesters or unpaired individuals traveling between the mainland and Nantucket or Martha's Vineyard in search of habitat or a mate.

**Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*)**

The northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) was historically common on coastal beaches from Massachusetts to central New Jersey as well as along the Chesapeake Bay in Maryland and Virginia. Only three beaches in Massachusetts contain populations of the beetle. Adult and larval beetles occur on large beaches that have little human or vehicular traffic. These beaches also consist of fine particle size sands and a high degree of exposure to tidal action.

Adult beetles measure approximately 0.6 inches in length and have a bronze green head and thorax with white or tan wing covers imprinted with fine dark lines. The larvae are pale in color with one pair of antennae and a long segmented abdomen. Adults emerge from the sand between mid-June and mid-August where they forage and mate in the intertidal zone, feeding on invertebrates and dead fish. After mating the females deposit eggs in the intertidal zone, and upon hatching, the larvae dig vertical burrows in the sand. After developing through three instars and overwintering twice, they emerge as adults.

The northeastern beach tiger beetle was federally-listed as threatened on August 7, 1990, and is also listed as a Massachusetts endangered species. Threats to this species includes degradation of habitat from human development, recreational disturbance, and pollution as well as natural factors such as beach erosion, storms, parasites, and predators.

**Red Knot (*Calidris canutus rufa*)**

The red knot (*Calidris canutus rufa*) is a medium-sized shorebird that is noted for having one of the longest migrations of any bird, and is capable of sustained flight for thousands of kilometers (Piersma, 1987). There are six subspecies, three of which occur regularly in North America; only the *C.c.rufa* population is described as "highly imperiled" in the US Shorebird Conservation Plan, and all subspecies nesting in North America are of "high concern" (USFWS, 2004; Brown et al., 2001). A decline in the number of red knot at stopover sites in the western Atlantic has been documented since the 1970's, with sharp drops observed from 1999 to 2004 (Baker et al., 2004; Morrison et al., 1994). This decline has been attributed to reduction in stopover food resources and habitat loss, in conjunction with global climate change and general human disturbances. Based on the threats to the Delaware Bay ecosystem attributed to over harvesting of horseshoe crab, coastal habitat degradation, and projected decrease in intertidal foraging habitat, the USFWS determined that *C.c.rufa* is a candidate species for listing under the ESA (1973, as amended).

***Life History***

The red knot nests in the high-central Canadian arctic and winter in austral South America, a sojourn of approximately 30,000 km (USFWS, 2006). The boreal winter is spent in Argentina and Chile, although some individuals, particularly juveniles, may winter further north (Harrington et al., 2001). A large percentage of the population winters in Bahia Lomas, Chile, thought to be the highest density of wintering red knot (Morrison and Ross, 1989). Northward migration begins as early as February, with individuals reaching the southeastern U.S. coast around March, and peak abundance occurs in April and early May (Harrington, 2001). Red knot arrive on Delaware and New Jersey coasts around the third week of April and remain through the first week of June, with peak abundance occurring in mid to late May, and few individuals remaining after June 5th (Robinson et al., 2003). The species is less prevalent in Massachusetts and eastern Canada during northward migration than during the late summer and early fall (Morrison et al., 1994).

The timing of arrival at Canadian breeding grounds has been poorly studied. Other red knot subspecies arrive in breeding territories in late May and early June, and typically begin establishing nesting territories within a few days (Parmelee and MacDonald, 1960). Eggs are laid in mid to late June and nesting is completed by mid July (Nettleship, 1974 *as cited in* Harrington, 2001). Red knots are known to have only one clutch per breeding season which typically consists of 4 eggs (Nettleship, 1974 *as cited in* Harrington, 2001). During fall migration individuals move south by mid-July, in Massachusetts numbers increase steadily until early August, then decrease between August 10 and August 20. First year juvenile birds may arrive latter and depart at the end of August, but tend not to concentrate at traditional staging areas like mature birds. The species is uncommon on the Southeastern U.S. coast before August during southward movement (Morrison and Harrington, 1979).

During spring and fall migration red knot stop on sandy shorelines, typically the intertidal zone near coastal inlets of bays and estuaries (Clark et al., 1993). Optimal foraging areas support a high density of infaunal prey organisms and/or horseshoe crab eggs, and are often associated with areas of high wave and current action, coincident with sandy substratum. Clark et al. (1993) demonstrated an association between areas of red knot foraging activity and close proximity to salt marshes, as well as a correlation between foraging activity and concentrations of other shorebirds. Red knot may be found on rocky or pebble beaches and in salt marshes and muddy areas where it exhibits foraging behavior similar to dowitchers (*Limnodromus* spp.) (Harrington, 2001). Nesting occurs most often on dry and elevated tundra, typically inland, and foraging occurs more frequently in non-marine areas during nesting (Harrington, 2001; Portenko, 1981).

Red knots wade in water to from 0.8 to 1.1 inches (2-3 cm) deep and may forage on eroded peat banks, during stops along the New England coast. It hunts primarily for infaunal bivalves, small mollusks, marine invertebrates, and gastropods. The amount of habitat used to forage for invertebrates depends on prey diversity and prey availability, and may be influenced by disturbance factors and interspecific competition (Harrington, 2001; Piersma and Koolhaas, 1997). In Massachusetts mussel spat are the most common prey species taken in July and August, where red knot forage about 2 hours on either side of low tide (Schneider and Harrington, 1981). In addition to animal prey, red knot may eat vegetation, under some circumstances, such as early arrival at high arctic breeding grounds before adequate insect prey bases have developed.

***Population Dynamics***

Red knot use the eastern U.S. coastal flyway as their primary migration route (Engelmoer and Roselaar, 1998). Important stopover areas are in Delaware, New Jersey, Maryland, Virginia and New England (USFWS, 2006). Of particular importance is the Delaware Bay staging area, with abundant seasonal food resources and foraging habitat. Individuals often increase in body mass by between 50 and 80 percent during the few weeks spent foraging on horseshoe crab (*Limulus polyphemus*) eggs there (Tsipoura and Burger, 1999, Botton et al., 1994). The red knot population using the Massachusetts coastline is mostly migratory and are most abundant during the early fall at staging areas near Plymouth-Duxbury Bay, Nauset Marsh, Monomoy National Wildlife Refuge, Scituate, and Plum Island/Parker River (USFWS, 2006). During the 1970's, 60 to 90 percent of the entire suspected population was observed in Massachusetts and New Jersey, during southward migration (USFWS, 2006). The maximum count of red knot recorded is approximately 950 at Plymouth-Duxbury Bay Complex, 300 at Nauset Marsh, 3,000 at Monomoy NWR, 2,800 at Scituate, and 100 at Plum Island/Parker River (Chan, 2003).

Studies of staging areas along the western Atlantic coast and of wintering areas in South America demonstrate a clear demographic decline. Morrison et al. (1994) calculated a fifteen percent rate of annual decline in adult red knot at stopover sites in maritime Canada, between 1974 and 1991 with an overall 10-year decrease of 81 percent. Donaldson et al. (2000) documented a population decline of more than 13 percent from 1974 to 1998. Surveys conducted in 1986 and repeated in 2002 showed a 55 percent decline in red knot wintering in six South American study areas (Niles et al., 2006). In Delaware Bay a consistent decline in maximum number of migrants was observed each year from 1999 through 2004.

***Status and Distribution***

Recent population estimates vary widely from approximately 30,000 to 140,000 individuals (USFWS, 2006; Harrington, 2001). Research by Baker et al. (2004) determined that the red knot population would likely decline to very low numbers by 2010. Subsequent counts of wintering red knot in 2004 and 2005 demonstrated evidence of the demographic trends predicted by Baker. The population was estimated at 152,900 ± 50,300 during the spring of 1989 (Morrison et al., 1994) and Clark et al. (1993) estimated the population at 94,460 during peak abundances at Delaware Bay. Peak counts at Delaware Bay in 2004 and 2005 diminished to 13,315 and 15,345, respectively (USFWS, 2006). Although the observed fluctuations of red knot at stopovers in the mid-Atlantic and New England are appropriate estimates of trends in demographics and total abundances at those areas, they may not necessarily be appropriate estimates of the entire population (Morrison et al., 1994; Clark et al., 1993; Robinson et al., 2003). Nonetheless, Clark et al. (1993) and others have demonstrated a clear downward trend in population size, as evident in counts from both stopovers areas and wintering sites in South America.

One red knot was observed during one boat survey and no other individuals were observed during aerial surveys conducted by the applicant or by MAS.

Changes in the management of horseshoe crab stocks since 1997, coupled with better conditions on breeding grounds in recent years, give some positive indications of population stabilization (USFWS, 2006). Recent surveys of migrants at Delaware Bay and Virginia, in conjunction with censuses of wintering birds in South America, indicate that the population decline may have abated. A slight increase of approximately 2,000 individuals (from ca. 13,300 to 15,300) in peak migrant abundance was recorded between 2004 and 2005 at Delaware Bay (USFWS, 2006).

***Threats***

The primary factor for the status of the red knot is the decline in food resources at the Delaware Bay spring staging area (USFWS, 2006; Baker et al., 2004; Robinson et al., 2003; Tsipoura and Burger, 1999; Botton et al., 1994; Clark et al., 1993; Piersma, 1987; Morrison and Harrington, 1979). The commercial harvest of horseshoe crabs used for bait in other fisheries and for biomedical research has reduced the spawning population in the Delaware Bay area, and subsequently led to a substantial decline in eggs available for migrating red knot. Because the red knot and other shorebird species rely on the seasonally abundant food resources at a small number of staging areas along their migration route, the decimation of any one food resource may have implications for overall population health (Wilson and Barter, 1998). The reduction in available food resources in Delaware Bay has caused individuals to be "underweight" and less likely to reach breeding grounds in good health. Baker et al. (2004) found survival rates declined by more than 35 percent in adults and by more than 45 percent in juveniles between spring 2000 and spring 2001. This decline has been attributed to reductions in key food resources at the stopover site preventing individuals from reaching threshold weights for migration to the arctic. A number of management actions have been under taken since the 1990's, by federal and state management agencies (i.e., ASMFC Horseshoe Crab Management Board) to limit the number of horseshoe crabs harvested.

Shoreline alteration and changes in long shore sediment drift patterns may also be a threat to red knot using the Massachusetts coastline (Niles et al., 2006). Of particular concern for conservation efforts is the species' high fidelity to stopover sites. Of the 3,316 red knot banded by Harrington et al. (1988) in nine years of study at Scituate, Massachusetts, 1,661 ± 724 banded birds used the stopover site during peak periods of migration. Similar patterns have been observed in Delaware Bay (Baker et al., 2004). Loss and/or degradation of coastal habitat in South America attributed to changes in drainage patterns by farm irrigation practices coupled with widespread oil pollution may be effecting the red knot wintering population as well (USFWS, 2006).

During migration periods, direct human disturbance is also a threat, particularly along beaches where their behavior may alter the foraging behavior of migrants, or where boats are present near roosting sites (USFWS, 2006). Peters and Otis (2007) found that red knot avoided roost sites that had boat activity within 1000 m. Anthropogenic disturbance in suitable foraging habitat throughout the Atlantic seaboard, including Massachusetts, is reported to have "major negative impact(s)" on red knot (Niles et al., 2006). Disturbance in conjunction with losses of intertidal foraging habitat may cause red knot to forage in sub-optimal areas.

**New England Cottontail (*Sylvilagus transitionalis*)**

The New England cottontail (*Sylvilagus transitionalis*) is a species of rabbit that is a candidate for protection under the ESA (Capitol Reports, 2006). Decline of New England cottontail populations are believed to be due to reduction of favorable habitats and displacement by the adaptable populations of the introduced Eastern cottontail (*Sylvilagus floridanus*) (MDFWELE, 2008; NatureServe, 2007). Historically, New England cottontails were present in all 14 counties of Massachusetts and prior to 1930 were the only cottontails appearing among 59 reports except for seven that were from Nantucket where Eastern cottontails were introduced in the late 1800's (MDFWELE, 2008).

***Description and Life History***

The New England Cottontail, first described as a species in 1895 from a Connecticut specimen, was the dominant cottontail species that was found throughout the northeast (MDFWELE, 2008). This species is now split into two species with the Appalachian cottontail (*Sylvilagus obscurus*) being found in the Appalachian Mountains from New York to Georgia and Alabama, and the New England cottontail being found from the Hudson River Valley in New York through central and southern New England (MDFWELE, 2008). New England cottontail numbers appear to have decreased sharply as has their distribution over the past 25 to 50 years (MDFWELE, 2008).

New England cottontails and Eastern cottontails cannot be easily identified by field observation. Differences can be determined with certainty by examining skull characteristics and measurements and by DNA techniques (MDFWELE, 2008).

The New England cottontail is an early successional or thicket-dwelling species (MDFW, 2008). This species appears to prefer areas that are brushy, areas with woodlands, areas with shrub-dominated wetlands and areas that are mountainous (MDFWELE, 2008). This species can be found where clearcuts are regenerating, in dense coniferous areas, and along powerline corridors or highway medians that have dense coniferous habitats (MDFWELE, 2008). When large trees are growing in a stand, shrub layers tend to thin and a habitat is created that is no longer suitable for New England cottontails (USFWS, 2008a).

Home ranges of this species have been noted to be between 0.5 to 8.3 acres (2023 $m^2$ to 33,588 $m^2$) depending on the habitat and the geographical area with males having a larger home range than the females (MDFWELE, 2008). New England cottontails are active at dawn and dusk or at night, and feed on tender grasses and herbs in spring/summer, and bark, twigs and buds of young trees and shrubs in winter (MDFWELE, 2008; USFWS, 2008a). This species forages alone, and they groom themselves but not each other (SNMNH, 2008). This species' breeding period is from March to July, occasionally extending to September (MDFWELE, 2008). The average litter size is five (range three-eight) and there are two or three litters per year (MDFWELE, 2008).

***Distribution and Abundance***

As noted previously, New England cottontails were present in all 14 counties of Massachusetts and prior to 1930 were the only cottontails appearing among 59 reports except for seven that were from Nantucket where Eastern cottontails were introduced in the late 1800's (MDFWELE, 2008). Of four surveys conducted during 1950-1993, New England cottontails maintained an overall abundance of approximately 22 percent of all cottontail specimens (MDFW, 2008). In a 1990-1993 survey, New England cottontails were found in only six counties in Massachusetts, while the Eastern cottontail was found in 13 of 14 counties (MDFW, 2008). Small populations of New England cottontails were observed in Barnstable County and southern Berkshire County during a 2000-2003 survey conducted by other researchers (MDFW, 2008).

***Threats***

Reduced extent of thicket habitat is believed to be the primary reason for decline in the range and numbers of New England cottontails (USFWS, 2008a). Commercial and residential development in pitch pine-scrub oak barrens or other early successional communities has contributed to fragmentation, degradation, or eradication of habitat for this species (MDFW, 2008). In addition, the introduction of exotic invasive species such as multiflora rose (*Rosa multiflora*), honeysuckle bush (*Lonicera japonica*), and autumn olive (*Elaeagnus umbellata*) has changed types of habitat available to New England cottontails (USFWS, 2008a). Stands dominated by such non-native species may not provide New England cottontails with food resources that native plants would provide (USFWS, 2008a). White-tailed deer (*Odocoileus virginianus*) are also found in extremely high densities throughout the New England cottontail range and not only eat many of the same plants as New England cottontails, but also can affect the structure and density of many understory plants that provide a thicket habitat (USFWS, 2008a).

## 4.3 SOCIOECONOMIC RESOURCES AND LAND USE

This section assesses the existing socioeconomic resources and land use in the area to provide an understanding of the people who live in the area and the economic conditions that exist including information about housing, construction and manufacturing industries, service industries, waste disposal, energy industries and population statistics such as race and population density. This information provides a baseline from which to compare socio economic impacts as discussed in Section 5.

### 4.3.1 Socioeconomic Analysis Area

This section addresses the geographic scope of the study area and the sources of information used in the study.

#### *4.3.1.1 Metropolitan Statistical Area*

With respect to socioeconomic analysis, the MMS defined the region of impact (ROI) as four locations in Massachusetts; Barnstable County, Nantucket Island in Nantucket County, Martha's Vineyard in Dukes County, and New Bedford in Bristol County in Massachusetts, and Quonset, in Washington County, Rhode Island.

Barnstable County was included in the ROI because this would be the daily debarkation point for workers involved in construction and operation and would require the presence of an on-shore support base to support offshore construction and annual O&M activities, and the presence of on-shore infrastructure such as the 115 kV transmission cable system that would convey power from the project to the existing regional T&D system. Nantucket and Martha's Vineyard would be included in the ROI due to their close proximity to the proposed action and possible contribution of workers. Quonset Rhode Island and Washington County Rhode Island were included in the ROI as this is where fabrication and assembly of the WTB components is likely to occur as well as the majority of construction and decommissioning activities would be staged here. Bristol County was included because maintenance vessels related to the proposed action would be operated out of New Bedford, in Bristol County. The manufacture and purchase of much of the specialized equipment that would comprise the WTGs such as the rotors, generators, and nacelles, etc. would occur outside the ROI.

Additionally, construction and operational employees may come from areas beyond the ROI, and that in a broader sense, the entire New England region would be affected by the proposed action via the electricity delivered into the New England electricity grid. However, the majority of the socio-economic impacts would be in the referenced ROI.

Socioeconomic data provided to describe existing socioeconomic conditions in this section came from the U.S. Census unless otherwise noted (http://factfinder.census.gov). The most recent available U.S. Census community data for Barnstable County, Massachusetts and Washington County, Rhode Island came from 2005 estimates, and the most recent available community data for Nantucket County, Dukes County, and Bristol County, Massachusetts came from the 2000 census (U.S. Census, 2005 and U.S. Census, 2000).

### 4.3.2 Urban and Suburban Infrastructure

#### *4.3.2.1 Housing*

In 2005, there were approximately 100,000 housing units in Barnstable County, with approximately 80 percent of them owner occupied, and 20 percent renter occupied. The vacancy rate for owner occupied homes was approximately 1 percent and the vacancy rate for rental homes was 10 percent.

Approximately 89 percent of those vacant units are considered to be seasonal or recreational in nature, which would leave approximately 1,200 units available for rent.

In 2000, there were approximately 9,210 housing units in Nantucket County, with approximately 85 percent of them owner occupied, and 15 percent renter occupied. The vacancy rate was approximately 2.4 percent for owner occupied homes and the vacancy rate was approximately 3.9 percent for rental homes. Approximately 56.1 percent of those vacant units are considered to be seasonal, recreational, or occasional use.

In 2000, there were approximately 14,836 housing units in Dukes County, with approximately 71.3 percent of them owner occupied, and 28.7 percent renter occupied. The vacancy rate for owner occupied homes was approximately 1.3 percent and the vacancy rate for rental homes was approximately 3.6 percent. Approximately 53.9 percent of those homes are considered to be seasonal, recreational, or occasional use homes.

During the summer months vacancy rates in Barnstable County, Nantucket County and Dukes County decline as these areas are very popular summer vacation destinations for tourists and available vacant rental units help to address this seasonal demand.

In 2005, there were approximately 59,903 housing units in Washington County, with approximately 72.7 percent of them owner occupied, and 27.3 percent renter occupied. The vacancy rate for owner occupied homes was approximately 0.9 percent and the vacancy rate for rental homes was approximately 4.8 percent. Approximately 14.4 percent of those homes are considered to be seasonal, recreational, or occasional use homes.

In 2000, there were approximately 216,918 housing units in Bristol County, with approximately 61.6 percent of them owner occupied, and 38.4 percent renter occupied. The vacancy rate for owner occupied homes was approximately 0.8 percent and the vacancy rate for rental homes was approximately 5.5 percent. Approximately 0.9 percent of those homes are considered to be seasonal, recreational, or occasional use homes.

Median house values in all counties located in the ROI are considerably higher than the average applicable state median housing values indicating there is a high level of desirability and demand for housing stock in these locations. Further details on house prices are provided in Section 4.3.3.2 of this document.

#### *4.3.2.2 Construction and Manufacturing Industries*

In 2002, construction and manufacturing sectors employed 7.1 percent and 4.1 percent of the population of Barnstable County, respectively. From 1990 through 2002, the construction and manufacturing industries in Barnstable County have had an employment growth rate of 5.8 percent and -0.07 percent, respectively. In 2000, construction and manufacturing sectors employed 12.4 percent and 1.8 percent of the population of Nantucket County, respectively. From 1990 through 2000, the construction and manufacturing industries in Nantucket County have had an employment growth rate of -0.4 percent and 0.5 percent, respectively. In 2000, construction and manufacturing sectors employed 18.3 percent and 2.9 percent of the population of Dukes County, respectively. From 1990 through 2000, the construction and manufacturing industries in Dukes County have had an employment growth rate of 10 percent and 1.3 percent, respectively. In 2005, construction and manufacturing sectors employed 4.1 percent and 6 percent of the population of Washington County, respectively. From 1990 through 2005, the construction and manufacturing industries in Washington County have had an employment growth rate of 0.8 percent and -3.0 percent, respectively. In 2000, construction and manufacturing sectors employed 6.9 percent and 18.5 percent of the population of Bristol County, respectively.

#### 4.3.2.3 Service Industries

The main service industries in the ROI include: Educational Services, Professional, Scientific and Technical Services, Admin, Support, Waste Management, Remediation Services, and Accommodation and food services. Additional information on business activity by job sector is provided in Section 4.3.3.2.2.

#### 4.3.2.4 Waste Disposal and Transit Facilities

There are no waste disposal facilities in Barnstable County. Solid waste is collected at local and regional transfer stations and sent to the SEAMASS incinerator in Rochester, Massachusetts via rail or truck. Commercial solid waste is either taken directly to SEAMASS by a private hauler, or a fee is paid to the truck transfer station/railhead transfer station. Waste disposal in Rhode Island is handled by the Central Landfill, which spans across 1,200 acres and is located on Shun Pike in Johnston, Rhode Island. The Rhode Island Resource Recovery Corporation has owned and operated the Central Landfill since December 1980, and currently manages approximately 4,000 tons (3,628,739 kg) of residential and commercial waste per day.

#### 4.3.2.5 Military Activity

The MMR is located on Cape Cod and consists of 21,000 acres (85 $km^2$) of land split between the towns of Bourne, Mashpee, and Sandwich. Units operating at MMR include:

- Massachusetts Air National Guard (ANG), Otis ANG Base;
- Massachusetts Army National Guard (ARNG), Camp Edwards;
- U.S. Air Force's 6th Space Warning Squadron PAVE PAWS radar site (Cape Cod Air Force Station);
- USCG Air Station Cape Cod;
- Veterans Administration Cemetery; and
- U.S. Department of Agriculture (USDA).

#### 4.3.2.6 Energy Industries

##### 4.3.2.6.1 Electrical Generating Capacity

Canal Station, owned by Mirant Corporation, is the bulk electric generation facility that currently serves Barnstable County. The facility is located in Bourne, Massachusetts, and has a 1,120 MW generation capacity (560 MW peak unit) and is capable of being run on both number six fuel oil and natural gas. The electricity supply produced by the proposed action would be consumed primarily on the Cape and Islands. Since electricity follows the path of least resistance, the power would flow to the homes, schools and businesses of the Cape and Islands. Only when the proposed action is producing more power than demanded locally would some of the power cross the Cape Cod Canal via high voltage transmission lines. The expected production of 182 MWs of electricity in average wind conditions would meet three quarters of the 230 MW average electric demand of Cape Cod and the Islands.

##### 4.3.2.6.2 Base and Surge Load Servicing

The electricity grid is built with redundancy to account for planned and unplanned outages from power production facilities. The New England Region electrical grid system is run by ISO-NE, an independent system operator, which ensures that adequate base load and peak demand capacity is available at all times. As part of the redundancy of the electrical grid system, ISO-NE requires a certain capacity of spinning reserves, which are sources of power available to start up quickly to compensate for any sudden drop in electricity production. During a power plant outage, whether a conventional plant or a wind plant, backup is provided by the entire interconnected utility system. The system operating strategy strives to make best use of all elements of the overall system, taking into account the operating characteristics of each generating unit and planning for contingencies such as plant or transmission line outages. The utility system is also designed to accommodate load fluctuations, which occur continuously. This feature facilitates accommodation of wind plant output fluctuations.

##### 4.3.2.6.3 Transmission and Relay System

The existing transmission system on Cape Cod operates at 115 kV and 345 kV. Crossing the Cape Cod Canal, there are two 115 kV lines and two 345 kV lines. The 115 kV lines are capable of carrying 225 MW each and the 345 kV lines are capable of carrying 1000 MW each. The existing substation in the town of Barnstable, Massachusetts operates at 115 kV and, once it has been upgraded, would be able to accept and deliver the additional power from the two 115 kV lines from the proposed action.

##### 4.3.2.6.4 Wholesale Energy Market

ISO-NE also is responsible for regulating the electricity market in New England. Electricity prices are determined through the ISO-NE's wholesale energy market. The wholesale energy market functions just like an auction. Electric utility companies and competitive suppliers forecast customers' electricity consumption, and bid to buy wholesale power at a specified price per megawatt-hour (MWh). Similarly, power plants offer into the auction to produce a certain amount of electricity at a specified price per MWh. The ISO-NE takes the lowest priced energy bid by suppliers until the point where total demand equals supply.

### 4.3.3 Population and Economic Background

#### *4.3.3.1 Demographics*

The following information is largely presented based on the county statistics for those counties likely to supply the goods and services needed for construction, operation, and decommissioning of the project. There are four counties in Massachusetts and one in Rhode Island.

##### 4.3.3.1.1 Population

In 2005, Barnstable County had a household population of 221,000, with 116,000 (52 percent) females and 105,000 (48 percent) males. The average annual population growth rate from 1990 through 2005 was 1.2 percent.

In 2000, Nantucket County had a total population of 9,520, with 4,884 (51.3 percent) males and 4,636 (48.7 percent) females. The average annual population growth rate from 1990 through 2000 was 5.8 percent.

In 2000, Dukes County had a total population of 14,987 with 7,323 (48.9 percent) males and 7,664 (51.1 percent) females. The average annual population growth rate from 1990 through 2000 was 2.9 percent.

In 2005, Washington County had a total population of 123,322 with 60,221 (48.8 percent) males and 63,101 (51.2 percent) females. The average annual population growth rate from 1990 through 2005 was 0.7 percent.

In 2000, Bristol County had a total population of 534,678 with 256,747 (48.0 percent) males and 277,931 (52.0 percent) females. The average annual population growth rate from 1990 through 2000 was 0.56 percent. Further information on population of the ROI is provided in Table 4.3.3-1.

#### 4.3.3.1.2 Age

The median age in Barnstable County in 2005 was 45.6 years. Nineteen percent of the population were under 18 years, 6 percent were between 18 and 24 years, 24 percent were between 25 and 44 years, 28 percent were between 45 and 64 years, and 23 percent were 65 years and older.

The median age in Nantucket County in 2000 was 36.7 years. Approximately 20.7 percent of the population were 19 years and younger, 5.9 percent were between 20 and 24 years, 40.5 percent were between 25 and 44 years, 22.5 percent were between 45 and 64 years, and 10.5 percent were 65 years and older.

The median age in Dukes County in 2000 was 40.7 years. Approximately 24.5 percent of the population were 19 years and younger, 3.7 percent were between 20 and 24 years, 29.6 percent were between 25 and 44 years, 27.8 percent were between 45 and 64 years, and 14.4 percent were 65 years and older.

The median age in Washington County in 2005 was 40.5 years. Approximately 27.5 percent of the population were 19 years and younger, seven percent were between 20 and 24 years, 28.4 percent were between 25 and 44 years, 24.3 percent were between 45 and 64 years, and 12.7 percent were 65 years and older.

The median age in Bristol County in 2000 was 36.7 years. Approximately 27.3 percent of the population were 19 years and younger, 5.9 percent were between 20 and 24 years, 30.5 percent were between 25 and 44 years, 22.2 percent were between 45 and 64 years, and 14.2 percent were 65 years and older. Further information on age is provided in Table 4.3.3-1.

#### 4.3.3.1.3 Race and Ethnic Composition

In Barnstable County in 2005, of people who were one race, 96 percent of the population was White; two percent were Black or African American; less than 0.5 percent were American Indian and Alaska Native; one percent were Asian; less than 0.5 percent were Native Hawaiian and Other Pacific Islander, and one percent were some other race. In addition, one percent reported two or more races and two percent of the people in Barnstable County were Hispanic or Latino. Ninety-four percent of the people in Barnstable County were White non-Hispanic. (People of Hispanic origin may be of any race [U.S. Census, 2005]).

In Nantucket County in 2000, of people who were one race, 87.8 percent were White; 8.3 percent were Black or African American; 0.6 percent were Asian; and 1.6 percent were some other race. In addition, 1.6 percent reported two or more races and 2.2 percent of the people in Nantucket County were Hispanic or Latino.

In Dukes County in 2000, of people who were one race, 90.7 percent were White; 2.4 percent were Black or African American; 1.7 percent were American Indian and Alaska Native; 0.5 percent were Asian; 0.1 percent were Native Hawaiian and Other Pacific Islander; and 1.5 percent were some other race. In addition, 3.2 percent reported two or more races and one percent of people in Dukes County were Hispanic or Latino.

In Washington County in 2005, of people who were one race, 94.8 percent were White; 0.9 percent were Black or African American; 0.9 percent were American Indian and Alaska Native; 1.5 percent were Asian; and 0.5 percent were some other race. In addition, 1.4 percent reported two or more races and 1.4 percent of people in Washington County were Hispanic or Latino.

In Bristol County in 2000, of people who were one race, 91.0 percent were White; 2.0 percent were Black or African American; 0.2 percent were American Indian and Alaska Native; 1.3 percent were Asian; 0.0 percent were Native Hawaiian and Other Pacific Islander; and 3.1 percent were some other race. In addition, 2.3 percent reported two or more races and 3.6 percent of people in Bristol County were Hispanic or Latino. Further information on ethnicity is provided in Table 4.3.3-1. For information regarding Native American tribes, refer to section 4.3.5.3.

#### 4.3.3.1.4 Education

In Barnstable County in 2005, 94 percent of the adult population had graduated high school and 36 percent had a bachelor's degree or higher (U.S. Census, 2005). In Dukes County in 2000, 90.4 percent of the adult population had graduated high school and 38.4 percent had a bachelor's degree or higher (U.S. Census, 2000). In Nantucket County in 2000, 91.6 percent of the adult population had graduated high school and 38.4 percent had a bachelor's degree or higher (U.S. Census, 2000). In Washington County in 2005, 90.6 percent of the adult population had graduated high school and 40.6 percent had a bachelor's degree or higher (U.S. Census, 2005). In Bristol County in 2000, 73.2 percent of the adult population had graduated high school and 19.9 percent had a bachelor's degree or higher (U.S. Census, 2000).

### *4.3.3.2 Economic Factors*

#### 4.3.3.2.1 Current Economic Baseline Data

In 2005, the median income of households in Barnstable County was $54,439. Seventy-two percent of the households received earnings and 25 percent received retirement income other than Social Security. Forty-one percent of the households received Social Security. The average income from Social Security was $14,696. These income sources are not mutually exclusive; that is, some households received income from more than one source (U.S. Census, 2005).

In 2005, seven percent of people in Barnstable County were in poverty. Nine percent of related children under 18 were below the poverty level, compared with 5 percent of people 65 years old and over. Five percent of all families and 18 percent of families with a female householder and no husband present had incomes below the poverty level (U.S. Census, 2005).

In 2005, the median income of households in Washington County was $62,536. Eighty-one percent of the households received earnings and 24 percent received retirement income other than Social Security. Twenty-nine percent of the households received Social Security. The average income from Social Security was $15,466. These income sources are not mutually exclusive; that is, some households received income from more than one source (U.S. Census, 2005).

In 1999, the median income of households in Dukes County was $45,559. Eighty-three percent of the households received earnings and 15.1 percent received retirement income other than Social Security. Twenty-six percent of the households received Social Security. The average income from Social Security was $11,008. These income sources are not mutually exclusive; that is, some households received income from more than one source (U.S. Census, 2000).

In 1999, the median income of households in Nantucket County was $55,522. Eighty-seven percent of the households received earnings and 12.2 percent received retirement income other than Social

Security. Twenty percent of the households received Social Security. The average income from Social Security was $11,567. These income sources are not mutually exclusive; that is, some households received income from more than one source (U.S. Census, 2000).

In 1999, the median income of households in Bristol County was $43,496. Seventy-seven percent of the households received earnings and 16.9 percent received retirement income other than Social Security. Twenty-eight percent of the households received Social Security. The average income from Social Security was $10,237. These income sources are not mutually exclusive; that is, some households received income from more than one source (U.S. Census, 2000).

#### 4.3.3.2.2 Business Activity by Industrial Sector

Among the most common occupations in Barnstable County in 2005 were: management, professional, and related occupations, 32 percent; sales and office occupations, 27 percent; service occupations, 23 percent; construction, extraction, maintenance and repair occupations, 11 percent; and production, transportation, and material moving occupations, 6 percent. Seventy-three percent of the people employed were private wage and salary workers; 14 percent were Federal, state, or local government workers; and 13 percent were self-employed (U.S. Census, 2005).

Among the most common occupations in Dukes County in 2000 were: management, professional, and related occupations, 32 percent; sales and office occupations, 25 percent; construction, extraction, and maintenance occupations, 19 percent; service occupations, 16 percent; production, transportation, and material moving operations, 8 percent; and farming, fishing, and forestry occupations, 1 percent. Sixty-six percent of the people employed were private wage and salary workers; 22 percent were self-employed; and 12 percent were government workers (U.S. Census, 2000).

Among the most common occupations in Nantucket County in 2000 were: management, professional, and related occupations, 30 percent; sales and office occupations, 24 percent; construction, extraction, maintenance and repair occupations, 22 percent; service occupations, 17 percent; production, transportation, and material moving occupations, 6 percent; and farming, fishing, and forestry occupations, 1 percent. Sixty-two percent of the people employed were private wage and salary workers; 25 percent were self-employed; and 12 percent were Federal, state, or local government workers (U.S. Census, 2000).

Among the most common occupations in Washington County in 2005 were: management, professional, and related occupations, 40 percent; sales and office occupations, 22 percent; service occupations, 19 percent; construction, extraction, maintenance and repair occupations, 10 percent; production, transportation, and material moving occupations, 8 percent; and farming, fishing, and forestry occupations, 1 percent. Seventy-three percent of the people employed were private wage and salary workers; 19 percent were Federal, state, or local government workers; and 7 percent were self-employed (U.S. Census, 2005).

Among the most common occupations in Bristol County in 2000 were: management, professional, and related occupations, 31 percent; sales and office occupations, 26 percent; construction, extraction, maintenance and repair occupations, 10 percent; service occupations, 15 percent; production, transportation, and material moving occupations, 18 percent; and farming, fishing, and forestry occupations, less than 1 percent. Eighty-two percent of the people employed were private wage and salary workers; 5 percent were self-employed; and 13 percent were Federal, state, or local government workers (U.S. Census, 2000).

#### 4.3.3.2.3 Employment

In 2005, there was an estimated labor force of 113, 026 in Barnstable County with an unemployment rate of 7.4 percent. In 2000, there was an estimated labor force of 5,788 in Nantucket County with an unemployment rate of 3.1 percent[16]. In 2000, there was an estimated labor force of 8,150 in Dukes County with an unemployment rate of 1.8 percent. In 2005, there was an estimated labor force of 71,286 in Washington County with an unemployment rate of 3.1 percent. In 2000, there was an estimated labor force of 132,883 in Bristol County with an unemployment rate of 5.3 percent.

#### 4.3.3.2.4 Income and Wealth

In 2005, the median income of households in Barnstable County was $54,439 versus the state of Massachusetts median income of $57,184. In 2000, the median income of households in Nantucket County was $55,522 versus the state of Massachusetts median income of $46,753. In 2000, the median income of households in Dukes County was $45,559 versus the state of Massachusetts median income of $46,753. In 2005, the median income of households in Washington County was $62,536 versus the state of Rhode Island median income of $51,458. In 2000, the median income of households in Bristol County was $43,496 versus the state of Massachusetts median income of $46,753.

#### 4.3.3.2.5 Property Values

In 2005, the median house value in Barnstable County was $400,500 versus the state of Massachusetts median house value of $361,500. In 2000, the median house value in Nantucket County was $577,500 versus the state of Massachusetts median house value of $185,700. In 2000, the median house value in Dukes County was $304,000 versus the state of Massachusetts median house value of $185,700. In 2005, the median house value in Washington County was $349,900 versus the state of Rhode Island median house value of $281,300. In 2000, the median house value in Bristol County was $151,500 versus the state of Massachusetts median house value of $185,700. In summary, the information shows that the counties within the ROI have considerably higher housing values than the overall housing values of the state in which they are located (with the exception of Bristol County), indicating the high demand for housing in these areas and relative wealth in these areas.

### *4.3.3.3 Environmental Justice Considerations*

This section contains environmental justice statistics to determine whether the construction and operation of the proposed action would have a significant adverse effect on minority and low-income populations. As part of the environmental justice data, socioeconomic characteristics of the area of the proposed action have been examined to determine whether the proposed would disproportionately impact any minority or low-income population(s).

#### 4.3.3.3.1 Federal Guidance

The USEPA Headquarters Office of Environmental Justice defines environmental justice as the following:

> *"Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences*

[16] At the time of preparation of this DEIS, 2005 data was not available from the US Census on Nantucket County and Dukes County.

*resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies."*

The concept of performing an environmental justice analysis for the proposed action is related to the establishment of Executive Order 12898, entitled "Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations" (February 11, 1994). The order requires Federal agencies to consider disproportionate adverse human health and environmental impacts on minority and low-income populations.

The focus of an environmental justice analysis is the determination of whether the construction and operation of a proposed action would have both adverse and disproportionate impacts on minority and low income populations. Minority populations are generally defined by USEPA as areas that have a "meaningfully greater" percent of minorities than the general population in the surrounding area, and low income populations are defined based on the U.S. Census poverty statistics. In performing the environmental justice analysis, the MMS used the methodology in USEPA's "Final Guidance for Incorporating Environmental Justice Concerns in USEPA's NEPA Compliance Analyses, April 1998."

The poverty rate of Barnstable County was 6.6 percent in 2005, versus the state poverty rate of 10.3 percent. The poverty rate in Washington County was 6.3 percent in 2005 versus the state wide poverty rate of 12.3 percent. The poverty rates in Nantucket, Dukes, and Bristol Counties were 7.5 percent, 7.3 percent, and 10.0 percent, respectively in 2000 versus the state wide poverty rate of 9.3 percent. This poverty rate information shows that overall area of the ROI is in general more affluent than the rest of the state, which indicates it is unlikely to be an environmental justice area of concern.

The percent minorities in Barnstable, Nantucket, Dukes, and Bristol Counties were 6.6 percent, 13.1 percent, 10.0 percent, and 10.6 percent, respectively in 2000, versus a state wide percentage of 18.1 percent (U.S. Census, 2000).[17] The percent minorities in Washington County was 5.1 percent in 2005 versus a state wide average of 17 percent. These statistics show again that the ROI in general is not an area of environmental justice concern as the ROI has a smaller percentage of minorities than the rest of the state. There are two tribes of Indians in the ROI, the WTGHA and the Wampanoag Indians of Mashpee. See Section 4.3.3.1.3 for a description of them, and see Section 5.0 for information on environmental impacts to these areas. The Environmental Justice Impact assessment is provided at Section 5.3.3.3.

Although the statistics for Barnstable County as a whole indicate that the area is not an environmental justice area of concern, the Massachusetts Environmental Justice GIS Map shows that there is a smaller census block group in and around Hyannis, Massachusetts that is an Environmental Justice Population (see Figure 4.3.3-1). The Mass GIS defines an Environmental Justice Population as any area that has: (1) greater than or equal to 25 percent minority population; or (2) less than or equal to a median household income of $30,515; or (3) less than 75 percent of the households are English proficient; or greater than 25 percent of a foreign born population. (http://www.mass.gov/mgis/cen2000_ej.htm). The proposed action on-land cable portion of the proposed action is located outside of this area, but the existing substation where the cable connects is located within this area. Impacts are described in Section 5.3.3.3 of this document.

[17] To obtain the total minority population, the "population of one race, white alone, was subtracted by the total population (to obtain all minorities), and divided by the total population (to obtain percent minorities). It should be noted that, using this methodology, any individual identified as "other race" or "two or more races" is considered a member of a minority.

### 4.3.4 Visual Resources

Visual resources were surveyed and assessed via two main groupings: Visual Resources associated with Historic Areas, to address requirements of Section 106 historic review requirements, and visual resources associated with Recreational Areas, to address visual impact under the National Environmental Policy Act regulations. For the purposes of this work, recreational areas include but are not limited to beaches, parks, conservation lands, and ocean areas.

The land area surrounding the site of the proposed action has a variety of historic structures and recreational areas that would be in view of the proposed action. With respect to historic areas, there are both individual homes on the NRHP and larger historic districts on the NRHP that would have a view of the proposed action, including the island of Nantucket which is designated a National Historic District. With respect to recreational areas, Cape Cod, Nantucket, Martha's Vineyard and the waters of Nantucket Sound are well known for coastal recreational and summer tourism activities including beach going, swimming, boating, fishing, hiking, biking, picnicking, golfing, and bird watching. Marinas, yachts clubs, and public boat ramps line most of the harbors and inlets that have sufficient water depths.

#### *4.3.4.1 Visual Resources Associated with Historic Structures and Districts*

In order to assess visual impacts to historic structures, 12 simulation locations were selected in consultation with the MEPA and MHC as representative worst case visual impacts to historic structures from the proposed action (Report No. 4.3.4-1). Table 4.3.4-1 indicates the historic properties and districts in the area that were assessed and their distance to the proposed action and Figure 4.3.4-1 shows the location of these areas on a map. Figure 4.3.4-2 shows the existing view (prior to the proposed action) toward the site from the nearest unobstructed viewing area from each of the visual simulation locations plus a photograph of the historic structure that would be affected, and additional photographs that show the general visual character and context at each location.

A description of the visual character and setting at each of the 12 visual simulation locations is presented below, based upon field reconnaissance, background research, and review of NRHP Inventory Nomination Forms, where available, and other documentation in MHC files.

**South Side of Cape Cod**

***Nobska Point Light Station, Woods Hole, Falmouth (VP 1 in Figure 4.3.4-1; Character photos on Figure 4.3.4-2, sheets 1-7)***

The Nobska Point Light Station complex dates from 1876, when the existing white cylindrical tower was constructed to replace a navigational light atop a keeper's dwelling that had operated since 1828. The light is a major navigational aid located on a rocky headland near the entrance to Woods Hole Harbor. A photograph of the structure and the existing view toward the site of the proposed action is shown on sheet 1; locations of these photographs are shown on sheet 2. The complex consists of the 40 ft-high light tower with entry porch (1876), two keeper's dwellings (1876, 1990) connected by a porch, a brick oil house (1876), paint lockers (1876), garage (1931) and a radio beacon building (1937). The light has been unmanned and automated since 1985.

The Light Station complex is listed on the NRHP as part of the Lighthouses of Massachusetts Thematic Group. The 2.11 acre (8,538 $m^2$) site is largely bare of vegetation and the white tower can be seen clearly from all directions. According to MHC's Lighthouse Information Form (MHC, 1981) "the Light possesses integrity of location, design, setting, materials and workmanship as well as significant associations with the development of aids of navigation in Massachusetts. It is important for its scenic qualities, sited on a bluff overlooking Vineyard Sound, and for its strategic location. The complex meets criteria A and C of the NRHP on the state level."

Visitors to the historic lighthouse are presented with open views of Nantucket Sound (see sheet 1) from the southeast to the southwest, including views of Martha's Vineyard. The base of the light is publicly accessible, and a plaque provides historic information to visitors that park at a small adjacent lot.

Character photos of the area around the Nobska Light are shown in Viewpoint (VP) 1 photographs on sheets 4-6. Locations are shown on sheet 2. The area is generally characterized by low to medium-density residential land use, with commercial use in the village of Woods Hole to the northwest. Large homes are generally scattered along winding roads among low wooded hills. Views toward the water from most roads and residences are generally well screened by trees. Open views easterly toward the site of the proposed action are available from Fay Road, and are expected from the easterly and southeasterly-facing upper stories of area homes. Open views of the site of the proposed action were not found in Woods Hole village.

***Other nearby viewpoints not selected for simulation***

A representative historic structure and the view toward the proposed action from the southern end of VP 2, the locally-designated Woods Hole Historic District, are shown on sheet 6. The location of VP 2 is shown on sheet 2, and was the only ground-level location found within this district with some view of Nantucket Sound toward the site of the proposed action. The view is partially blocked by the point of land at Nobska Light and by Martha's Vineyard.

VP 3 at the Woods Hole School on 24 School Street is shown on sheet 6. Photograph VP 3-CE-4 on sheet 7 shows no view of Nantucket Sound at this interior historic property.

A representative photograph of VP 4 in the locally designated East Falmouth Historic District is shown on sheet 7; the location is shown on sheet 3. No ground-level views of Nantucket Sound toward the proposed action were found in this historic district.

***Cotuit (see Figure 4.3.4-1 for VP 5; Character photos in Figure 4.3.4-2, sheets 8-11), Town of Barnstable***

The Village of Cotuit Historic District is included in the Town of Barnstable Multiple Resource Area (MRA), which was listed on the NRHP on November 10, 1987. Other Barnstable MRAs in the vicinity of the proposed action viewshed and described in this section include historic districts in Wianno, Craigville, Centerville, and Hyannis Port.

The Cotuit Historic District, westernmost of the villages in Barnstable, occupies a neck of land surrounded by Popponesset Bay to the west, Nantucket Sound to the south, and Osterville Harbor to the east. Most of the 107 buildings in the district are residential, although some commercial and institutional buildings have also been designated in the village colonial center. A representative historic structure is shown on sheet 8.

Character photos of the district are presented on sheets 10-11; locations are shown on sheet 9. Public access and views to the shoreline and south-southeasterly toward the site of the proposed action are limited. Street level views toward the water are generally broken/partially screened by vegetation and structures. However, views are likely available from many of the large shoreline homes, especially from the upper stories.

The National Register Criteria Statement found the Cotuit Historic District significant as a major collection of 19th and early 20th century buildings related to the maritime industries and summer resort activities. The district was determined to possess integrity of location, design, setting, materials, workmanship, feeling and association, and to meet criteria A, B, and C of the NRHP (MHC, Village Summary Sheet: Cotuit, 1987).

Cotuit was first settled in the early 1700s in the interior Santuit area, near what is now Route 28, to utilize fertile lands and early transportation corridors. As local economies shifted from land-based activities to the maritime industries in the early 19th century, the settlement shifted to the shore along the west side of Cotuit Bay. Key maritime activities included oystering, fishing, shipbuilding, coastal trade, and salt making. Many of the houses in the district were built by ship captains, and reflected their wealth. As the maritime trades ebbed in the late 19th century, summer residents discovered the village. Federal and Greek Revival architectural styles represent the district's early seafaring heritage, while later Italianate, Second Empire, Gothic Revival, Queen Anne and Colonial Revival structures reflect the area's later evolution into a quiet summer resort.

Most buildings are framed by mature wooded vegetation. Cotuit has retained a quiet, settled atmosphere due to its location several miles from busy main routes. Its small harbor offers moorings for many boats, and the village has an active local sailing program. The village is traditionally known for its oysters, which continue to be harvested in Cotuit Bay. Oyster Harbors, a gated community of large seasonal homes, is located across Cotuit Bay to the east and is not included in the Barnstable MRAs.

***Wianno (see Figure 4.3.4-1 for location of VP 6; Character photos in Figure 4.3.4-2, sheets 12-16)***

The Wianno Historic District in the Village of Osterville is comprised of 28 main buildings and 13 outbuildings on approximately 40 acres (0.16 $km^2$) along Sea View Avenue and Wianno Avenue. The lands were originally assembled in the late 19th century by a consortium of businessmen and developed as a summer colony. The large well-kept lots on either side of Sea View Avenue along Nantucket Sound contain grand Shingle Style and Colonial Revival style summer houses, most of which were constructed between the late 19th century and World War I.

The focal point of the Wianno Historic District is the Wianno Club on Sea View Avenue, a massive three-story shingled main building and two-story rear ell, both with mansard roofs. The Wianno Club is shown on sheet 14, photograph VP 6-CE-10. The structure was designed by architect Horace Frazer of Boston (who also designed a number of private residences in the district). The Club overlooks Nantucket Sound on almost 1,000 ft (305 m) of beach frontage. The building is described as architecturally extremely significant, as much of its original and interior detailing survives. The structure was individually listed in the NRHP in 1979, and was listed as a Barnstable MRA in 1987.

On the Sound side of Sea View Avenue, which runs parallel to the shore, the structures are regularly spaced with open well-maintained lawns and unobscured views toward the site of the proposed action to the south. Across Sea View Avenue, views toward the site of the proposed action are limited to areas between intervening structures. Mature trees and large hedges also effectively screen views.

The National Register Criteria Statement found the Wianno Historic District in excellent condition, and possessing integrity of location, design, setting, materials, workmanship, feeling and association. It is significant as one of three well-preserved summer resort colonies developed in Barnstable in the late 19th century, and contains an extraordinary collection of Colonial Revival and Shingle Style architecture. The district is also significant for its association with a notable Boston architect and many prominent seasonal residents. The district meets criteria A, B, and C of the NRHC (MHC, Wianno Historic District Form B, 1986).

***Other nearby areas visited but not selected for simulation***

No views toward the water to the south were found in the Village of Osterville.

***Craigville, Town of Barnstable (see Figure 4.3.4-1 for location of VP 7; Character photos in Figure 4.3.4-2, sheets 17-20)***

Craigville is located at the center of a large crescent-shaped sandy beach system bordered by headlands at Wianno in Osterville on the west and Squaw Island in Hyannis Port on the east. Open views of Nantucket Sound to the south are available from this large beach system. The busy shorefront area contains popular public, semi-private and private beaches and associated parking areas, as described in Section 5.3.3.4. The most open and extensive southerly views toward the water and the proposed action are from Craigville Beach, the bluff above the apex of Craigville Beach, and shorefront homes on Long Beach Road in Centerville.

The Craigville Historic District includes 33 buildings and one park within the larger village of Craigville. The southernmost boundary of the historic district is 0.25 miles (0.4 km) north and topographically low compared to the bluff overlooking Nantucket Sound, from which VP 7 was taken (see sheet 17; for locations see sheet 18.) The district is limited to the core of the original development of the earliest buildings associated with a camp meeting ground developed by the New England Convention of Christian Churches in the 1870s. Although most of the structures in the district are now privately owned summer homes, the Craigville Conference Center owns the Craigville Inn and runs religious retreats. The district is within the interior portions of Craigville, does not extend to the bluff above Craigville Beach, is well vegetated and has no open views of Nantucket Sound. Representative historic structures within the district are shown on sheet 20 (VP 7 CE-7 and CE-8). The structures on the bluff at VP 7 have not been determined eligible for listing on the NRHP.

The focus of the Craigville camp meeting ground was the Tabernacle, a simple wooden church constructed in 1887, at the head of a triangular shaped park. The Tabernacle is shown on sheet 20, VP 7-CE-8. The Craigville Historic District was determined to possess integrity of location, design, materials, workmanship and feeling, and meets criteria A and C of the NRHP. It was found to be significant for its association with the Christian camp meeting movement the 19$^{th}$ century, and contains a well-preserved collection of associated buildings (MHC, 1985).

The religious campground settlement was similar to other earlier Methodist camp meetings in Eastham, Yarmouth and Martha's Vineyard, and drew lay people and ministers who journeyed by train then carriage or barge for summer services. The architecture is very similar to the Yarmouth Camp Ground Historic District (MHC No. YAR.B), which is located in an interior wooded location just south of the mid-Cape Highway (Route 6) at Exit 7 and several miles north of Nantucket Sound. The Yarmouth Camp Ground Historic District also has no open views of Nantucket Sound.

***Other nearby areas visited but not selected for simulation***

The Centerville Historic District, which contains 49 buildings and one object along Main Street, does not offer ground-level views of Nantucket Sound toward the proposed action; representative character photographs of Centerville are provided on sheet 19.

***Hyannis Port, Town of Barnstable (see Figure 4.3.4-1 for location of VP 8; Character photos in Figure 4.3.4-2, sheets 21 through 30)***

The summer community in the Hyannis Port Historic District is characterized by large, well-maintained colonial and shingled Victorian beach homes. The district contains 127 buildings on 1,000 acres (4.0 km$^2$), and is roughly bounded by Massachusetts Avenue and Edgehill Road, Hyannis Avenue, Hyannis Harbor and Scudder Avenue. A representative historic structure is shown on sheet 21. Character photographs are shown on sheets 25 through 28; locations of the photographs are shown on sheets 22-24. Open views of the water to the south-southwest are available along the shorefront (see sheet 21, bottom photograph), and intervening structures and vegetation provide broken views from the road and near shore locations. Public access to the shoreline is very limited.

The Kennedy Compound is located along the shore within the Hyannis Port Historic District and is also represented by VP 8. The Compound was listed as a National Historic Landmark in 1972. The Compound contains approximately 6 acres (24, 300 $m^2$) of waterfront property on Nantucket Sound, and includes the white clapboard residences that formerly housed Kennedy family patriarch Joseph P. Kennedy and his sons Robert F. Kennedy and John F. Kennedy (U.S. Department of the Interior [USDOI], 1972). The largest is the Joseph P. Kennedy house, where the family summered starting in 1926, and where Rose Kennedy lived until her death in 1995. The smaller houses were purchased by the sons for their families, and together comprise the Kennedy Compound. The Compound was the base of John F. Kennedy's presidential campaign in 1960, and served as the Summer White House in 1961. Subsequent presidential summer stays were nearby at Squaw Island, which provided better security and privacy. Although the Compound itself was not visited during the field reconnaissance, observations from adjacent locations indicate that open views of the site of the proposed action would be available from the Kennedy Compound.

***Other nearby areas visited but not selected for simulation***

Other historic districts and properties visited during field reconnaissance in Hyannis, Yarmouth, Dennis, Harwich and Chatham are listed in Table 4.3.4-1. Locations are shown on Figure 4.3.4-1, and on the appropriate sheets in Figure 4.3.4-2. These locations either did not have open views of Nantucket Sound, or were not designated historic properties, and were therefore not selected for simulation.

***Monomoy Point Lighthouse, Town of Chatham (see Figure 4.3.4-1 for location of VP 26, Character photo in Figure 4.3.4-2, sheets 31-33)***

The Monomoy Point Lighthouse is located at the southern end of Monomoy Island, a coastal barrier beach island extending approximately 10 miles (16.1 km) south of the Cape's elbow at Chatham. The island is an uninhabited coastal dune and marsh complex, and comprises most of the Monomoy National Wildlife Refuge managed by the USFWS. The island is accessible only by boat, and little human disturbance or development is evident except for footpaths and the historic lighthouse and its associated buildings. The land form is characterized by rolling dunes and bluffs, with beach grass and sparse, scattered woody vegetation. Marshes and open water dominate views near the shoreline.

Wildlife such as gulls, terns and seals are abundant and add to the remote and undeveloped character of the island. The island is a National Wilderness Area, although the parcel that contains the lighthouse is not included in that designation. The MAS has owned the parcel since 1977. A lighthouse has occupied the site since 1823. The present light was constructed around 1871. The lighthouse complex is unmanned, and includes a brick light tower and a two-story keeper's house, both of which have deteriorated. The complex was determined significant in the areas of engineering, exploration and settlement, and transportation.

**North and East Sides of Martha's Vineyard**

***Oak Bluffs, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 21, Character photographs Figure 4.3.4-2, sheets 45-50)***

This island village area is characterized by fairly high-density residential and commercial land use. Topography is relatively flat, except for a steep shoreline bluff. The lack of topographic relief and abundant structures tend to screen views toward the water from the interior of the area. The most open easterly-northeasterly views toward the proposed action are available along East Chop Avenue, Sea View Avenue and Ocean Avenue, as well as from residences along these roads, and from the East Chop Lighthouse. Ocean Park on Ocean Avenue (the selected viewpoint) also offers unobscured views toward the proposed action.

The VP 21 is representative of open views from East Chop Light and the Dr. Harrison A. Tucker Cottage at 65 (formerly 42) Ocean Avenue in Oak Bluffs, which are both listed on the NRHP.

The Tucker Cottage was originally built in the American Stick Style in 1872, and then was substantially altered into a large Queen Anne summer house in 1877. The house and carriage house is part of the Ocean Park neighborhood of large, late 19th century summer homes, near the Methodist camp meeting ground at Wesleyan Grove (see Martha's Vineyard Campground Historic District, below).

The street pattern of Ocean Park is a curvilinear series of narrow streets around Ocean Park, a 7 acre (0.03 $km^2$) semi-circular green space that faces Sea View Avenue and the Sound beyond. The Tucker Cottage overlooks the bandstand at Ocean Park on Ocean Avenue, the innermost crescent along the Park. The Dr. Harrison A. Tucker Cottage was determined to retain integrity of location, design, materials, workmanship, feeling, and association, and meets Criteria B and C of the NRHP (USDOI, 1990).

The East Chop Lighthouse is located on the highest bluff on East Chop, on the east side of Vineyard Haven Harbor. The cast-iron lighthouse was constructed in 1878, to replace a private lighthouse that was destroyed by fire. Open views toward the proposed action are available from this structure.

The West Chop Lighthouse, on the western side of Vineyard Haven Harbor, was originally constructed in 1817, replaced with the present brick tower in 1838, and was moved back from the sea in 1848 and 1891. Views toward the proposed action are screened by a line of white pines from roadside by the West Chop light, which is posted private property. Ground level views from the property itself are expected to be screened by the trees, although open views from atop the light are anticipated. Both East Chop and West Chop lighthouses have protected mariners entering Vineyard Haven Harbor since Colonial times, and both are listed on the NRHP's multiple listing of lighthouses on Martha's Vineyard.

***Other nearby areas visited but not selected for simulation***

Several other historic properties or districts in Oak Bluffs have more limited views of Nantucket Sound toward the area of the proposed action, due to screening provided by mature vegetation such as shade trees and intervening structures. These include the Martha's Vineyard Campground Historic District in Oak Bluffs (also called Wesleyan Grove), which contains 306 19th century cottages and 6 public buildings on 34 acres. The district is located close to, but does not border, Nantucket Sound. No ground level views of Nantucket Sound were found within this district. The campground was founded in 1835 as a summer Methodist meeting area; the first participants stayed in tents that were later replaced by small cottages. The focal points of the camp are the iron Tabernacle and the Trinity Methodist Church, both located on Trinity Park near the center of the campground. The typical campground cottage is a simple 1.5-story rectangular structure, approximately 15 ft (4.6 m) wide by 20 ft (6.1 m) deep. Porches, typically late 19th century additions, are heavily ornamented with trim. Much of the historic district is shaded with mature trees and other vegetation. The Martha's Vineyard Campground is significant for its unique architecture, state of preservation, and its association with 19th century religious practices (USDOI, 1978).

Religious activity in the 19th century caused the campground to grow rapidly. The original week-long religious meeting in August evolved as people began arriving earlier in the summer, sparking the resort development of the adjacent area. The resulting town of Cottage City was created in 1880, and was renamed Oak Bluffs in 1907.

The Oak Bluffs Christian Union Chapel (known as Union Chapel) is west of Ocean Park and close to the Methodist campground of Wesleyan Grove. The chapel was built in 1870 in the American Stick Style. The mature vegetation around the church partially obscures the chapel from contiguous streets, and fully screens the chapel from views of Nantucket Sound. The chapel exhibits integrity of location, design, materials, workmanship, feeling and association, and meets Criteria A and C of the NRHP (USDOI, 1990).

The Flying Horses Carousel at 33 Oak Bluffs Avenue is located in the business district of Oak Bluffs. It is listed on the NRHP, and has also been listed as a National Historic Landmark since 1987. The carousel of 20 prancing horses and four chariots has operated at this location since 1889, and is indicative of the late 19$^{th}$ century interest in amusements and recreation at summer resorts such as Oak Bluffs. The Flying Horses Carousel possesses integrity of location (since 1889), design, material, workmanship and association, and is significant as the oldest platform carousel operating in the United States (USDOI, 1979). No open views were available from this structure.

The Arcade at 31 (formerly 134) Circuit Avenue is a commercial building listed on the NRHP. No ground level views of the proposed action are available from this building, which is surrounded by other commercial buildings and shops along this busy street in downtown Oak Bluffs.

Limited views to the north-northeast are available from West Chop, a residential area in Tisbury. Views toward the site of the proposed action are not generally available from the center of Vineyard Haven.

***Edgartown, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 20; Character photos Figure 4.3.4-2, sheets 38 through 44)***

This island colonial village area has relatively high-density residential and commercial land use, with well-maintained large homes, small shops, inns and restaurants connected by narrow streets. Public views toward the water from the village area are generally partially or fully screened by intervening structures and vegetation. Views toward the proposed action to the northeast are available from shoreline residences and associated private beaches. The only publicly accessible open northeasterly views are from Water Street and Lighthouse Beach. The selected viewpoint VP 20 is the most open view from a historic site (the Edgartown Lighthouse at the entrance to Edgartown Harbor). Almost all other views toward the site of the proposed action from Edgartown are partially blocked by Chappaquiddick Island.

The Edgartown Village Historic District comprises approximately 150 acres (0.6 km$^2$) along the west side of Edgartown Harbor. The district contains approximately 500 contributing buildings (constructed pre-1933), mostly wood frame houses of the 19$^{th}$ and early 20$^{th}$ centuries. A smaller, locally designated district (the Edgartown Local Historic District) is contained within the NRHP District. The village's two major periods of significance relate to late 18$^{th}$ to 19$^{th}$ century whaling activities, and late 19$^{th}$ century to present day summer tourism. Architectural styles vary from First Period Colonial (circa 1650's to 1750), late Georgian and Federal sea captains homes, Greek Revival, Victorian and Colonial Revival. The boundaries of the historic district do not extend to Nantucket Sound except at Edgartown Light (also called the Harbor Light Lighthouse), but views of the Sound to the east and northeast are available from easternmost structures within the district.

The Edgartown Lighthouse is located on a rock breakwater off a spit along the northeastern side of Edgartown Harbor. The original lighthouse at the eastern end of the Harbor was built in 1828 and destroyed following the Hurricane of 1938. This structure was replaced by a cast-iron lighthouse that originally stood at Crane's Beach in Ipswich, and was disassembled and moved by barge to Edgartown in 1939. The structure is part of the Lighthouses of Massachusetts multiple listing on the NRHP, and is one of five lighthouses included on the listing within Martha's Vineyard.

***Cape Poge, Edgartown, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 19; Character photos in Figure 4.3.4-2, sheets 34-37)***

This largely natural area on the north side of Chappaquiddick Island is protected by the Massachusetts Trustees of Reservations, a private land and property conservation organization. The area contains dunes and low coastal vegetation, bordered in places by a steep 20 to 30 ft (6.1 to 9.1 m) high sandy bluff at the ocean shoreline. The area is undeveloped other than perhaps 5 to 10 large homes and several unimproved sand roads. Cape Poge offers expansive views at and near the shoreline. Once away from the shoreline, including at the base of the lighthouse discussed below, the dunes and dune vegetation effectively screen most views toward the water.

The Cape Poge Lighthouse at VP 19 is one of the five lighthouses on Martha's Vineyard listed on the NRHP. Built in 1922 on the northeastern tip of Chappaquiddick, the present wood-shingled lighthouse replaced several earlier decaying towers, the earliest of which was constructed in 1802. Encircling the top of the tower is a simple cast iron balustrade. The windows and doorway are pedimented.

**North Side of Nantucket**

Nantucket Village is a densely settled classic colonial New England maritime community on the western side of Nantucket Harbor. The entire island, including Muskeget and Tuckernuck Islands to the west, comprises a NRHP and was also designated as a National Historic Landmark in 1966. Muskeget Island was designated as a National Natural Landmark in 1980, as the only known locality where the Muskeget vole is found and the southernmost area where the gray seal breeds (National Registry of Natural Landmarks, 1999).

The historic character of the village is defined by the clean pious lines of the houses of former sailors, fishermen and clergy as well as the grand federal-style mansions of former ship captains and owners. These varied structures are linked by cobblestone streets and shaded with large street trees. Views of the northwest toward the site of the proposed action are not available at ground level within Nantucket village itself (although views may be available from the upper stories of some buildings) or from the docks and wharfs along the western side of Nantucket Harbor. Representative photographs of Nantucket Village and locations are provided on sheets 52-58. The simulation location is discussed below.

***Nantucket Cliffs along Cliff Road, North of Nantucket Village Center (see Figure 4.3.4-1 for location of VP 22; Character photos in Figure 4.3.4-2, sheets 51-58)***

Upon leaving the village area and heading to the northwest, narrow roads traverse a landscape of rolling dunes and low-density residential development. The dunes and vegetation tend to block views toward the water. An open area atop the shore-facing bluff along Cliff Road (the selected VP 22) offers the first open views toward the proposed action. The beach below also offers unobscured views. The beach continues to the west to the Eel Point conservation area at Madaket. Homes along the north shore and associated private beaches also have open views toward the proposed action, as does the shorefront area off Cliff Road to the east to Jetties Beach at West Jetty. Public access to the north-facing beaches is generally limited, and as one moves inland, views of the water toward the proposed action quickly disappear.

***Great Point, Nantucket (see Figure 4.3.4-1 for location of VP 23, Character photos in Figure 4.3.4-2, sheets 59 through 61)***

Great Point is a unique undeveloped beach area that forms the northeastern most part of Nantucket, and separates the Atlantic Ocean to the east from Nantucket Sound to the west. Characterized by crashing surf, rolling sand dunes, low beach grass and tidal marsh, the area is a remote and wild setting. The point is managed by the Trustees of Reservations, and is accessible only by four-wheel drive vehicle along a sand track. The Nantucket Light (also called Great Point Light or Sandy Point Light) and the immediately surrounding land constitute the historic property. Lighthouses have operated at Great Point since 1789. The existing unmanned masonry structure was constructed in 1818, and is one of the oldest existing lighthouse structures in the state.

Great Point Light was determined to possess integrity of location, design, setting, materials and workmanship, as well as significant associations with the development of aids to Massachusetts navigation. The tower is the first landfall on Nantucket seen from the Atlantic Ocean, and meets criteria A and C of the NRHP.

The Nantucket Conservation Foundation protects barrier beach south of the Great Point area. The area is remote and is characterized by ocean surf on the east, sand dunes and salt marshes. The area is largely undeveloped with only one or two private homes, a sand road, and the Great Point lighthouse, which is a visual focal point. Panoramic open views in all directions are available from many locations on Great Point, as well as along the sand access road, where not screened by sand dunes. The viewpoint from Great Point is representative of open views toward the proposed action from the Wauwinet area of Nantucket.

***Tuckernuck Island (see Figure 4.3.4-1 for location of VP 24, Character photos in Figure 4.3.4-2, sheets 62 through 64)***

Tuckernuck Island is roughly 2 miles (3.2 km) long and 1 mile (1.6 km) wide, and is located approximately 1 mile (1.6 km) west of Nantucket Island and 8 miles (12.9 km) east of Martha's Vineyard. This sparsely settled island off the western tip of Nantucket is accessible by boat only. The island is composed of moraine deposits (in the rocky northwestern portion of the island), sandy outwash plains along the south, and sand dunes.

The island contains about 30 to 40 seasonal cottages and larger homes, and a network of sand roads. The historic houses on Tuckernuck are clustered within two groupings, one around North Pond (on the northwest side of the island) and one around East Pond, and consist of wood-frame shingle-clad structures that generally reflect early fishing, hunting and livestock grazing economies. Topography is generally flat and vegetation consists of low to medium height shoreline scrub. Vegetation is taller and denser in the interior of the island, and more open and sparse near the shoreline. As a result of the level topography and scrub vegetation, views toward the proposed action are concentrated near the shoreline and from private residences.

**Additional Properties Analyzed for the FEIS**

In addition to the properties discussed above, twenty-two other properties were assessed based on comments from consulting parties. Of these, 18 were evaluated as eligible for inclusion in the NRHP. Each eligible property is described below, along with an assessment of the view from each property toward the proposed action. A summary of the view from these properties is presented in Table 4.3.4-1.

***Falmouth Heights Historic District, Falmouth (see Figure 4.3.4-3).***

The summer residential community of Falmouth Heights was the town's first planned summer resort community. Designed originally by noted Worcester architect Elbridge Boyden and developed between 1870 and 1930 on high bluff, the district includes approximately 500 properties, curvilinear streets, parks, and broad views of Vineyard Sound. The Falmouth Heights Historic District is entered in the MHC inventory as FAL.I and was previously determined eligible for the NRHP by the MHC. The Falmouth Heights Historic District is eligible for listing in the NRHP and meets criteria A and C.

The visibility of Nantucket Sound and the wind park site is unobstructed from the bluffs of the Falmouth Heights Historic District. It is approximately 3.5 miles northeast of VP-1, closer to the wind park, so turbines would be more visible from this historic property than from VP-1.

***Maravista Historic District, Falmouth (see Figure 4.3.4-3)***

The Maravista (meaning "view of the sea) area is defined by a cluster of approximately 25 well-preserved early 20th century summer cottages on Vineyard Sound that developed beginning in 1906 at one of the prime shoreline areas of Falmouth. The Maravista Historic District is entered in the MHC inventory as FAL.K and is potentially eligible for listing in the NRHP and meets criteria A and C.

Maravista Historic District is approximately 4 miles northeast of VP-1, so turbines would be more visible from this historic property than from VP-1. Views of Nantucket Sound and the wind park site are unobstructed from the shoreline areas of the district.

***Menahaunt Historic District, Falmouth (see Figure 4.3.4-3)***

The Menahunt (meaning "Island Place") area consists of approximately 25 well-preserved summer cottages from the 1870s and 1880s surrounded by coastal ponds and Vineyard Sound. The Menahaunt Historic District is entered in the MHC inventory as FAL.J and is potentially eligible for listing in the NRHP and meets criteria A and C.

Views of Nantucket Sound and the wind park site are unobstructed from the shoreline areas of the Menahaunt Historic District. The district is located approximately 6 miles northeast of VP-1; thus, turbines would appear larger on the horizon from this historic property than they would from VP-1.

***Church Street Historic District, Falmouth (see Figure 4.3.4-3)***

Located east of Little Harbor, the Church Street Historic District occupies the spit of land called Nobska Point, which contains Nobska Light (NRHP-Listed) at its highest point. The approximately 25 buildings range from the circa 1685 Abner Davis Tavern to the Church of the Messiah built in 1888, and large summer estates. The area was associated with 19th century shipping lanes and settlement at Woods Hole and later summer resort development. The Church Street Historic District is entered in the MHC inventory as FAL.M and is potentially eligible for listing in the NRHP and meets criteria A and C.

Views of Nantucket Sound and the wind park site are unobstructed from the Nobska Point bluff looking east, although most of the Church Street Historic District faces west towards Little Harbor. Views from this resource are represented by VP-1.

***Stage Harbor Lighthouse, Chatham (see Figure 4.3.4-3)***

Stage Harbor Lighthouse is located in low sand dunes and scrub growth at the southeast tip of Harding's Beach at the entrance to Stage Harbor. The intact complex consists of the cast iron lighthouse, erected and commissioned in 1880, attached shingle-clad keeper's house, boat shed, and outhouse in an undeveloped marine setting. The lantern and lens were removed when the light was decommissioned in

1935; otherwise the Stage Harbor Light remains essentially intact from the 19th century. Stage Harbor Lighthouse is entered in the MHC inventory as CHA.917 and was previously recommended as eligible for the NRHP. Stage Harbor Light is potentially eligible for listing in the NRHP and meets criteria A and C.

The Stage Harbor Lighthouse's location provides an unobstructed and panoramic view of Nantucket Sound and the location of the wind park. It is located approximately 4 miles east of VP-15, so the views of the wind turbines would be a little smaller and less visible than in VP-15 since atmospheric interference increases with distance.

***Captain Joshua Nickerson House, 190 Bridge Street, Chatham (see Figure 4.3.4-3)***

Set well back from the south side of Bridge Street on a knoll overlooking the Mitchell River, the Captain Joshua Nickerson House at 190 Bridge Street is a large and elegant two-story Federal period dwelling with a hip roof, rear wall chimneys, and a rear ell. The house was built about 1810 and has associations with 19th century Chatham's maritime history starting with retired sea Captain Joshua Nickerson, and with summer resort activities in the 20th century. The Captain Joshua Nickerson House is entered in the MHC inventory as CHA.260 and was previously recommended as eligible for the NRHP. The Captain Joshua Nickerson House is potentially eligible for listing in the NRHP and meets criteria A and C.

The Captain Joshua Nickerson House façade faces south; however, the intervening land mass of Stage Island obstructs views toward the site of the proposed action.

***Jonathan Higgins House, 300 Stage Neck Road, Chatham (see Figure 4.3.4-3)***

The Deacon Jonathan Higgins House at 300 Stage Neck Road is a traditional five-bay Cape Cod dwelling that was originally erected in Wellfleet about 1760. It was dismantled and re-assembled at its current site overlooking Oyster Pond River in 1939, under the guidance of architect George Forsyth, to be the summer home of Chief Justice Louis Brandeis of the U.S. Supreme Court. The Deacon Jonathan Higgins House is entered in the MHC inventory as CHA.419. The house is potentially eligible for inclusion in the NRHP for its associations with the Colonial Revival period in the early 20th century and meets NRHP criteria A and C. In 1999, the MHC requested additional information in order to determine eligibility.

There are no views towards the wind park site from the Deacon Jonathan Higgins House due to the land mass of Harding's Beach with lies between the house and Nantucket Sound.

***Stage Harbor Road Historic District, Chatham (see Figure 4.3.4-3)***

The Stage Harbor Road area extends from the Oyster Pond shoreline at Champlain Road northwards along Stage Harbor Road. A monument commemorates Samuel deChamplain's three week visit to Stage Harbor in 1606, which marked the first European exploration of the Chatham area. The approximately 50 properties in the area include Cape Cod cottages, Federal, Greek Revival, and Italianate style houses and barns that attest to the area's agricultural history and more importantly, it's connection to maritime industries and the sea in the 18th, 19th, and 20th centuries. The Stage Harbor Road area is entered in the MHC inventory as CHA.K and was previously recommended as eligible for the NRHP. The Stage Harbor Road Historic District is potentially eligible for listing in the NRHP and meets criteria A and C.

Due to the configuration of the Stage Harbor Road Historic District extending away from the shore and the presence of Harding's Beach and the Dike that create Stage Harbor, the visibility of the wind park site is limited to a narrow view through harbor mouth.

***Champlain Road Historic District, Chatham (see Figure 4.3.4-3)***

Approximately 25 historic Cape Cod and Greek Revival style cottages from the 18th through 20th centuries are positioned on a bluff along Champlain Road above Stage Harbor, where Samuel de Champlain anchored for three weeks in 1606. A yacht club and boatyard are set at the shoreline. The Champlain Road Historic District is entered in the MHC inventory as CHA.J. The Champlain Road Historic District is potentially eligible for listing in the NRHP and meets criteria A and C.

Views of Nantucket Sound and the wind park location beyond the intervening land spits that frame the entrance to Stage Harbor are experienced from the Champlain Road Historic District due to its relatively high elevation. The district is located approximately 4 miles east of VP-15, so the views of the wind turbines would be smaller and less visible than in VP-15 since atmospheric interference increases with distance.

***Hithe Cote, 32 Snow Inn Road, Harwich (see Figure 4.3.4-3)***

Stewart Church a doctor from Brooklyn New York built this two-story frame summer residence about 1890. Hithe Cote occupies the crest of a prominent hill above Vineyard Sound near Wychmere Harbor that was developed by Church and others as a summer resort. Hithe Cote is entered in the MHC inventory as HAR.211. The house is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

Although a more recent house has been constructed nearby, Hithe Cote's location continues to provide an unobstructed and panoramic view of Vineyard Sound and the location of the wind park. This view is represented by VP-15.

***Ocean Grove Historic District, Harwich (see Figure 4.3.4-3)***

Modestly-scaled and well-preserved Victorian cottages set along narrow streets characterize the Ocean Grove Historic District which began as a Spiritualist campground in the 1880s. In addition to approximately 100 houses, prominent topographical features include the Grove, which is formed in a natural bowl, and the Beach along Nantucket Sound. In the early 20th century use of the area shifted from Spiritualist gatherings to summer recreation, which continues today. The Ocean Grove Historic District is entered in the MHC inventory as HAR.L and was previously evaluated as eligible for the NRHP by the MHC. The Ocean Grove Historic District is eligible for listing in the NRHP and meets criteria A and C.

Open views of Nantucket Sound and the wind park location are present from the Ocean Grove Historic District properties and the beach along the shoreline. This resource is close to VP-15, so views to the project from this historic resource are represented by VP-15.

***205 South Street, Yarmouth (see Figure 4.3.4-3)***

The residence at 205 South Street is a three-quarter Cape Cod cottage built circa 1770. Its original site is unknown and it was apparently moved to its current location in the shore community near Bass River in the early to mid 20th century. Despite the move, which was not uncommon in that era, the house appears to be largely intact from the 18th century. 205 South Street is entered in the MHC inventory as YAR.365. The house is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

Views of Nantucket Sound and the location of the wind park are obstructed from 205 South Street.

***Park Avenue Historic District, Yarmouth (see Figure 4.3.4-3)***

The Park Avenue area includes approximately 25 modest summer residences from the late 19th and early 20th centuries. The district runs parallel to the water in a Lewis Bay shoreline resort neighborhood just west of Hyannis Inner Harbor. The area was not previously entered in the MHC inventory. The Park Avenue Historic District is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

Views of Nantucket Sound and the location of the wind park are present through the mouth of Lewis Bay. This resource is located approximately 2.5 miles northeast of VP-8, which approximates the view one might have through the mouth of Lewis Bay.

***Massachusetts Avenue Historic District, Yarmouth (see Figure 4.3.4-3)***

The Massachusetts Avenue area extends from the Lewis Bay shoreline northward away from the water and encompasses approximately 25 modest summer residences from the late 19th and early 20th centuries. The area was not previously entered in the MHC inventory. The Massachusetts Avenue Historic District is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

There are no views of Nantucket Sound and the location of the wind park due to the intervening presence of Great Island.

***Cottage City Historic District, Oak Bluffs (see Figure 4.3.4-3)***

Cottage City is a sprawling district of approximately 386 19th and 20th century summer cottages and houses, many of which are highly ornate, on the bluff overlooking Nantucket Sound. Two large focal parks, Central Park and Waban Park on the water, and several other parks are dispersed in the district. Cottage City is a local historic district and is entered in the MHC inventory on multiple area forms. The Cottage City Historic District is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

Views of Nantucket Sound and the location of the wind park are unobstructed from Cottage City, and are represented by VP-21.

***Vineyard Highlands, Oak Bluffs (see Figure 4.3.4-3)***

Vineyard Highlands was the third major area developed on Oak Bluffs, and was an effort in 1870 to establish a new camp meeting area with a wharf, hotel, and residences. Although development was slow, the area did emerge as a popular tourist and summer residence center by 1900. Curved streets, small parks, and approximately 300 cottages with a curving road along the high bluff at Nantucket Sound are defining characteristics. The Vineyard Highlands Historic District is entered in the MHC inventory as OAK.B. The Vineyard Highlands Historic District is potentially eligible for inclusion in the NRHP and meets NRHP criteria A and C.

Views of Nantucket Sound and the location of the wind park are unobstructed from the bluff of the Vineyard Highlands Historic District, and are represented by VP-21.

***Seaman's Reading Room, Tisbury (see Figure 4.3.4-3)***

The Seaman's Reading Room on West Chop Road/Main Street in Tisbury is a traditional Cape Cod cottage built about 1711 and is one of the oldest remaining houses on Martha's Vineyard. The house was moved from Hatch Road in 1918 and added on to in the 20th century. The Seaman's Reading Room is entered in the MHC inventory as TIS.135 and was determined eligible by consensus for individual listing in the NRHP.

There are no views of Nantucket Sound and the wind park from the Seaman's Reading Room due to intervening buildings.

***West Chop Historic District, Tisbury (see Figure 4.3.4-3)***

The West Chop Historic District, Tisbury, is an enclave of early 20th century Shingle style houses, club buildings, recreational facilities, and shore line beaches at the northern tip of West Chop in Nantucket Sound. The West Chop Historic District is entered in the MHC inventory as TIS.D and was listed in the NRHP in 2008. The West Chop Historic District meets NRHP criteria A and C.

There are panoramic views from West Chop eastward in Nantucket Sound to the wind park location. This resource is located approximately 2.5 miles northwest of VP-21, which provides a representative view from this district.

### *4.3.4.2 Visual Resources Associated with Tribal Areas of Cultural and Religious Importance*

The potential visual impact of the proposed action on the Wampanoag Tribe of Gay Head/Aquinnah and the Wampanoag Tribe of Mashpee, was raised as a concern during government-to-government consultations about the proposed action between the MMS and the Tribal Historic Preservation Offices.

At the Cape Wind public hearing at University of Massachusetts in Boston, the Chairwoman of the Wampanoag Tribe of Gay Head Aquinnah expressed concern that the right to practice their religious ceremony in the traditional manner will be forever denied by the proposed action. The Chairwoman stated "as the People of the First Light, one of the most important aspects and fundamental components of their religious and cultural beliefs and practices is their ability to experience, embrace, and give ceremony and prayers of thanksgiving to the first light. These ceremonies, spiritual and religious practices are dependent upon maintaining the ability to view the first light, the eastern horizon vista and viewshed. Additionally, there will be other impacts, such as the celestial and solstice ceremonies, which will also be adversely impacted." In a subsequent Section 106 Consultation meeting with the Gay Head/Aquinnah and Mashpee Wampanoag Tribes, Bettina Washington, Tribal Historic Preservation Officer for the Gay Head/Aquinnah, stated that by the alteration of their tribal members' ability to conduct their religious ceremonies with an unobstructed view of the rising sun on the eastern horizon, "... you're asking me to give up my identity."

At the Cape Wind public hearing in West Yarmouth, the Tribal Historic Preservation Officer of the Mashpee Wampanoag Tribe, Mr. George "Chuckie" Green Jr. stated, "historical, cultural, religious values that we place on the sound are immense. Our celestial ceremonies are held (on the sound). The blocking of those views, of that sunrise, would be an issue to the tribe." In addition, in their letter of comment on the DEIS, Mr. Green states, "The Mashpee are members of the Great Wampanoag Nation (the People of the First Light). Our name defines who we are…" The letter goes on to state that the Mashpee have a significant cultural and religious need to have a clear unobstructed view of the southeast horizon.

### *4.3.4.3 Visual Resources Associated With Recreational Areas*

Onshore Cape Cod, Nantucket, Martha's Vineyard (and the state waters of Nantucket Sound) are well known for coastal recreational and summer tourism activities including beach going, swimming, boating, fishing, hiking, biking, picnicking, golfing and bird watching. Marinas, yacht clubs and public boat ramps line most of the harbors and inlets with sufficient water depths. Large areas of undeveloped protected shoreline are found along Monomoy Island south of Chatham, Cape Poge on Chappaquiddick Island on Martha's Vineyard, and Tuckernuck Island and Great Point in Nantucket.

Sandy beaches nearly continuously rim the Cape and Islands landforms, supplied with sediments deposited by receding glaciers and reworked since then by fluvial processes (see Section 4.1.1). The shorelines around Nantucket Sound are generally developed with large seasonal shorefront homes or shorefront resorts and associated private beaches, most constructed during the 20th century. The public beaches attract thousands of recreational users in the summer months. Public and semi-private beaches (such as association and resident-only beaches) with expected open views toward the proposed action are shown on Figure 4.3.4-4. This figure also indicates the locations chosen for visual simulations. The names of the recreational areas shown in Figure 4.3.4-4 and their distance to the site of the proposed action are provided in Table 4.3.4-2. Identification numbers on the table and figure pertain to those resources identified by the MassGIS databases; resources identified by other information sources were placed on Table 4.3.4-2 in the rows between the nearest GIS-listed resources. Due to the generally level topography, mature wooded vegetation, and intervening structures found on the Cape and Islands, open views were generally limited to recreational areas in the immediate vicinity (i.e., within approximately 300 ft [91 m]) of the shoreline.

Note that all twelve visual simulation locations chosen for historical structures referenced in 4.3.4-1 (see Figure 4.3.4-2) are also in fact representative of recreational and or park areas, as the historic structure simulation locations were taken from nearby beaches and or at parks to allow for unobstructed, worst case visual impacts.

The following is a description of recreational areas that would have a view toward the site of the proposed action.

**South Side of Cape Cod**

***Nobska Point Light Station, Woods Hole, Falmouth (see Figure 4.3.4-1 for location of VP 1; Character photos in 4.3.4-2, sheets 1-7)***

Visitors to the historic lighthouse are presented with open views of Nantucket Sound from the southeast to the southwest, including views of Martha's Vineyard. The base of the light is publicly accessible, and a plaque provides historic information to visitors that park at a small adjacent lot. The surrounding area is residential, with large homes scattered along winding roads among low wooded hills. The popular Shining Sea Bike Path meanders through woods and along the shore near this area.

Heading easterly from Woods Hole to Cotuit (described below) are popular shorefront areas in Falmouth, and Falmouth Heights, as well as a number of small parks (see Table 4.3.4-2). The shoreline is nearly continuously rimmed with wide sandy beaches and contains large waterfront resorts, public beaches, and many seasonal homes with associated private beaches. These areas have open views of Nantucket Sound to the south.

***Cotuit, Town of Barnstable (see Figure 4.3.4-1 for location of VP 5; Character photos in Figure 4.3.4-2, sheets 8-11)***

Recreational resources in the vicinity of VP 5 are the Mashpee beaches, including South Beach State Park, the New Seabury beach, and Popponesset Beach, as well as Loop Beach in Cotuit. The New Seabury Country Club and golf course are also located in the vicinity of this viewpoint. The Waquoit Bay National Estuarine Research Reserve, a 3,000 acre (12.14 $km^2$) Area of Critical Environmental Concern (ACEC), bordering Falmouth and Mashpee, offers opportunities for passive recreation such as bird watching. Sampson Island, a 15 acre (6.1 hectare) MAS Sanctuary and barrier island at the mouth of Cotuit Harbor between Cotuit and Oyster Harbors, and many local sailing and boating programs are located within Cotuit and Osterville Harbors.

***Wianno (see Figure 4.3.4-1 for location of VP 6; Character photos in Figure 4.3.4-2, sheets 12-16)***

A small Town Beach with limited parking is located on Wianno Avenue at the eastern end of Sea View Avenue. Open views of the proposed action would be available from this location. Wianno Beach and the larger Dowses Beach in Osterville are also located in the vicinity of VP 6. Boating is a popular activity in the Osterville area, which includes a number of marinas.

***Craigville, Town of Barnstable (see Figure 4.3.4-1 for location of VP 7; Character photos in Figure 4.3.4-2, sheets 17-20)***

Craigville is located at the center of a large crescent-shaped sandy beach system bordered by headlands at Wianno on the west and Squaw Island in Hyannis Port on the east. Open views of Nantucket Sound to the south are available from this large beach system. The popular public beaches of Craigville Beach, the Association Beach, and Covell Beach are located in the vicinity of this viewpoint, as well as associated beach parking areas. Several summer rental cottage communities are located on the opposite side of Craigville Beach Road, with a popular snack bar servicing beach-goers in the summer months.

The private Beach Club on Long Beach Road in Centerville abuts the western end of the large Craigville Public Beach. Private beaches are located adjacent to large shorefront homes down Long Beach Road. The Long Beach Conservation Area, a 3.5 acre (14,100 $m^2$) protected barrier beach at the west end of Long Beach Road, offers passive recreation with limited parking.

***Hyannis Port, Town of Barnstable (see Figure 4.3.4-1 for location of VP 8; Character photos in Figure 4.3.4-2, sheets 21-30)***

Private recreational resources near this viewpoint include the Hyannis Port Golf Club and the Hyannis Port Yacht Club, which have open views of the water to the south. Public access to the shorefront is extremely limited.

Heading easterly along the shore from Hyannis Port to Chatham are the communities of Hyannis around Lewis Bay, including the boat and ferry docks of Hyannis, the Hyannis beaches of Keyes, Sea Street and Kalmus Park, the private residential Point Gammon area, and the beaches and recreational areas in West Yarmouth, Yarmouth, Bass River, West Dennis, Dennis, Dennisport, Harwich, Harwich Port, Wychmere Harbor, and Chatham. These are listed in Table 4.3.4-2, along with the distances and directions of the resource from the nearest viewpoints.

Open views of Nantucket Sound to the south-southwest are available from immediate shorelines of these areas, which include resorts and other accommodations, as well large seasonal homes and associated private beaches. Intervening topography, structures and vegetation typically screens views to the south and southwest from within Hyannis Inner Harbor and other smaller harbors to the east, such as Wychmere Harbor in Harwich Port.

***Monomoy Point Lighthouse, Town of Chatham (see Figure 4.3.4-1 for location of VP 24, Character photo in Figure 4.3.4-2, sheets 31-33)***

The 2,750 acre (11.12 $km^2$) island comprises most of the Monomoy National Wildlife Refuge managed by the USFWS and is a National Wilderness Area, although the parcel that contains the lighthouse is not included in the designation. Monomoy is only accessible by boat, and visitation at night is prohibited. The island offers opportunities for swimming and boating, as well as passive recreation, such as bird and wildlife watching.

VP 24 is also representative of the views from the beaches of Harwich and Chatham, and from Harding Beach boat landing.

**North and East Sides of Martha's Vineyard**

***Oak Bluffs, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 21, Character photographs Figure 4.3.4-2, sheets 45-50)***

VP 21 at Ocean Park is also representative of open views from East Chop Light in Oak Bluffs. Ocean Park is a 7 acre (28,300 $m^2$) park overlooking Nantucket Sound, with a bandstand that offers musical and other outside entertainment. The East Chop Lighthouse is both a scenic and historic attraction.

The Flying Horses Carousel at 33 Oak Bluffs Avenue is located in the business district of Oak Bluffs. The carousel of 20 prancing horses and four chariots has operated at this location since 1889, and is a popular tourist attraction. No open views of Nantucket Sound are available from this structure.

VP 21 and VP 20 (below) are indicative of views from the bike path from Edgartown Beach Road between Oak Bluffs and Edgartown, and from beaches along this roadway. The viewpoints are also representative of views from Felix Neck Wildlife Sanctuary and Sarson's Island Bird Sanctuary, and the Farm Neck Golf Course.

***Edgartown, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 20; Character photos Figure 4.3.4-2, sheets 38-44)***

Views at VP 20 are indicative of views at Lighthouse Beach and the Harbor Light Lighthouse, as well as recreational resources south of Oak Bluffs, as identified above.

***Cape Poge, Edgartown, Martha's Vineyard (see Figure 4.3.4-1 for location of VP 19; Character photos in Figure 4.3.4-2, sheets 34-37)***

This largely undeveloped area on the north side of Chappaquiddick Island is protected by the Massachusetts Trustees of Reservations. The area contains dunes and low coastal vegetation, bordered in places by a steep 20 to 30 ft (6.1 to 9.1 m) high sandy bluff at the shoreline. The Cape Poge Lighthouse is one of the five lighthouses on Martha's Vineyard listed on the NRHP. Built in 1922 on the northeastern tip of Chappaquiddick, the present wood-shingled lighthouse replaced several earlier decaying towers, the earliest of which was constructed in 1802.

A wide barrier beach open to the public extends to the south from Cape Poge Lighthouse. Several sand roads and a small number of large homes comprise the limited development. The Reservation offers expansive views across Nantucket Sound to the northeast, although once away from the shoreline (including at the base of the lighthouse), the dunes and association vegetation effectively limit most views of the water. Fishing is popular along the barrier beach at Cape Poge.

**North Side of Nantucket**

***Nantucket Cliffs along Cliff Road, North of Nantucket Village Center (see Figure 4.3.4-1 for location of VP 22; Character photos in Figure 4.3.4-2, sheets 51-58)***

An open area atop the shore-facing bluff along Cliff Road (the selected VP 22) offers the first open views toward the proposed action when coming from Nantucket Village. Cliff Beach below also offers unobscured views, and is representative of views continuing westerly to Dionis Beach, Capaum Beach and to the Eel Point conservation area at Madaket. Homes along the north shore and associated private beaches also have open views toward the proposed action, as does the shorefront area off Cliff Road to the east to Jetties Beach at West Jetty. Public access to the north-facing beaches is generally limited.

***Great Point, Nantucket (see Figure 4.3.4-1 for location of VP 23, Character photos in Figure 4.3.4-2, sheets 59-61)***

Great Point is a unique nearly pristine beach area that forms the northeastern most part of Nantucket, and separates the Atlantic Ocean to the east from Nantucket Sound to the west. The point is managed by the Trustees of Reservations, and is accessible only by four-wheel drive vehicle along a sand track out to Nantucket Light.

The Nantucket Conservation Foundation protects barrier beach south of the Great Point area. The area is remote, and is characterized by ocean surf on the east, sand dunes and salt marshes. The area is largely undeveloped, with only one or two private homes, a sand road, and the Great Point lighthouse, which is a visual focal point. Panoramic open views in all directions are available from many locations on Great Point, as well as along the sand access road, where not screened by sand dunes. Beaches include Coskata Beach and Coatue Beach. The area offers opportunities for passive recreation.

***Tuckernuck Island (see Figure 4.3.4-1 for location of VP 24, Character photos in Figure 4.3.4-2, sheets 62-64)***

This island has several colonies of seasonal houses. No recreational resources available to the public were identified on the island itself.

#### *4.3.4.4 On-shore Cable Route*

Since the cable route would be located beneath public roadways or within the existing NSTAR easement, no historic properties listed or eligible for listing on the NRHP are located within the proposed action's Area of Potential Effect (APE) for ground disturbance along the onshore route. There are over 30 recorded buildings in the hamlets of West Yarmouth and Englewood in the vicinity of the landfall, which are included in MHC's Inventory. While not considered a historic district, a number of these buildings date from the early 1700s to late 1800s and are documented as belonging to sea captains or other wealthy residents of Yarmouth. The buildings are arranged in three clusters in Englewood. There are no other historic structures recorded along the route northward to the NSTAR ROW.

Two historic buildings and an historic cemetery are located in Barnstable, approximately 0.25 to 0.75 miles (0.4 to 1.2 km) north of the cable route along the NSTAR ROW. Both historic buildings are off Marstons Lane; the cemetery is located on Mary Dunn Road.

### 4.3.5 Cultural Resources

For the purposes of this analysis, the term "Archaeological Resources" refers to deposits of material remains of past human cultural activities, both historic and prehistoric, whether onshore or offshore. "Above-ground Historic Resources" will be used for onshore historical structures, districts and landscapes, and the term "Historic Archaeological Resources" will be used for onshore deposits of historic material that are at the ground surface and below.

#### *4.3.5.1 Onshore Cultural Resources*

##### 4.3.5.1.1 Historic

An APE for a project is defined as that geographic area or areas within which construction/decommissioning, operation or maintenance of a project may directly or indirectly cause alterations in the character or use of historic properties [36 CFR Part 800 Section 16(d)].

The APE for the onshore component of the proposed action includes areas of physical ground disturbance during construction/decommissioning, operation and maintenance, such as the construction areas along the overland route to the tie-in at the Barnstable Switching Station, as well as those areas within view of the proposed action (such as those historic properties on Cape Cod, Martha's Vineyard, and Nantucket from which open views of the visible components of the proposed action (aboveground or above water) would be available.

**Historic Archaeological**

Through consultation with the MHC, an archaeological survey was conducted to identify any historic archaeological sites that may be located within the proposed action's APE (Report No. 4.3.5-1). No on-shore historic archaeological sites were identified in the proposed action's APE. In a letter dated April 22, 2004, MHC accepted these recommendations that no on-shore historic archaeological sites would be impacted by requesting an additional copy of the final report.

**Above Ground Historic Resources**

Given the proposed location of the onshore electric transmission cable system underground beneath existing public roads and the NSTAR ROW, there are no physical impacts to historic structures, and the APE for visual effects focused on potential views of the offshore proposed action. Due to the generally level topography, mature wooded vegetation, and intervening structures found on the Cape and Islands, it was found during field reconnaissance that open views were generally limited to historic resources in the immediate vicinity (within approximately 300 ft [91 m]) of the shoreline).

Known historic resources in communities within potential visual range of the offshore turbines were compiled based upon a review of available databases and records at MHC. Historic structures and districts were identified in the Towns of Barnstable, Falmouth, Yarmouth, Dennis, Harwich, Chatham, Nantucket, Oak Bluffs, Tisbury and Edgartown. Subsequent to publication of the DEIS, interested parties provided MMS with a list of 22 additional properties that were evaluated for NRHP eligibility and potential project impacts. Interested parties also provided a list of eight properties located in the Town of Yarmouth, five of which are within the South Yarmouth/Bass River Historic District, expressing concern that these properties potentially were within view of the proposed action. Field visits were conducted for these properties, but none has a view of the proposed action. It also was determined that no properties within the District have a view of the proposed action. Therefore, because these properties are outside of the project's APE, they were not evaluated for NRHP eligibility.

The initial inventory of historic resources within the APE followed the USACE guidance, and included only properties that were already listed on the NRHP. In response to comments received on the proposed action, the inventory was expanded to include properties included in MHC's Inventory of Historic and Archaeological Assets of the Commonwealth, along with other properties noted in public comments (e.g., Ritter House and William Street Historic District on Martha's Vineyard).

Twenty-two existing historic structures and districts listed or eligible for listing on the NRHP that may potentially be visually affected by the built proposed action were identified within the proposed action's APE on Cape Cod, Martha's Vineyard, and Nantucket prior to publication of the DEIS. Based on information received after publication of the DEIS, 22 additional properties were assessed (18 of which are considered eligible for the NRHP and four that are not eligible for inclusion in the NRHP). A detailed description of these historic structures and districts and their visual resources is provided in Section 4.3.4.

#### 4.3.5.1.2 Prehistoric

Through consultation with the MHC, an archaeological survey was conducted to identify any prehistoric archaeological sites that may be located within the proposed action's APE along the onshore portion of the transmission cable route (Report No. 4.3.5-1). No onshore prehistoric archaeological sites were identified in the proposed action's APE. In a letter dated April 22, 2004, the MHC requested a copy of the final report.

#### 4.3.5.1.3 Tribal Areas of Traditional Cultural and Religious Importance

Indian lands belonging to two groups of the Wampanoag Indians are located somewhat in the vicinity of the proposed action: One in Aquinnah (Gay Head) on the western end of the island of Martha's Vineyard in Dukes County, and one in Mashpee, in Barnstable County, Massachusetts.

**Wampanoag Tribe of Gay Head (WTGHA)**

In 1972 the Wampanoag Tribal Council of Gay Head, Inc., was formed to promote self-determination, to ensure preservation and continuation of Wampanoag history and culture, to achieve Federal recognition for the tribe, and to seek the return of tribal lands to the Wampanoag people. The WTGHA became a federally acknowledged tribe on February 10, 1987 through the Bureau of Indian Affairs (BIA). The WTGHA is governed by a popularly elected representative Tribal Council.

As of February 2005, the WTGHA had a population of approximately 1,100 members enrolled. Approximately 68 live on tribal lands in the Town of Aquinnah and 298 live within the Tribe's service area (Dukes County) (WTGHA, 2008). The Tribe owns approximately 485 acres (1.96 $km^2$) of land, including approximately 160 acres (0.65 $km^2$) of private and 325 acres (1.31 $km^2$) of common lands (MWT, 2008).

Maintaining and protecting tribal cultural resources is a top priority of the WTGHA. The Tribe is currently in the process of developing a Cultural Resource Protection Program that would incorporate the Tribe's responsibilities under the NHPA, the Archaeological Resource Protection Act (ARPA) and the Native American Graves Protection and Repatriation Act (NAGPRA).

Enterprises run by the WTGHA include several stores that sell tribal merchandise and the operation of a shellfish hatchery. The tribe also uses Vineyard Sound and surrounding waters for subsistence fishing.

The WTGHA are descendants of Wampanoag people who traditionally inhabited the southeastern portion of present day Massachusetts, including Cape Cod, eastern Rhode Island and Martha's Vineyard since at least the late 15$^{th}$ century. Of eastern Algonquin linguistic stock, the Wampanoag were referred to as Pokanoket in early documents describing Native Americans in the area. A horticultural people, during the early 17$^{th}$ century, the Wampanoag occupied approximately 30 villages in this region. Best known in the literature for their relationship with the Plymouth Pilgrims, the Wampanoag's leader, Massasoit, welcomed the English and remained at peace with them until his death in 1661. By that time the Wampanoag had suffered grave population losses due to the introduction of epidemic causing disease and the usurpation of much of their ancestral land. The Wampanoag Nation was established in 1928 through the involvement of the two Mashpee men, Eben Queppish and Nelson Simons, in the Pan-Indian movement in the early part of this century.
(http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs/22massachusettes_2epdf/v1/22massachusettes.pdf)

Cheryl Maltais, Chairwoman of the Wampanoag Tribe of Massachusetts stated in the public hearing held on March 13, 2008 at the University of Massachusetts that, "the Wampanoag Tribe of Gay Head (Aquinnah) is a member tribe of the Great Nation of the Wampanoag People, they are known as the People of the First Light. The name defines who they are and differentiates them from all other tribal nations. Their name and its definition are the cultural and spiritual identity and the essence of who they are. Since time immemorial the Wampanoag people have inhabited the area of the easternmost lands and waters and have maintained their traditional spiritual and cultural connection to them." An unobstructed view of the southeastern horizon from the locations used for the practice of their traditional religious beliefs is sacred to the Wampanoag.

**Wampanoag Indian Reservation in Mashpee**

The Mashpee Wampanoag Tribe was federally acknowledged on February 15th, 2007 (BIA, 2007). The tribal membership is approximately 1,530 members, of whom over half live in Barnstable County. The Tribe has approximately 140 acres (0.57 $km^2$) of tribally owned land in the town of Mashpee, Barnstable County, as well as approximately 540 acres (2.18 $km^2$) in the town of Middleboro in Plymouth County (73 Fed. Reg. No. 35, March 6, 2008). The Mashpee Wampanoag Tribal lands in Barnstable County are located in the town of Mashpee on the western end of Cape Cod. It is common land owned by the tribe and serves as the tribe's land base. The tribal building is located off Great Neck Road in the town of Mashpee.

The Wampanoag Indians of Mashpee were the first to greet the pilgrims in 1620 and played host to them in the first Thanksgiving in 1621. Since that historic period, the Mashpee Wampanoag have served their tribal community and their fellow citizens in the town of Mashpee, the Commonwealth of Massachusetts, and the United States of America as neighbors and friends. Today, the Mashpee (whose name evolved from the aboriginal name Massippie, meaning "Land of the Great Cove") have the largest native population in Massachusetts. With approximately 1,500 members, the tribe has lived on its native homeland since at least the time of European contact in the early 16th century. The Mashpee pride themselves in honoring a heritage that pre-dates American Independence by 125 years (MWT, 2008).

In their letter of comment on the DEIS, George "Chuckie" Green, Jr., Tribal Historic Preservation Officer for the Mashpee Wampanoag Tribe, states, "The Mashpee are members of the Great Wampanoag Nation (the People of the First Light). Our name defines who we are ...." The letter goes on to state that the Mashpee have a significant cultural and religious need to have a clear unobstructed view of the southeast horizon.

### *4.3.5.2 Offshore Cultural Resources*

The APE for offshore archaeological resources includes the footprints of the WTG structures on the sea bottom; the work area around each WTG where marine sediments may be disturbed; the jet plowed trenches for installation of the inner-array cables connecting the WTGs to the ESP; the jet plowed trenches for the transmission cable system from the ESP to the landfall, and associated marine work areas such as anchor drop areas.

A marine sensitivity assessment of approximately 15,360 acre (62.15 $km^2$) of Nantucket Sound seafloor comprising the proposed action study area, as well as along the 115 kV transmission cable system route to the Yarmouth landfall, was conducted in 2003 (Report No. 4.3.5-2). Based on this assessment, a marine archaeological reconnaissance survey was conducted in the offshore study area in 2003 (Report No. 4.3.5-3). A follow-up marine archaeological reconnaissance survey was performed once the WTG array was revised (Report No. 4.3.5-4).

#### 4.3.5.2.1 Historic

The Marine Archaeological Sensitivity Assessment conducted for the proposed action by PAL (Report No. 4.3.5-2) indicated that there were 45 ships reported lost within the general vicinity of the project area. The dates of the vessels lost range from 1841 to 1963; however 19 of the vessels had no date of loss given in the source databases used by PAL. The primary sources of shipwreck data used in the PAL analysis were the Massachusetts Board of Underwater Archaeological Research (MBUAR), the

Northern Shipwreck Database, and the NOAA Automated Wreck and Obstruction Information System (AWOIS) database. A listing of these reported shipwrecks is found in Appendix A of PAL's report (Report No. 4.3.5-2).

A subsequent compilation of reported shipwreck losses by J.F. Jenney (Jenney, 2007) produced a list of 95 shipwrecks reported lost in the general vicinity of the project area; the dates of loss ranging from 1744 to 1990. The sources used by Jenney included those used by PAL, as well as local sources of information such as newspapers and family genealogical reports. Only 13 vessels could be directly correlated by name between the PAL report and the list compiled by Jenney. This discrepancy is probably due in large part to the additional primary sources used in compiling Jenney's list. Compilation of shipwreck data is very problematic, and there are many additional reasons that such discrepancies may exist between shipwreck listings for a given area (e.g., the extent of the geographic area included in the search; uncertainty about the exact location of loss; multiple listings for the same ship with variations in the details given, including alternate spellings of the vessel name; listings indicated as unidentified vessel, or unidentified date of sinking; and listings of obstructions that may be shipwrecks, but which have not been verified). Other considerations in relating lists of shipwreck losses to actual shipwreck sites within a given geographic area are that some vessels were burned or otherwise destroyed, and many were salvaged with no record of the salvage having taken place.

In addition to the potential for historic period shipwrecks, it should be noted that a local researcher, Mr. Neil Good of Mashpee, has been investigating the potential for early Viking contact sites in the Nantucket Sound area. Norse sagas describe a settlement (Vineland) founded by Leif Ericson on the east coast of North America. In the 1960s an early European settlement (ca. A.D. 1000) was found outside of L'Anse aux Meadows, Newfoundland; however, many researchers do not believe this site represents Vineland because of inconsistencies in the description of the location and environment of Vineland in the Norse sagas compared to that of the site in Newfoundland. According to Mr. Good, over 30 scholars have placed Vineland on or near Cape Cod, with many favoring sites in the immediate vicinity of Nantucket Sound. Mr. Good is presently focusing his research efforts on Waquoit Bay, approximately 6.5 miles west-northwest of the proposed project area on the south side of Cape Cod.

A marine archaeological survey was completed in June and July 2003 by PAL in water depths greater than 3 ft to locate any evidence of potential archaeological sites within the offshore portion of the proposed project area. This survey recorded 154 magnetic anomalies and 109 side-scan sonar contacts. Of the 263 magnetic anomalies, and side-scan sonar contacts all but 29 were determined to have a source that was non-cultural in nature or was interpreted as isolated debris, and, therefore, were eliminated from further consideration. Survey data for the remaining 29 anomalies were post-processed and additional analyses were completed.

Analyses of the post-processed data associated with the 29 anomalies of interest and additional data collected during September 2003 produced three targets with moderate probability of representing historic period submerged cultural resources. All are in the vicinity of Horseshoe Shoal. Locations were provided to MHC and the Massachusetts MBUAR, but are not publicly distributed to protect the integrity of these potential sites.

#### 4.3.5.2.2 Prehistoric

A marine archaeological sensitivity assessment and a marine archaeological reconnaissance survey indicate that a majority of the offshore study area has a low probability for containing submerged prehistoric archaeological resources. However, it also concluded that prehistoric archaeological deposits with contextual integrity might be present within limited parts of the eastern offshore study area where former natural soil strata (paleosols) may be present. Some of these areas occur in the location proposed for the proposed action. The turbine array has been adjusted to avoid these potential prehistoric site areas.

##### 4.3.5.2.3 Tribal Areas of Traditional Cultural and Religious Importance

The Wampanoag consider the entirety of Nantucket Sound to be ancestral lands, based on their oral traditions. This area, as well as a vast extent of the entire continental shelf was exposed as dry land during the late Wisconsinan glacial period (ca. 19,000 to 3000 B.P.). In their letter of comment on the DEIS, George "Chuckie" Green, Jr., Tribal Historic Preservation Officer for the Mashpee Wampanoag Tribe, states, "The Wampanoag people have inhabited the land from the western shore of Narragansett Bay to the Neponset estuaries since time immemorial, even the land now called Horseshoe Shoals. Our oral traditions tell us this land was walked and lived on by our ancestors."

### 4.3.6 Recreation and Tourism

#### *4.3.6.1 General Information on Recreation and Tourism*

Cape Cod and the Islands receive a large percentage of their revenue from the tourism industry. The focus of most area tourism is the high quality recreational activities the area offers. The Cape Cod Chamber of Commerce estimates that approximately 44 percent of the economic base for Cape Cod comes from seasonal tourism. An estimated six million tourists visit Cape Cod annually, spending nearly one billion dollars. Almost two-thirds of these visitors vacation during the summer and fall seasons. Tourism on the Cape and Islands includes recreational activities such as: beach going, fishing, boating (including windsurfing and jet skiing), boat racing, golfing, hiking, picnicking, sightseeing (light houses and other historic areas, etc.), and shopping. Guided tours or charters are available for many of these activities including fishing; whale watching; wildlife, kayaking, canoeing tours, and bike tours.

Beaches that are within the viewshed of the area of the proposed action are located in the towns of Falmouth, Mashpee, Chatham, Harwich, Dennis, Yarmouth, Edgartown, Oak Bluffs, Barnstable, Tisbury, and Nantucket. Detailed estimates of the annual number of beachgoers are not available. However, using data from those towns who responded to inquiries of the number of beach stickers issued to residents and non-residents as an indicator (over 33,000 stickers between Mashpee, Chatham and Yarmouth alone) suggest that beachgoers within the viewshed number in the hundreds of thousands. A complete listing of beaches is provided in the Table 4.3.4-2 of the visual impact section.

The construction of the onshore transmission cable system may temporarily affect the parking lot to a recreational resource at Englewood Beach, off of New Hampshire Avenue. However, any impact to this onshore recreational resource is expected to be minimal and limited to off-season beach visitors due to the onshore construction timeframe (Labor Day through Memorial Day).

The near shore and offshore waters of Nantucket Sound were also identified as important recreational resources and therefore economically valuable tourist attractions. The site of the proposed action is centrally located within Nantucket Sound. Peak recreational activity is during the warmer months of the year (typically April through October), corresponding with the peak tourist season.

Recreational users such as fishermen, windsurfers, swimmers, water skiers, jet skiers, and other boaters are active along the near shore and shoreline areas facing Nantucket Sound. Scuba diving is limited in the area because the soft sediment habitat is generally uninteresting. The offshore waters are used by larger power and sailboats.

#### 4.3.6.2 Birding

Several locations on Cape Cod and the Islands focus on bird watching as a recreational activity. These include MAS's Felix Neck and Wellfleet Bay Wildlife Sanctuaries, Monomoy National Wildlife Refuge, and Cape Pogue Wildlife Refuge. In addition, the Cape Cod Museum of Natural History, and the Cape Cod Bird Club are organizations active in bird watching. The vast majority of birding takes place on shore. Birding that takes place offshore in Nantucket Sound is close to shore. MAS runs some trips in the vicinity of Monomoy National Wildlife Refuge and there are kayaking tours around Cape Poge.

#### 4.3.6.3 Federal or State Parklands and Reserves

Information regarding Federal or State Parklands and Reserves is provided in Section 4.3.4 along with a map showing these locations relative to the site of the proposed action. Table 4.3.4-2 provides a breakdown of Federal or State Parklands and reserves in the area, their distance to the site, and reference to visual simulations from these areas or nearby representative locations.

#### 4.3.6.4 Beach and Shoreline Activities

Onshore Cape Cod, Nantucket, Martha's Vineyard (and the State waters of Nantucket Sound) are well known for coastal recreational and summer tourism activities including beach going, swimming, boating, fishing, hiking, biking, picnicking, golfing, and bird watching. Marinas, yacht clubs and public boat ramps line most of the harbors and inlets with sufficient water depths.

Sandy beaches nearly continuously rim the Cape and Islands landforms, supplied with sediments deposited by receding glaciers and reworked since then by fluvial and coastal processes (see Section 4.1.1). The shorelines around Nantucket Sound are generally developed with large seasonal shorefront homes or shorefront resorts and associated private beaches, most constructed during the 20$^{th}$ century. The public beaches attract thousands of recreational users in the summer months. Public and semi-private beaches (such as association and resident-only beaches) with expected open views toward the proposed action are listed on Table 4.3.4-2, as are conservation areas and other recreational resources such as golf courses and bike paths with expected open views toward the proposed action. Visual simulation locations from representative historic sites are provided in the tables for each resource, to capture a sense of the overall anticipated visual change at the recreational area due to the proposed action. Due to the generally level topography, mature wooded vegetation, and intervening structures found on the Cape and Islands, open views were generally limited to recreational areas in the immediate vicinity (i.e., within approximately 300 ft [91 m]) of the shoreline. Recreational resources identified from the MassGIS database are shown on Figure 4.3.4-3.

#### 4.3.6.5 Recreational Boating and Water Activities

Boating on Nantucket Sound consists of a mix of commercial and recreational activity. Commercial activity includes passenger ferries, vessels, and barges carrying liquid and dry bulk goods, occasional cruise ship visits, commercial fishing vessels, charter fishing vessels, and research activity. Recreational activity includes fishing, sailing, cruising, boat racing, jet skiing, kayaking, and canoeing.

Recreational traffic in the Sound is seasonal with the summer months from June to October seeing a dramatic increase in water activities by recreational traffic both by boats that originate from the area marinas as well as recreational craft that visit the area from the entire New England and Mid Atlantic Region.

Nantucket Sound is a well known area that attracts all types of recreational craft from the smallest runabout to very large yachts; it is a very desirable location for yachtsman, with destinations on both Islands and the Cape Cod shore. These yachts not only include world class power boats/cruisers privately or corporately owned (*Lone Ranger Length 254 ft [77 m]/Acquisition 121 ft [37 m]*) but also sail boats of all sizes (*Southern Cross Maxi 88*). Many remain in the region for the entire boating season, while others use the area to transit to other ports of call along the New England and Mid Atlantic Coasts as well as Canada.

Coastwise and recreational vessels tend to use the Main Channel (south of Horseshoe Shoal) when transiting Nantucket Sound for points within Nantucket Sound and for the Atlantic Ocean. The Main Channel also serves as an inside passage for medium draft vessels to avoid Nantucket Shoals (south and east of Nantucket in the Atlantic Ocean). This channel is marked with aids-to-navigation, and has a minimum depth of approximately 30 ft (9.1 m) MLLW. However, the drafts of vessels using the Main Channel seldom exceed 24 ft (7.3 m) MLLW (NOAA, 2008).

The North Channel (north of Horseshoe Shoal) is used by vessels bound for the Cape Cod shore and by vessels transiting the Sound during northerly winds. This channel is marked with aids-to-navigation, and has a minimum depth of approximately 16 ft (4.9 m) (NOAA, 1994).

The numerous shoals in Nantucket Sound limit the operating areas for vessels depending on the vessel's draft. Charted water depths on Horseshoe Shoal range from one to 45 ft (13.7 m) at MLLW, with the majority of the shoal covered by between 20 ft and 30 ft (6.1 and 9.1 m) of water at MLLW. As a result, larger vessels avoid Horseshoe Shoal and stay in the Main Channel and the North Channel. Changes in water depths over short distances and strong tidal currents (with peak currents often exceeding 2 knots [1 m/s]) also tend to create steep waves that break on the shoals, causing many shallow-draft boaters to avoid the shoals. In addition, the long distance from shore and the wave and tidal action also limit use by very small recreational vessels, such as open runabouts.

Recreational boating use data are available based on 53 total days of proposed action related field work during the summers of 2001, 2002 and 2003. According to this information, recreational vessels observed during the summer (Memorial Day through Labor Day) within the proposed action area at Horseshoe Shoal ranged from no vessels observed (30 percent of the field days) to 11 vessels observed (in one day). Using these field observations the estimated median number of recreational vessels observed daily is two.

To supplement these field observations, observations were made from the SMDS platform of vessel movements on and around Horseshoe Shoal over three summer weekend days (Saturday, June 12, 2004; Sunday, June 13, 2004; and Saturday, July 3, 2004) when recreational boating activities are generally at their highest. Weather conditions were clear and conducive to recreational boating. These observations involved visually scanning the Horseshoe Shoal area and the Main Channel at intervals of approximately 15 minutes to count the number of vessels observed. Vessels observed were characterized as being either on Horseshoe Shoal or in the Main Channel.[18] Approximately 81 percent of the vessels observed were recreational vessels, and approximately 57 percent of the vessels observed were operating in the Main Channel. Recreational vessels observed on Horseshoe Shoal on these days ranged from no vessels observed in a 15 minute period to 12 vessels observed. On average, approximately 2 recreational vessels and/or one commercial vessel were observed during each 15 minute period. Additional information and discussion of boating activities is included in Section 4.4.3 of this document.

[18] For the purposes of the observations, the boundaries of Horseshoe Shoal were Buoy N2 to the west, bell buoy G5 to the north, the ferry route to the east, and the Main Channel to the south. This study area encompasses approximately 51 square miles and is significantly larger than the area of the proposed action.

#### *4.3.6.6 Recreational Fishing*

Because of its location adjacent to several key vacation destinations (i.e., Cape Cod, Nantucket, and Martha's Vineyard), Nantucket Sound and the waters around the islands of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities. Details on recreational fishing statistics and fish caught are discussed in Section 4.2.7.2.2.

### 4.3.7 Competing Uses in the Vicinity of the Proposed Action

In addition to the proposed action, other activities in the past, present or future which may contribute to competing uses of OCS space and would include submarine transmission cable or pipeline installations and bottom founded structures, navigational features, sand mining and mineral extraction, commercial and recreational fishing and boating, military training, and other OCS alternative energy development. The following section describes the potential competing uses of the proposed action (i.e., the space use conflicts of the proposed action) on each type of use.

#### *4.3.7.1 Pipelines and Cables*

Presently, there are three existing submarine transmission cable systems located in Nantucket Sound that interconnect the mainland with the offshore islands to provide reliable island-wide power supply. There are no current proposals for new submarine pipelines in the Nantucket Sound area. One cable system interconnects Falmouth, on the mainland, to Martha's Vineyard at Vineyard Haven on the westerly side of Nantucket Sound approximately 13 miles (21 km) to the west of the proposed action locus. The other two submarine transmission cable systems connect the mainland transmission system from Harwich and Barnstable (Lewis Bay) to Nantucket Island located approximately 8 miles (13 km) east of the proposed action locus. The first submarine solid dielectric cable system was installed in 1995 and the second system was installed in 2006. The Martha's Vineyard Island submarine transmission cable systems have been in place for decades, with the most recent replacement cable installed in the seabed off of Falmouth in 1997. There are no publicly available plans at this time for any future submarine transmission cable system installations in Nantucket Sound except for those associated with the proposed action.

Other large offshore projects that could potentially be constructed in the future include two Liquefied Natural Gas (LNG) projects with submarine and upland gas pipelines that have been proposed by Excelerate and Neptune Energy. These projects are located in Massachusetts Bay north of Cape Cod and far from the site of the proposed action and could not be considered competing uses.

#### *4.3.7.2 Navigation Features*

There are two main shipping lanes, the Main Channel and the North Channel, used for safe navigation by larger vessels in Nantucket Sound. The USCG marks both of these areas with aids-to-navigation (buoys, lights, etc.). These shipping lanes are described as follows:

- The Main Channel starts in the West at the juncture of Vineyard Sound and Nantucket Sound at Nobska Point, passes north of West Chop and East Chop on MV, and passes south of Hedge Fence shoal. It then continues in a Southeasterly direction passing between Horseshoe Shoals to the North, and Hawes Shoal (Chappaquiddick Island) to the South. The channel is fairly wide in most areas being approximately 1.15 miles (1.9 km) across from edge to edge as marked on NOAA Chart 13237 for a draft of 30 ft (9.1 m). It constricts down to approximately 0.86 miles (1.4 km) wide directly south of Horseshoe Shoal at Cross Rip Shoal. It widens soon after heading eastward and immediately south of Half Moon Shoal hosts the channel heading toward Nantucket Island. The Channel width for the Nantucket Harbor is approximately 1 mile (1.6 km) in width. The Main Channel continues and turns East North East and then North East heading for the south of Monomoy Island and Butler Hole which provides the deep water for the channel as it bisects Monomoy Island and Bearse Shoal to the north and Monomoy Shoal to the South. The channel passage through this area is narrow. It is reported that vessels using the channel seldom exceed a draft of 24 ft (7.3 m) (NOAA, 2008).

- The other major channel is called North Channel, which skirts the south of Cape Cod and provides access to ports along the Cape Cod shore such as Falmouth, Hyannis, Yarmouth and Chatham. This channel runs north of Horseshoe Shoal and runs in an East-West direction. The channel is well marked by aids to navigation and has a restricted depth of 16 ft (4.9 m) MLLW.
- This channel is used mostly by vessels bound for the south shore of Cape Cod, and by vessels transiting the Sound during northerly winds.

In addition to these shipping channels, privately and federally maintained channels are located at the approaches to Cotuit Bay, Centerville Harbor, and Hyannis Harbor (see Figure 4.3.7-1).

The area between the Main Channel and the Cape Cod shoreline, including Horseshoe Shoal, is designated as an anchorage ground, known as “Anchorage I.” Floats or buoys for marking anchors or moorings in place are allowed in this area. Fixed mooring piles or stakes are prohibited (NOAA, 1994).

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the proposed action vicinity. Hyannis Harbor was dredged in 1985, 1991, and 1998. No future dredging activities are currently scheduled. However, any future USACE maintenance dredging in Hyannis Harbor would most likely be the subject of additional environmental assessment.

Quonset Point, which would be used for construction staging, assembly and loading of supplies onto marine vessels is an existing industrial port and equipped to handle the requirements of the proposed action during construction and decommissioning. Channel depth is sufficient for large vessels to dock in the vicinity of the area and such work would not interfere or compete with an existing use at the Quonset Point area.

Given that the shore-side facilities proposed for use have adequate channels to accommodate the necessary vessels during construction, operation and decommissioning, it is unlikely that any channel maintenance would occur in association with the proposed action.

#### *4.3.7.3 Sand Mining and Mineral Extraction*

Presently, there are no sand mining projects proposed within the site of the proposed action that would cause space use conflicts; however, the demand for sand to nourish eroding beaches has risen in recent years and would be expected to increase given the rising sea levels and eroding shorelines. For example, there is currently one proposal for an offshore sand mining project in the vicinity of Nantucket Sound. The Sconset Beach Nourishment Project is proposing a 345 acre (1.4 $km^2$) dredge site approximately 3 miles (4.8 km) east of Nantucket Island just outside the CIOS. The Sconset Beach Nourishment Project is under MEPA review and is contingent upon approval and licensing from several other state and Federal agencies including MMS and the USACE.

There is a current moratorium on oil and gas drilling off of the Atlantic coast with extended protections set to last until 2012.

### 4.3.7.4 Commercial Fishing and Boating

In response to comments on the draft EIS prepared by the USACE from the MDMF, NOAA Fisheries, and the Massachusetts Office of CZM, the applicant conducted a survey of recreational and commercial fishing activities (Report No. 4.2.5-6). The commercial fishing survey, conducted in the late summer, early fall of 2005 consisted of 18 surveyed commercial fishermen who owned a total of 21 boats that commercially fished Nantucket Sound for at least part of an annual fishing season. Of these boats, 16 (76 percent) hauled mobile gear and 5 (24 percent) hauled fixed gear. The reported mobile gear types utilized in Nantucket Sound among the survey group include trawlers (13 boats, also called draggers which drag the sea floor), and hook and line (3 boats). Fixed gear types included pots and traps (4 boats), and gill nets (1 boat). Three of the 21 boats reported fishing in Nantucket 100 percent of the time and eight fished in Nantucket Sound the majority of the season.

As discussed in Section 4.4.3.9, various sources documented that over 70 fishing vessels varying from 30 to 60 ft (9.1 to 18.2 m) in length and 4 to 8 ft (1.2 to 2.4 m) in draft fish Nantucket Sound. Other references indicate that local fisherman attribute 50 to 60 percent of their livelihood to fishing Nantucket Sound. Actions by NMFS reducing "days-at-sea" by 40 percent average for ground fish may result in fishing vessels that fished away from the area returning to the Sound to comply with the at sea reduction to fill their ground fish quotas. It is also documented that 200 to 250 commercial fishing vessels, many from New Bedford, Massachusetts use the Main Channel across Nantucket Sound to gain access to fishing grounds on Georges Bank and elsewhere. These vessels range in size from 60 to 100 ft (18.2 to 30.5 m) in length and have drafts of 8 to 15 ft (2.4 to 4.6 m).

The main vessel traffic patterns follow the Main Channel and North Channel as previously discussed in Section 4.3.7.2 and as shown in Figure 4.3.7-1, which depicts main ferry routes in the area. The numerous shoals in Nantucket Sound limit the operating areas for vessels depending on the vessel's draft. Charted water depths on Horseshoe Shoal range from 1 to 45 ft (0.3 to 14.7 m) measured at MLLW. The majority of the Shoal is 20 to 30 ft (6.1 to 9.1 m) at MLLW. Analysis of the vessel make-up by type, size and service shows that only one quarter of Horseshoe Shoal has depths that allow the majority of the vessel types using the area to operate and/or drift without going aground.

Ferries out of Woods Hole and Hyannis servicing the Islands of Martha's Vineyard and Nantucket use the North Channel between the Hyannis sea buoy ("HH") and green can "11", and pass to the north and west of Horseshoe Shoal. Vessels on the Hyannis to Nantucket route cross the North Channel, pass to the east of Horseshoe Shoal, and cross the main Channel. Ferries traveling between Martha's Vineyard and Nantucket use the Main Channel, and pass to the south of Horseshoe Shoal. (see Figure 4.3.7-1).

There are not any major or significant Port Facilities that handle large deep draft traffic and are engaged in commercial cargoes in the vicinity of the site of the proposed action. The closest port facilities that handle significant quantities of commercial products including containers and bulk cargoes are located in Providence, Rhode Island, Boston, Massachusetts and to a lesser extent New Bedford, Massachusetts. Deep draft ship traffic carrying containers and bulk cargoes do utilize Buzzards Bay for access to the Cape Cod Canal; however this vessel activity is well separated from the site of the proposed action by the Elizabeth Islands and thus would not be affected by the proposed action.

### 4.3.7.5 Recreational Fishing

Because of its location adjacent to several key vacation destinations (i.e., Cape Cod, Nantucket, and Martha's Vineyard), Nantucket Sound and the waters around the islands of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities. Results from the MMFS MRFSS from three counties surrounding Nantucket Sound (Dukes, Barnstable, and Nantucket) from 1990 through-2004 were summarized (this survey is also discussed in Section 4.3.6.6). In those fifteen years there have been

40,130 MRFSS surveys reported from Dukes, Barnstable, and Nantucket Counties. It is important, though, to note that the data obtained from these surveys cannot be directly related to Nantucket Sound. Even though the surveys were conducted in the counties surrounding the Sound, only a portion would have been engaged in recreational fishing activities in Nantucket Sound because these surveys likely include anglers engaged in fishing activities offshore, in waters further out on the Cape, further offshore to the south of Nantucket and Martha's Vineyard, or even in portions of Buzzards Bay.

Information was summarized from the recreational fishing data including fishing effort by mode, fishing effort by hours fished as reported by individual anglers, type of gear used by individual anglers, number of fish reported by anglers, as well as the number of fish observed by interviewers during the surveys, and the fish species observed by the interviewers during surveys (Report No. 4.2.5-5).

Based on the surveyed population, the use of private or rental boats appears to be the most common mode of recreational fishing over the past 15 years. Approximately 45 percent of the anglers surveyed reported using private and/or rental boats when participating in recreational fishing activities. Those reporting the use of party or charter boats were far lower than private boats at only 15 percent. Fishing from shore was also more common than the use of charter and party boats. Approximately 40 percent of the surveyed population reported fishing from shore as the mode of fishing from 1990-2004. The average time spent fishing by surveyed anglers ranged from a low of 3.1 hours in 1993 to a high of 3.6 hours in 1997 and 2004.

The various fishing gear reported by surveyed anglers included hook and line, dip/A-frame net, cast net, gill net, seine, trawl, trap, spear, hand, or other. The majority surveyed (99.7 percent) reported hook and line as gear type used for recreational fishing. The use of a dip net ranked second in terms of gear used (0.105 percent). Some type of fish trap use was reported in only 20 of the 40,079 surveys from 1990 through 2004. Gill nets were reported one time over the fifteen-year period.

The Cape Cod, southern Massachusetts, Rhode Island and Martha's Vineyard and Nantucket areas are home to thousands of small craft, both power and sail and host to hundreds more cruising the waters of Nantucket Sound during the summer months (May through October). Significant recreational traffic can be found in the Ports of Hyannis, Chatham, Dennis Port, Harwich Port, Yarmouth, Falmouth and Woods Hole as well as the many inlets, bays and backwaters in between. On the Islands, harbors frequented by pleasure craft include Vineyard Haven, Oak Bluffs and Edgartown while on Nantucket Island they include Nantucket Harbor. These port facilities mainly consist of yacht clubs and marina type environments that are made up of small boat piers and quays and mooring areas for recreational boats and fish offloading and processing equipment for the commercial fishing fleet.

A complete discussion of recreational fishing and boating can be found in Section 4.3.6.6 and 4.3.6.5, respectively.

#### 4.3.7.6 Military Training

There are no designated naval training areas within the site of the proposed action and submarine activity could not occur within Horseshoe Shoal due to insufficient depths. On nearby Cape Cod, some military training activities occur at the MMR, and this may include military flights that could pass over the Horseshoe Shoal area.

#### 4.3.7.7 Outer Continental Shelf (OCS) Alternative Energy

Other reasonably foreseeable offshore alternative energy projects include TISEC Devices, other offshore wind turbines, and wave turbine technology. TISEC devices are a similar technology to wind turbines except that they are installed in the water column and are moved by underwater tidal currents. At present, one such project is being considered in Vineyard Sound, approximately 10 miles (16.1 km) west of the site of the proposed action.

There is currently 804 MW of commercial offshore wind power in Europe, and a few other proposed offshore wind energy projects in the United States (Musial, 2005). With the ever-increasing demand and cost of energy, and the excellent-to-outstanding wind resources on the northern part of Cape Cod, the southern part of Cape Cod, and along the shore of Martha's Vineyard and Nantucket (according to the DOE Energy Efficiency and Renewable Energy (EERE, 2005) the potential for further wind energy development is high.

Wave turbine technology can be defined as a system of reacting forces, in which two or more bodies move relative to each other, while at least one body interacts with the waves. At present no wave turbine projects are proposed in the area of the proposed action.

#### *4.3.7.8 Onshore Competing Use Activities*

The onshore portion of the proposed action includes the underground electric transmission cable system. As the cables would be entirely located under streets and underground in an existing electric transmission ROW, onshore competing uses that could affect the proposed action are limited to those specific locations. There are no known proposals for other utilities in these areas that would represent a competing use to the proposed action.

## 4.4 NAVIGATION AND TRANSPORTATION

### 4.4.1 Overland Transportation Arteries

The major overland transportation arteries in Barnstable County are U.S. Route 6, and State Routes 28 and 6A. The three towns in Barnstable County that would experience vehicular traffic related to the construction and maintenance of the wind farm include Falmouth, Barnstable and Yarmouth. The major highway in Falmouth is State Route 28, and in Barnstable and Yarmouth both Route 28 and Route 6 are major arteries. Route 28 travels in a west to east direction terminating between Chatham and Orleans. U.S. 6 continues into Cape Cod as a freeway from Bourne to Orleans. North of Orleans, Route 6 becomes a surface road again to its terminus in Provincetown.

The Regional access to the Quonset Point, which would be used for manufacturing and assembly of components, and as a marine staging/loading area, is provided by Route I-95. Route 4, a limited access highway connects Route I-95 to Route 403, which provides access directly into the area. Route 403 is a winding two-lane road which Rhode Island Department of Transportation has plans of replacing. Route 1 also passes along the entrance to the area.

#### *4.4.1.1 Roadways Located in the Vicinity of the On-land Transmission Cable*

The installation of the proposed action's onshore transmission cable system would be located under New Hampshire Avenue, Berry Avenue, Route 28 between Berry Avenue and Higgins Crowell Road, Higgins Crowell Road, Buck Island Road, Willow Street, and at the Route 6 overpass. These locations are described further below.

##### 4.4.1.1.1 New Hampshire Avenue

New Hampshire Avenue is a two-lane residential road allowing vehicle access in a north-south direction. The roadway is a dead-end roadway with a concrete retaining wall at its southern end. There are no sidewalks on either side of the roadway. In addition, there is no on-street parking. During the summer of 2002, over the course of multiple site visits, observations were made of the relative traffic volumes at various points along the proposed route. Mid-day volumes along New Hampshire Avenue were observed to be very light. The transmission cable would be installed within the east side of the roadway.

##### 4.4.1.1.2 Berry Avenue

Berry Avenue is a two-lane residential road allowing vehicle access to travel in a north-south direction. There are sidewalks on both sides of the roadway. Mid-day volumes were observed to be light. The transmission cable would cross to the west side of Berry Avenue off of New Hampshire Avenue. No on-street parking was observed on Berry Avenue. Berry Avenue is approximately 22 ft (6.7 m) wide.

##### 4.4.1.1.3 Intersection 1 - Route 28 between Berry Avenue and Higgins Crowell Road

The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle access on Route 28 travels in an east-west direction. The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is signalized. There are sidewalks on both sides of Route 28. Mid-day volumes were observed to be moderate to heavy. The transmission cable would be installed underneath Route 28 using trenchless technologies.

##### 4.4.1.1.4 Higgins Crowell Road

Higgins Crowell Road is a two-lane road with a painted divider. Vehicle access travels in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. Mid-day volumes were observed to be moderate to heavy. The transmission cable would be placed on the east side of Higgins Crowell Road. The street width for this road is approximately 24 ft (7.5 m).

##### 4.4.1.1.5 Intersection 2 - Buck Island Road

The intersection of Buck Island Road with Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle access on Buck Island Road travels in an east-west direction. The intersection of Buck Island Road with Higgins Crowell Road is signalized. Mid-day volumes were observed to be moderate to heavy. The transmission cable would be installed beneath Buck Island Road using trenchless technologies.

##### 4.4.1.1.6 Willow Street

Willow Street is a two-lane road with a painted divider. Vehicle access travels in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. Mid-day volumes were observed to be heavy. The transmission cable would be placed on the west side of Willow Street. The street width for this road is approximately 30 ft (9.1 m).

##### 4.4.1.1.7 Intersection 3 – Route 6 Overpass

The transmission cable would be installed using trenchless technologies as it passes underneath the Route 6 overpass. Approximately 0.5 miles (0.8 km) past the Route 6 overpass, the transmission cable would cross to the west side and enter the NSTAR Electric ROW. The transmission cable would also cross under Route 6 from the NSTAR Electric ROW from north to south to connect with the Barnstable Switching Station. This crossing would also be accomplished using trenchless techniques.

### 4.4.2 Airport Facilities

There are three airports located in the vicinity of the site of the proposed action and Nantucket Sound. These include Barnstable Airport (Boardman-Polando Field) in Hyannis on Cape Cod, and Martha's Vineyard Municipal Airport and Nantucket Memorial Airport (ACK). Provincetown Airport is also in the region. The next larger commercial airports include Logan International Airport in Boston, Massachusetts; Providence T.F. Green Airport in Providence, Rhode Island and at a greater distance yet, John F. Kennedy Airport on Long Island near New York City. The nearest military installation is Otis ANG Base in the upper western portion of Cape Cod, immediately south of the Cape Cod Canal in Barnstable County, Massachusetts. It includes parts of the towns of Bourne, Mashpee, and Sandwich and abuts the town of Falmouth.

Barnstable Municipal Airport is a vital transportation link to Cape Cod and the Islands. The airport is home to Cape Air/Nantucket Air, Island Airlines, Colgan/US Airways Express and numerous other charter, corporate and general aviation aircraft. Local airlines operate flights to Boston, Nantucket, Martha's Vineyard and New York. Aircraft operating from the airport range from J3 Piper Cubs to Cessna 402's, Falcon 50's and Boeing 727's. Barnstable's Primary Runway is has a length of 5,425 ft (1654 m) and a width of 150 ft (45.7 m). Its secondary runway has a length of 5,252 ft (1601.2 m) and a width of 150 ft (45.7 m).

Martha's Vineyard Airport is a municipal airport that serves as a vital transportation link to the mainland and to Nantucket. Cape Air regularly serves the Martha's Vineyard Airport, year-round, from many locations including: Boston's Logan Airport (BOS), New Bedford Regional Airport (EWB), Provincetown Municipal Airport (PVC), Hyannis' Boardman-Polando Field (HYA), and the ACK. U.S. Airways Express seasonally serves the Martha's Vineyard Airport from the following locations: New York's LaGuardia Airport (LGA), Washington D.C.'s Reagan National Airport (DCA), Philadelphia, Pennsylvania (PHL), and HYA. In calendar year 2004 the Martha's Vineyard Airport had 63,378 flight "operations" (an "operation" includes each landing and takeoff) and in 2005 the Airport had 60,627 flight operations. Martha's Vineyard Primary runway has a length of 5,500 ft (1,676.8 m) long and is 100 ft (30.5 m) wide. Its secondary runway has a length of 3,297 ft (1,005.2 m) long and is 75 ft (22.9 m) wide.

ACK is located in the heart of historic Nantucket Island. The airfield has three runways. The first runway is paved and is 6303 ft (1921.6 m) long and 150 ft (45.7 m) wide with pilot controlled lighting. The second runway is paved and is 3999 ft (1219.2 m) long and 100 ft (30.5 m) wide with pilot controlled lighting. The third runway is 3125 ft (952.7 m) long and 50 ft (15.2 m) wide, and also is paved. The airport can accommodate single and multi-engine aircraft, as well as corporate jets and helicopters. A control tower operates between the hours of 6:00 AM and 9:00 PM, and until 11:00 PM in the summer months. The airport has a variety of navigational aids including an instrument landing system and VOR, NDB, and GPS approaches. In 2004, airport operations totaled 144,267. Cape Air, Colgan Air, Continental, Island Airlines, Nantucket Airlines, Nantucket Shuttle, and US Airyways Express provide service to Nantucket from airports in Massachusetts, Rhode Island, and New York. Some of these airlines fly to the island seasonally.

Cape Air operates a fleet of over 50 Cessna 402's with up to 850 flights per day during high season. Colgan Air operates as Continental Connection, United Express, and US Airways Express, with 36 SAAB 340 and 11 Beech 1900D aircrafts. Island Airlines and Nantucket Airlines all operate Cessna 402's.

#### *4.4.2.1 Commercial Aviation Corridors*

High Altitude Jetways (North America – Europe and East Coast U.S.) are not considered a factor in this proposed action and are not considered in this assessment.

The proposed turbine array is not located in the flight path of any low altitude Instrument Flight Rules (IFR) routes. The IFR routes are used by aircraft flying at night or in restricted visibility, on instruments and under the control of Air Traffic Control (ATC). There are three IFR routes established for Nantucket Sound, however, they are not in the vicinity of the Horseshoe Shoal proposed action. The IFR Route

V167 that connects T.F. Green airport in Providence Rhode Island and Provincetown, Massachusetts comes from the direction of EWB and turns toward and passes north of Barnstable Airport approximately 2.3 miles (3.7 km) northwest of the proposed action at a minimum altitude of 1,600 ft (487.8 m). The IFR Route V141 from Logan Airport to Nantucket passes east of the site of the proposed action at a minimum altitude of 1,700 ft (518.3 m) and IFR Route V146 connects Martha's Vineyard with Nantucket at a minimum altitude of 2,000 ft (609.8 m) and is located approximately 9.8 miles (15.7 km) south of the proposed action. Another Route V46 that connects Nantucket with New York (Long Island) is not a factor since it lies south of Martha's Vineyard and south of V146 (Martha's Vineyard – Nantucket). IFR Route V34-58 from Block Island to Nantucket is also south of IFR V146 and north of IFR V46.

Analysis of recent aircraft flights between Rhode Island/Massachusetts and Nantucket/Martha's Vineyard revealed that most travel on the IFR routes at 3,000 to 5,000 ft (914.6 to 1,524.4 m) with some at 7,000 ft (2,134.1 m).

#### *4.4.2.2 General Aviation Traffic*

Like recreational boat traffic, general aviation (not commercial airlines or freight) is varied and increases for the summer season. Excluding high performance jet and turbo prop aircraft which generally file and follow IFR routes, general aviation use Visual Flight Rules or VFR. Low flying aircraft operating under VFR have to maintain a minimum 500 ft (152.5 m) clearance from any structure or vessel as required by 14 CFR 91.119. Over water, in the absence of any structures or vessels, there is no minimum altitude restriction.

### 4.4.3 Port Facilities

#### *4.4.3.1 General Description of the Area*

As shown in Figure 4.3.7-1, Nantucket Sound is bounded to the south by the islands of Martha's Vineyard and Nantucket, and to the north by Cape Cod. To the west of Nantucket Sound is Vineyard Sound, and to the east is the Atlantic Ocean. Horseshoe Shoal is located in the approximate middle of Nantucket Sound, with its geometric center at approximately 41°30'N; 70°20'W. The northeasterly tip of the shoal is known as "Broken Ground." The southeasterly tip of the shoal is known as "Halfmoon Shoal."

Nantucket Sound is used for navigation by recreational watercraft, commercial fishing vessels and commercial vessels engaged in waterborne commerce. Peak usage by recreational watercraft and commercial fishing vessels is during the warmer months of the year (typically April through October). Pilotage is not typically required for vessels transiting through central and eastern Nantucket Sound.

There are two main shipping lanes, the Main Channel and the North Channel, used for safe navigation by larger vessels in Nantucket Sound. The USCG marks both of these areas with aids-to-navigation (buoys, lights, etc.). These shipping lanes are described as follows:

- The Main Channel in Nantucket Sound is located south of Horseshoe Shoal. This channel is used by most of the vessels transiting through Nantucket Sound. It is reported that vessels using the channel seldom exceed a draft of 24 ft (7.3 m) (NOAA, 2008).
- The North Channel runs along the north side of Nantucket Sound, on either side of Bishop and Clerks, northward of Horseshoe Shoal, between Wreck Shoal and Eldridge Shoal, northward of L'Hommedieu Shoal, and through one of the openings in the shoals westward of L'Hommedieu Shoal into Vineyard Sound. This channel is

used mostly by vessels bound for the south shore of Cape Cod, and by vessels transiting the Sound during northerly winds. The shallowest depth in the channel is approximately 16 ft (4.9 m) at MLLW.

In addition to these shipping channels, privately and federally maintained channels are located at the approaches to Cotuit Bay, Centerville Harbor, and Hyannis Harbor (see Figure 4.3.7-1).

The area between the Main Channel and the Cape Cod shoreline, including Horseshoe Shoal, is designated as an anchorage named “Anchorage I.” Floats or buoys for marking anchors or moorings in place are allowed in this area. Fixed mooring piles or stakes are prohibited (NOAA, 1994).

The Coast Pilot describes Nantucket Sound as being located between the south coast of Cape Cod on the north, Nantucket Island and part of Martha’s Vineyard on the south, and Vineyard Sound on the west. Nantucket Sound has a length of about 23 miles (37 km) in an east-west direction and a width of 6 to 22 miles (9.7 to 35.4 km) in a north to south direction. At the eastern entrance and within the Sound are numerous shoals. Between the shoals are well-marked channels making the navigation of these waters comparatively easy for powered vessels and also sailing vessels with a fair wind. The shoals at the eastern entrance are subject to considerable shifting while those inside the Sound are somewhat more stable. Boulders are located along the shores in some locations.

Numerous fish traps are located in Nantucket Sound, particularly along the southern shore of Cape Cod. The Sound is home to many shoals and mariners need to stay vigilant to safely navigate these waters with their swift currents, convection fog in summer months, high winds and relative choppy seas in winter storms, and during adverse weather fronts moving through the area throughout the year.

The USCG has categorized the waters of Nantucket Sound as both Navigationally Critical and Environmentally Critical through its Waterways Analysis and Management System (WAMS). This means that for the waterway, degradation of the aids to navigation system would result in an unacceptable level of risk of a marine accident affecting the national economy due to the physical characteristics of the waterway, difficult navigational conditions, aid establishment difficulties, or high aid discrepancy rates. Environmentally Critical Waterways are waterways where a degradation of the aids to navigation system would present either an unacceptable level of risk to the general public or to sensitive environmental areas, because of the transport of hazardous material or dangerous cargoes. Information from the USCG’s 2004 Waterways Analysis and Management System (WAMS) report notes in its characterization of the waters of Nantucket Sound – Anchorage I (which includes Horseshoe Shoal) that “there is little or no reported commercial use of the anchorages due to the dangerous shoal water in the vicinity coupled with adequate harbors of refuge capable of accommodating most waterway users” and that “it is apparent these anchorages are disproportionate to the waterway and pose a myriad of safety issues as they relate to providing a safe, navigable waterway for the user.” As a result, the WAMS report recommends that the USCG reevaluate the necessity and size of these anchorages.

#### *4.4.3.2 Ports and Marinas*

There are no major or significant Port Facilities that handle large deep draft traffic and are engaged in commercial cargo trade in the vicinity of the site of the proposed action. The closest Port Facilities that handle significant quantities of commercial products including containers and bulk cargoes are located in Providence, Rhode Island, Boston, Massachusetts and to a lesser extent New Bedford, Massachusetts. Deep draft ship traffic carrying containers and bulk cargoes do utilize Buzzards Bay for access to the Cape Cod Canal; however this vessel activity is well separated from the site of the proposed action by the Elizabeth Islands and thus would not be affected by the proposed action.

There are many small ports surrounding Nantucket Sound that are home to a plethora of both sail and motor, small and large recreational vessels, excursion/sight seeing vessels and private and commercial fishing vessels and passenger vessels. There are larger ports that are the ports of embarkation for the extensive Passenger/Vehicle/Cargo ferry system that connects Cape Cod and the mainland with the Islands of Nantucket and Martha's Vineyard. This ferry system operated by the Martha's Vineyard and Nantucket Steam Ship Authority (SSA) is a vital link between the Islands and the Mainland. The ferry system provides goods and services to both residents and industry on Martha's Vineyard and Nantucket Islands. The SSA operates from Hyannis, Massachusetts with ferries to Nantucket and from Woods Hole, Massachusetts with ferry service to Martha's Vineyard calling on their main year-round port at Vineyard Haven and their seasonal port of Oak Bluffs from May to October. The port of Oak Bluffs and Vineyard Haven are approximately 3.5 miles (5.6 km) apart. The SSA operates their Hyannis to Nantucket service year round with the addition of a seasonal high speed ferry service that starts in April and takes approximately one hour to make the transit from Hyannis to Nantucket Island. These ferries carry passengers, personal vehicles and large tractor trailers loaded with goods for the economy of both islands. Other than transportation by air, the ferry service is by far the major means delivering essential goods to the islands and their economies.

There are other passenger ferries operating from Cape Cod (Falmouth) and Rhode Island taking passengers to Martha's Vineyard and Nantucket. Departing from New York, Clipper Cruise Lines operates a small passenger vessel that calls at Oak Bluffs or Vineyard Haven, on Martha's Vineyard and Nantucket Island during the summer months. Other than the SSA, none of these vessels require extensive port facilities other than a dock to off-load and on-load passengers for a day excursion ashore. The SSA operates at port facilities that employ roll-on and roll-off capabilities and sufficient land area to stage waiting vehicular and tractor trailer cargo. None of the ports found surrounding Nantucket Sound have sophisticated and extensive cargo handling capabilities.

The Cape Cod, southern Massachusetts, Rhode Island and Martha's Vineyard and Nantucket areas are home to thousands of small craft, both power and sail and host to hundreds more cruising the waters of Nantucket Sound during the summer months (May through October) from other parts of New England and beyond. Significant recreational traffic can be found in the Ports of Hyannis, Chatham, Dennis Port, Harwich Port, Yarmouth, Falmouth and Woods Hole as well as the many inlets, bays and backwaters in between. On the Islands, harbors frequented by pleasure craft include Vineyard Haven, Oak Bluffs and Edgartown while on Nantucket Island they include Nantucket Harbor. These port facilities mainly consist of yacht clubs and marina type environments that are made up of small boat piers and quays and mooring areas for recreational boats and fish offloading and processing equipment for the commercial fishing fleet.

#### *4.4.3.3 Commercial Ship Traffic and Berthing*

Commercial ship traffic for the purposes of this report is defined as that traffic that either takes on passengers for hire or is involved in commercial trade which may involve the carriage of cargo, packaged, containerized or bulk. This would include the Passenger/Cargo/Vehicular Ferry Systems that operate from different ports in Massachusetts including Cape Cod as well as from Rhode Island; commercial fishing vessels (fish, shell fish and lobster for sale and not personal consumption) and other vessels that deliver goods and services to the islands and transit Nantucket Sound. Some of the commercial vessel traffic operates on a year round basis (SSA and commercial fishing fleet) and on a schedule while other commercial traffic operates on a seasonal basis (ferries from Rhode Island and fast ferry from Hyannis).

The USCG Waterway Analysis and Management System of 2004 provides the following as commercial users of Nantucket Sound:

- Nantucket and Martha's Vineyard Steamship Authority operating out of Woods Hole and Hyannis, Massachusetts; Falmouth Ferries; Hy-Line Cruises; Patriot Party Boats; Freedom Cruise Lines; Hyannis Cruise Lines; Tisbury Towing (New Bedford, Massachusetts) and Shearwater Excursions.
- The Woods Hole Oceanographic Institute and NOAA operate several large oceanographic vessels that are home ported at Woods Hole and deploy throughout the world.
- Commercial Fishing vessels located throughout the many harbors surrounding Nantucket Sound with the highest concentration being in New Bedford, Massachusetts that transit through Nantucket Sound enroute to fishing grounds in the area and Georges Bank. An estimated two hundred to two hundred and fifty commercial fishing vessels transit this area to and from fishing grounds. It is also estimated that approximately 50 to 80 commercial fishing vessels fish in the Nantucket Sound itself.
- Large USCG Aids to Navigation cutters are stationed in Woods Hole, Massachusetts and smaller rescue boats at USCG Stations located at Menemsha, Martha's Vineyard, Brandt Point, Nantucket and Chatham, Massachusetts. These Stations are assigned the primary duties of patrolling and conducting search and rescue operations within Nantucket Sound and elsewhere.
- Clipper Cruises operating out of New York City also has a seasonal passenger vessel service that calls on ports in Martha's Vineyard and Nantucket.

From the Waterways Analysis the major ports that support commercial vessel operations surrounding Nantucket Sound include:

- Woods Hole, Falmouth and Hyannis in Barnstable County, Massachusetts
- Vineyard Haven and Oak Bluffs, in Dukes County, Massachusetts
- Nantucket Harbor in Nantucket County, Massachusetts

To support operation of these vessels, the ports have deep water piers and quays to allow these vessels to come along side and discharge their cargo and passengers. The SSA has a significant staging area to stack vehicular traffic awaiting arrival and the loading of ferries at both Woods Hole and Hyannis and at their ports of call in Martha's Vineyard and Nantucket.

The largest commercial vessels known to routinely operate in Nantucket Sound are in the order of 230 to 280 ft (70.1 to 85.4 m) in length; 13 to 20 ft (4 to 6.1 m) in draft and are approximately 1800 gross tons. These ships are of the type operated by the SSA and other operators engaged in commerce with the Islands. The height overall for these vessels is approximately 70 ft (21.3 m). Other vessels, cruise ships, of up to 330 ft (100.6 m) (*Clipper Adventurer*) and 4,300 gross tons have called on ports in the area of study.

#### 4.4.3.4 Ship, Container and Bulk Oil Handling Facilities

There are no ship and container handling facilities in ports surrounding Nantucket Sound. Containers are carried on SSA ferries as part of a tractor trailer rig and are on and off loaded by driving the rig onto or off the vessel on its vehicle deck. There are bulk liquid facilities at Vineyard Haven and Nantucket for offloading petroleum products that are transported by the *T/V Great Gull* and other barges. The largest ship handling facilities are those owned and operated by the SSA and the oil transfer facilities in Vineyard Haven and Nantucket.

#### *4.4.3.5 Navigation Channels*

Due to the characteristics of the waterway, most commercial traffic is restricted to navigation by its draft and for safety reasons to the navigation channels marked by the USCG. The area is transected by two named channels but only one major channel that provides a route for medium sized vessels to transit in an east/west direction in an area north of the Nantucket Shoals. Called the Main Channel, this passage way starts in the west at the juncture of Vineyard Sound and Nantucket Sound at Nobska Point, passes north of West Chop and East Chop on Martha's Vineyard, and passes south of Hedge Fence Shoal. It then continues in a southeasterly direction passing between Horseshoe Shoals to the north, and Hawes Shoal (Chappaquiddick Island) to the south. The channel is fairly wide in most areas being approximately 1.15 miles (1.9 km) across from edge to edge as marked on NOAA Chart 13237 for a draft of 30 ft (9.1 m). It constricts down to approximately 0.86 miles (1.4 km) wide directly south of Horseshoe Shoal at Cross Rip Shoal. It widens soon after heading eastward and immediately south of Half Moon Shoal and splits at the channel heading toward Nantucket Island. The channel width heading toward Nantucket Harbor is approximately 1 mile (1.6 km) and narrows to approximately 300 ft (91.4 m) in width upon entering Nantucket Harbor. The Main Channel continues and turns east north east and then north east heading for the south of Monomoy Island and Butler Hole which provides the deep water for the channel as it bisects Monomoy Island and Bearse Shoal to the north and Monomoy Shoal to the south. The channel through this area is narrow.

The other major channel is called North Channel which skirts the south of Cape Cod and provides access to ports along the Cape Cod shore such as Falmouth, Hyannis, Yarmouth, and Chatham. This channel runs north of Horseshoe Shoal in an east-west direction. The channel is well marked by aids to navigation and has a restricted depth of 16 ft (4.9 m).

The numerous shoals in Nantucket Sound limit the operating areas for vessels depending on the vessel's draft. Charted water depths on Horseshoe Shoal range from 1 to 45 ft (13.7 m) measured at MLLW. The majority of the Shoal is 20 to 30 ft (6.1 to 9.1 m) at MLLW (see Figure 4.4.3-1). Approximately 91 percent of Horseshoe Shoal has charted depths of 30 ft (9.1 m) or less MLLW. This fact limits the vessels that can transit over the shoals at any given time. Analysis of the vessel make-up by type, size and service shows that only one quarter of Horseshoe Shoal has depths that allow the majority of the vessel types using the area to operate and/or drift without going aground. A further breakdown of vessel type, size, draft, and ability to navigate the depth limitations at Horseshoe Shoal is provided in the *Revised Navigational Risk Assessment* (Report No. 4.4.3-1). Due to the swift currents and rapidly changing depths of water over very short distances steep short period waves are created that break on the shoal making operations more difficult.

Ferries out of Woods Hole and Hyannis servicing the Islands of Martha's Vineyard and Nantucket use the North Channel (Falmouth and Hyannis) and then the Main Channel for their transits to and from the ports of Vineyard Haven and Oak Bluffs. Ferries operating out of Rhode Island enter the Nantucket Sound through Vineyard Sound and pick up the Main Channel at Nobska Point for their transits to Martha's Vineyard and Nantucket. Those ferries transiting to Nantucket would follow the Main Channel until the Nantucket Channel intersects in the vicinity of Half Moon Shoal (see Figure 4.3.7-1).

The width of the Main Channel varies from approximately 1.15 nautical miles (1.6 km) at the eastern entrance to the channel, to approximately 0.86 nautical miles (1.4 km) at Cross Rip Shoal. The constriction for the North Channel in the vicinity of the proposed action at the Red #8 and Green Can 11 is 0.8 miles distant. The typical spacing between WGT's in the proposed action is 0.62 miles (1 km) by 0.39 miles (0.6 km).

### 4.4.3.6 Cruise Ship Traffic

For purposes of this assessment, Cruise Ships are defined as vessels that take passengers for hire and provide an itinerary that requires over night accommodations and visits to a number of ports on a multi day cruise. Cruise Ships call on Ports in Martha's Vineyard and at Nantucket. Clipper Cruise Lines operating out of New York City have in the past and plan to continue to call on Martha's Vineyard and Nantucket. Their vessels the *Clipper Adventurer* and the *Yorktown Clipper* have called on the area in the past. The *Clipper Adventurer* is 330 ft (100.6 m) long with a beam of 53.5 ft (16.3 m) and a draft of 15.5 ft (4.7 m). The *Yorktown Clipper* is 257 ft (78.4 m) in length, has a 43 ft (13.1m) beam and has a draft of 8 ft (2.4 m). The *Nantucket Clipper* continues to be listed as a possible visitor to the area. American Cruise Lines offers a New England Island itinerary that sails out of Providence, Rhode Island and visits both Martha's Vineyard and Nantucket in two vessels, the *American Spirit* (which is about 214 ft [65.2 m] long and carries 93 passengers) and the *American Glory.* Both vessels operate on a similar itinerary from June through the end of September. Their voyage plan calls for them to enter Nantucket Sound from Vineyard Sound at Nobska Point and use the Main Channel for transit to a port call in Nantucket and then return to Martha's Vineyard for the second port call exiting the Sound through Vineyard Sound enroute to Fall River, Massachusetts.

Due to the nature of the waterway, the harbor pilots state that they do not take vessels with drafts in excess of 24 ft (7.3 m) or greater east of a point located at 41-46.0N 70-54.3W just northeast of East Chop on Martha's Vineyard. Passenger vessels and cruise ships bound for a port call on Martha's Vineyard at Oak Bluffs or Vineyard Haven always approach these areas from the west (Vineyard Sound) and depart to the west at the termination of the port call. This track puts these vessels approximately 8 miles (13 km) NW from the nearest proposed WTG on Horseshoe Shoal.

### 4.4.3.7 Overwater Passenger Ferry Traffic

Passenger and freight ferries (including high-speed ferries) bound for both Nantucket and Martha's Vineyard operate out of Hyannis Inner Harbor and transit the area near Horseshoe Shoal. Steamship Authority vessels do not transit over Horseshoe Shoal. Ferries bound for Nantucket transit to the east of Horseshoe Shoal, while ferries bound for Martha's Vineyard transit to the north and west of the shoal (see Figure 4.3.7-1). According to USACE data for the 1998 through 2000 timeframe, an annual average of 1,305 vessel trips for vessels engaged in waterborne commerce were reported as passing Cross Rip Shoal, which is to the south of Horseshoe Shoal and the Main Channel.

The over water passenger ferry services in Nantucket Sound are the largest and most frequent users of the waterway; they carry thousands of passengers to and from the islands as well as most of the freight necessary to support the islands population and industry. The SSA operates a fleet of nine passenger/vehicle and freight/passenger ferries that service the islands from Hyannis and Woods Hole. The SSA operates 56 transits (28 round trips) per day starting at 0600 to 2330 over the summer months between Woods Hole and Martha's Vineyard by two vessels (Each vessel has seven round trips or fourteen transits per day). The run takes approximately 45 minutes from dock to dock. The traditional passenger/vehicle service from Hyannis to Nantucket takes 2 hours and 15 minutes and there are 12 transits (by two vessels [Each vessel makes three round trips or six transits per day]). In the summer months, the fast ferry *Flying Cloud* also makes 10 transits or 5 round trips per day from Hyannis to Nantucket in one hour. While the normal ferries operate at 14 to 15 knots (7.2 to 7.7 m/s), the *Flying Cloud* operates at 34 knots (17.5 m/second) or about 40 miles (74.1 km) per hour to make the one hour transit between Hyannis and Nantucket. The SSA ferries have drafts ranging from 7 ft to 12 ft (2.1 to 3.7 m).

Falmouth Cruises operates a passenger ferry regularly from Falmouth Harbor to Oak Bluffs. Eighteen transits are made daily in the summer season.

Hy-Line operates year round high speed ferries from Hyannis to Nantucket and Martha's Vineyard as well as traditional passenger ferry services (seasonal) to both islands and inter-island. The high speed passenger-only ferries operate ten transits per day to Nantucket and ten transits per day to Martha's Vineyard. Hy-Line's tradition ferry that operates seasonally makes six transits to Oak Bluffs, Martha's Vineyard. The Nantucket Ferry operates at six transits per day during the summer season as well as a high speed ferry that operates between Martha's Vineyard and Nantucket two transits per day in the summer months.

Freedom Cruise Lines operate a traditional passenger only ferry from Harwich Port to Nantucket. Its schedule shows six transits per day during the peak summer season.

Most of the commercial vessels routinely using the Nantucket Sound area conservatively have drafts less than 20 ft (6.1 m), 46.3 percent of the proposed action (96 WTGs) is located in waters with depths greater than 20 ft (6.1 m). Thirty-four of the 130 planned WTGs are located within this area. Refer to Table 4.1 of Report No. 4.4.3-1.

### *4.4.3.8 Marinas and Recreational Boating*

There are over forty marinas located in the immediate area surrounding Nantucket Sound. Most are located on Cape Cod. There are marinas and mooring areas located on both Martha's Vineyard and Nantucket predominately on Martha's Vineyard in Vineyard Haven, Menemsha, Oak Bluffs, and Edgartown. On Nantucket most marinas and moorings are located in the main harbor. Recreational traffic in the Sound is seasonal with the summer months from June to October seeing a dramatic increase on water activities by recreational traffic both by boats that originate from the area marinas as well as recreational craft that visit the area from the entire New England and Mid Atlantic Region.

Nantucket Sound is a well known area that attracts all types of recreational craft from the smallest runabout to very large and expensive yachts. These yachts not only include world class power boats/cruisers privately or corporately owned (*Lone Ranger 254 ft/Acquisition 121 ft*) but also sail boats of all sizes (*Southern Cross Maxi 88*). Many remain in the region for the entire boating season, while others use the area to transit to other ports of call along the New England and Mid Atlantic Coasts as well as Canada.

**Recreational Marine Events**

The website at USCG Sector Woods Hole provides a partial list of marine events in its area of operations that include Nantucket Sound. This site lists contains several events in the Nantucket Sound area, however they are located near shore and in various harbors of the Cape and the Islands.

One event called the Figawi Race between Hyannis and Nantucket and back is held every year on Memorial Day. It involves sailboats with LOA's of 20 ft (6.1 m) or greater. The actual course varies from year to year but typically starts to the north of and proceeds around or over portions of Horseshoe Shoal. Figure 4.4.3-2 shows the six courses published in the 2003 Figawi Race Sailing Instructions and similar to those published in the 2005 Figawi Race Sailing Instructions.

### *4.4.3.9 Commercial Fishing*

As is the case for recreational traffic, sources of fishing vessel traffic using Nantucket Sound is too broad to list due to the independence and mobility of fishing activity and practices. Various sources documented that over 70 fishing vessels varying from 30 to 60 ft (9.1 to 18.3 m) in length and 4 to 8 ft (1.2 to 2.4 m) in draft fish Nantucket Sound. Other references postulate that local fisherman attribute 50 to 60 percent of their livelihood to fishing Nantucket Sound. Actions by NMFS reducing "days-at-sea" by 40 percent average for ground fish may result in fishing vessels that fished away from the area returning to the Sound to comply with the at sea reduction to fill their ground fish quotas.

It is also documented that 200 to 250 commercial fishing vessels, many from New Bedford, Massachusetts use the Main Channel across Nantucket Sound to gain access to fishing grounds on Georges Bank and elsewhere. These vessels range in size from 60 to 100 ft (18.3 to 30.5 m) in length and have drafts of 8 to 15 ft (2.4 to 4.6 m).

Many newer and more profitable fishing vessels are well maintained and equipped with an extensive array of navigation and fish finding technology to support extended offshore operations and are staffed by seasoned and professional masters as well as adequate crew. Other fishing vessels are marginally seaworthy and minimally manned with only the most basic of navigation equipment. During bad weather or when making repairs, these vessels have been known to use the General Anchorages in the vicinity of the site of the proposed action.

### 4.4.4 Communications: Radar, Television, Radio, Cellular, and Satellite Signals and Beacons

#### *4.4.4.1 Existing Conditions*

The proposed action area encompasses a substantial amount of water within which a number of communications services are in use. These services fall into the following primary categories:

1. Recreational Communications (satellite, radio, TV, non-emergency cellular)
2. Navigation and Positioning Services
3. Safety and Emergency Communications
4. Aviation and Military Surveillance Radar

##### 4.4.4.1.1 Communications Towers in Area

To evaluate potential impact to existing RF communications in the area, a search of the FCC antenna structure database was made to identify existing and proposed communications towers in the area around Nantucket Sound, including Cape Cod and the islands. A search radius of 25 miles (40 km) from the center of the turbine area was used. This search revealed 69 existing structures that have been notified to the FCC; 51 of these are on the mainland, 11 are on Martha's Vineyard, and 7 are on Nantucket. There are 12 other tower notifications that are in "granted" status, meaning that they have been approved but the FCC has not been notified of their construction. Nine of these are on the mainland, one is one Martha's Vineyard and two are on Nantucket.

The antenna structures found in the area are a mix of broadcast towers, cellular base station towers, local public safety communications towers, and towers for industrial and business use.

##### 4.4.4.1.2 Broadcast Service in Area

On the AM broadcast band, there is one fulltime local station serving the Cape Cod area, WBUR on 1240 KHz, in West Yarmouth. There are also AM signals that are received from more distant stations.

There are 20 licensed full-service FM broadcast stations whose transmitters are within 25 miles (40 km) of the center of the turbine area. Seven of these are on the non-commercial band (88 to 92 MHz).

Many of these stations are low-power (less than 6 kWs) and may not cover the entire Cape Cod area. More distant FM signals are available from New Bedford, Plymouth and other communities.

On the TV broadcast band, local signals include WMPX-LP, a low-power station on Channel 33 in Dennis, and full-power station WDPX at Vineyard Haven (analog Channel 58, HDTV Channel 40). Barnstable, Dukes and Nantucket Counties are in the Boston Designated Television Market Area, but are also served by TV stations in Providence, Rhode Island.

#### 4.4.4.1.3 Aviation and Military Radar Facilities

The closest public airport with a control tower is Barnstable Municipal/Boardman Polando Field in Hyannis. The control tower is more than 8 miles (12.9 km) from the nearest turbine site.

There are two Terminal Radar Approach Control (TRACON) stations within 57.5 miles (92.6 km) of the turbine area. TRACONs are FAA radar stations staffed by air traffic controllers that guide aircraft approaching and departing airports generally within a 34.5 to 57.5 miles (55.6 to 92.6 km) radius up to 10,000 ft (3048 m), as well as assure safe separation of aircraft flying in busy areas near airports. The two TRACONs are at Otis Air Force Base on Cape Cod, about 10 miles (16.1 km) from the nearest turbine, and Theodore Francis Green State Airport in Providence, about 54 miles (87 km) from the nearest turbine.

The nearest Air Route Traffic Control Center (ARTCC) is in Nashua, New Hampshire, about 99 miles (159 km) from the nearest turbine. The purpose of an ARTCC is to guide aircraft at altitudes above 10,000 ft (3038 m) while in mid-flight.

There is a Long Range Joint Use[19] Radar Station (ARSR) in the area, located near North Truro, Massachusetts. The station is about 36 miles (57.9) from the nearest turbine site.

The PAVE PAWS radar station in the north portion of the Massachusetts Military Reservation, near Sagamore, is about 17 miles from the nearest planned turbine. PAVE PAWS is an Air Force Space Command radar system providing detection of ballistic missiles and space surveillance.

The closest VOR navigation beacon is located at Otis Air National Guard Base and is owned by the Department of Defense. There is no mechanism in place for the Department of Defense to share their plans with the FAA to phase out NAVAIDS in favor of GPS systems. However, it appears logical that t the more accurate GPS system would eventually replace the less accurate and fuel-wasting VOR system.

During the FAA aeronautical study, all instrument approach procedures and navigational aids were considered, including VOR impact, and it was determined that the turbine proposal did not affect any instrument approach procedure or navigational aid. The study also considered any GPS procedure that was on file.

The Cape Wind turbine proposal is unique, and proposes to use modern Glass Reinforced Plastic composite blades that have the minimum effect upon radar and communications facilities. Comparisons between impact results obtained at other turbine sites, whether domestic or international, should be conducted with caution.

[19] "Joint Use" means that the radar station is shared by the FAA and the U.S. Military.

Interference results obtained from one turbine site study, especially one that has been conducted many years ago, do not map directly onto a proposed new project because the following factors are not the same:

- Blade composition
- Blade profile
- Blade length
- Configuration of lightening protection wire
- Configuration of mechanical blade supports
- Dimensions of turbine support structures
- Type of equipment used for measurements
- Methodology and test equipment used for measurement procedure

The interference impact is highly dependent and variable depending upon the above factors, to the point where any differences completely negate the predictive value of the measurements. These and other potential communications interference topics are discussed in Section 5.3.4.

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# 5.0 ENVIRONMENTAL AND SOCIOECONOMIC CONSEQUENCES

## 5.1 IMPACT-PRODUCING FACTORS – NORMAL CONDITIONS

The identification and description of activities, equipment, materials, and processes that have the potential to create impacts on natural and human resources in areas proposed for use by the proposed action has been divided into two main categories, those items occurring under normal conditions, and under non-routine conditions. Normal conditions are discussed below, which are then followed by the non-routine conditions (Section 5.2). These factors are then used, as appropriate, in characterizing resource impacts in Sections 5.3 and 5.4, as well as to some extent in Section 6.0. It is important to note that these factors need to be considered within the larger context of other sources of the same or similar impact-producing factors that have occurred in the recent past, do currently occur, or could reasonably be expected to occur in the near future, within the site of the proposed action (refer to Table 5.1.1-1 for a summary of Impact Producing Factors).

### 5.1.1 Maintenance or Construction Vessels and Crew boats

Impacts associated with vessels to be used during construction, operation, and decommissioning of the proposed action, many of which are common to most commercial vessels operating in Nantucket Sound, can be placed into three timeframes during transit, while on station, and while at staging areas. The characteristics of how and what impact factors are associated with these three timeframes are described in the following subsections.

#### *5.1.1.1 Vessel Activity (in Transit, on Station, and at Staging or Maintenance Base)*

The most probable scenario is that the majority of material and equipment would be staged onshore, most likely at existing port facilities in Quonset, Rhode Island, and then loaded onto various vessels for transportation to the offshore site, and ultimately installation. Construction personnel would be ferried by boat and/or helicopter depending upon weather conditions and other factors. Once loaded, if traveling from Quonset, the vessels would pass through Narragansett Bay to Rhode Island Sound then to Vineyard Sound, and then North of Martha's Vineyard to the Main Channel, a distance of about 63.3 miles (101.9 km). While these vessels are in transit, certain aspects of their operation have the potential to generate a number of impacts on marine resources. During construction and decommissioning, the majority of vessel berthing and loading would likely occur at Quonset. Smaller supply or crew boats may also operate out of Cape Cod ports, such as Falmouth and New Bedford. During the proposed action operation phase, maintenance vessels would operate out of Hyannis or similar Cape Cod port, under normal conditions. These ports have adequate facilities for berthing and loading of the maintenance vessel(s). The impacts from all vessel activity are described below.

##### 5.1.1.1.1 Sumps, Ballast, and Bilge Discharges

Bilge water is water that collects in the lower part of a ship. The bilge water is often contaminated by oil that leaks from the machinery within the vessel. The discharge of any oil or oily mixtures is prohibited under 33 CFR 151.10; however, discharges may occur in waters greater than 13.8 miles (22.2 km) offshore if the oil concentration is less than 100 parts per million (ppm). Discharges may occur within 13.8 miles (22.2 km) if the concentration is less than 15 ppm. Ballast water is used to maintain stability and trim of the vessel and may be withdrawn from coastal or marine waters through structures in the hulls of ships called sea chests. Generally, the ballast water is pumped into and out of separate compartments or tanks depending upon the requirements to maintain proper vessel stability and trim as cargo is unloaded. Ballast compartments are not usually contaminated with oil as they are isolated from machinery and engines; however, the same discharge criteria apply as for bilge water (33 CFR 151.10).

In other instances, vessels that arrive empty or load and unload in different locations associated with the proposed action would also result in the discharge of ballast as cargo is taken on board. For example, a barge that is loaded with construction materials and equipment at the onshore staging area would have minimal ballast. After transit to the site of the proposed action and offloading materials as the WTGs are constructed, these vessels may take on ballast water to maintain trim and stability for the transit back to shore for re-loading. Ballast water withdrawals result in entrainment of planktonic marine life and then the discharge of these organisms at a different location. Withdrawal impacts are described further in Section 5.1.1.1.5. In addition to water quality concerns associated with ballast water discharge, an additional potential impact is the introduction of invasive species into local waters, from vessels coming from over seas or from other U.S. ports.

Impact characteristics that result from discharge from vessels described above are also similar to vessels in transit, except for the fact that vessels on station are discharging at a relatively constant location. Whereas vessels in transit have the advantage of a moving discharge resulting in greater dilution and dispersion of the discharged water, vessels on station rely on local currents and passive dispersion mechanisms to dilute the waste water within the receiving water. Should these discharges have characteristics that adversely affect water quality or marine organisms, such as low dissolved oxygen (DO) or pollutants, the severity of the localized impact may be greater than for a vessel in transit.

All vessels for the proposed action would comply with applicable mandatory ballast water management practices established by the USCG in order to minimize the inadvertent transport of invasive species as well as the potential for adversely impacting water quality.

#### 5.1.1.1.2 Deck Drainage

Deck drainage includes all wastewater resulting from deck washings, rainwater, and runoff from curbs, gutters, and drains including drip pans and work areas. The USEPA general guidelines for deck drainage require that no free oil be discharged, as determined by visual sheen. The quantities of deck drainage vary greatly depending on the size and location of the equipment. Large vessels employed during construction, operation, and decommissioning, particularly those with machinery operating on deck, such as cranes or generators, should be designed to avoid oily deck drainage discharge to the ocean.

#### 5.1.1.1.3 Greywater Discharges

On board vessels, domestic wastewater originating from sinks, showers, laundries, and galleys is referred to as greywater. Sanitary wastewater originates from toilets and is referred to as blackwater, which is discussed in Section 5.1.1.1.4. For greywater, no solids or foam may be discharged. In general, operation of large vessels with crew quarters and full live-on-board capabilities would result in the generation of 50 to 100 gallons/person/day (189 to 378 liters/person/day) of greywater. Given the currents and volume of water in an open water setting, it is assumed that where allowed, discharges of greywater are rapidly diluted and dispersed. State and local governments regulate greywater from vessels when operating near shore. Unlike vessels in transit, wastewater discharges from vessels on station would occur more like a point source discharge, with less potential for dispersal and dilution. In these instances, local currents and water depth, would affect the dispersal and dilution factors, and the concentration of a wastewater plume would be higher in the localized area around the point of discharge compared to a vessel in transit. However, again, Horseshoe Shoal is essentially in an open ocean setting and greywater discharges are anticipated to rapidly dilute and disperse.

Discharge of greywater would not occur into the harbor while vessels are berthed. Instead, wastewater would either be held until offshore disposal can occur or would be pumped onshore for proper disposal. All vessel waste would be offloaded, stored and disposed of in accordance with all applicable local, state and Federal regulations.

#### 5.1.1.1.4 Blackwater Discharges

In sanitary waste, floating solids are prohibited. Facilities with 10 or more people must meet and maintain the requirement of total residual chlorine greater than 1 mg/L. In general, operation of large vessels would result in the generation and discharge of 35 gallons/person/day (132.5 liters/person/day) of treated sanitary wastes. All vessels with toilet facilities must have a Marine Sanitation Device (MSD) that complies with 40 CFR 140 and 33 CFR 149. Vessels complying with 33 CFR 159 are not subject to State and local MSD requirements. Type I and II MSDs are systems that mechanically chop up the sewage, chemically treat it, and discharge it through a screen. These MSD systems can not be used, however, in coastal waters that are designated as No Discharge Areas (NDAs). The NDAs are areas where discharge of any treated or untreated sewage is prohibited. There are currently eight NDAs in Massachusetts: the coastal waters of Plymouth, Kingston, and Duxbury, all of Buzzards Bay, Waquoit Bay in Falmouth, the coastal waters of Harwich, Three Bays/Centerville Harbor in Barnstable, Stage Harbor in Chatham, Wellfleet Harbor, and the coastal waters of Nantucket from Muskeget Island to Great Point, including Nantucket Harbor. All Rhode Island waters are also designated as No Discharge (www.mass.gov/czm).

Unlike vessels in transit, wastewater discharges from vessels on station would occur more like a point source discharge, with less potential for dispersal and dilution. In these instances, local currents and water depth, would affect the dispersal and dilution factors, and the concentration of a wastewater plume would be higher in the localized area around the point of discharge compared to a vessel in transit. However, Horseshoe Shoal is essentially in an open ocean setting and blackwater discharges are anticipated to rapidly dilute and disperse.

Discharge blackwater would not occur into the harbor while vessels are berthed. Instead, wastewater would either be held until offshore disposal can occur or would be pumped onshore for proper disposal. All vessel waste would be offloaded, stored and disposed of in accordance with all applicable local, state and Federal regulations.

#### 5.1.1.1.5 Water Withdrawals

While no water withdrawal is associated with the operation of the proposed action's WTGs or electric service platform, water withdrawals by vessels would occur during transits and while on station for construction and maintenance. As indicated above, water withdrawals may occur for ballasting, but other water withdrawals would occur for vessel engine cooling, hoteling, and operation of on-board reverse osmosis water systems (for those vessels with such systems). Water withdrawals by themselves would not have a measurable impact on water quality or quantity in the site of the proposed action where vessels operate, but they can result in the entrainment of planktonic marine organisms, and to a lesser extent, impingement of poor swimming species on the grates of the sea chests. Impingement while under way is not usually an issue as there is a sweeping velocity across the sea chest grating, but while vessels are anchored or moored this sweeping velocity is minimal. Entrainment of organisms typically results in high mortality due to temperature changes and mechanical and hydraulic injury from pump impellors and passage through piping. Any use of a biocide to prevent fouling growth on the interior walls of pipes would further diminish survival of entrained organisms.

While some vessels are moored at the staging or maintenance base their engines would remain at idle speeds, requiring engine cooling water withdrawals. Typically these vessels are of the size of ocean going freighters. Smaller vessels, such as tugs or small crew or supply vessels would shut down engines overnight or for extended periods. In addition, as cargo is removed from freighters or supply barges, ballast water may be taken on while moored in order to maintain vessel trim and stability. As with vessels in transit and on station, water withdrawals have the potential to affect planktonic marine life through entrainment, or poor swimming fish through impingement.

### 5.1.1.1.6 Solid Waste and Trash Handling

The discharge of trash and debris is prohibited (33 CFR 151.51-77) unless it is passed through a shredding and screening device and can pass through a 25 mm mesh screen. All other trash and debris must be returned to shore for proper disposal at municipal or private solid waste landfill or recycling facilities.

### 5.1.1.1.7 Floating Debris and Trash

Trash and debris that may be lost overboard from WTGs, ESP and construction/maintenance vessels can wash ashore on Cape Cod and islands surrounding the proposed action. However, according to the Ocean Conservancy (formerly the Center for Marine Conservation), beachgoers are a prime source of beach pollution, with other sources of coastal trash including runoff from storm drains and antiquated storm and sewage systems in older cities and commercial and recreational fishermen. Cleanup of OCS trash and debris from coastal beaches adds to operation and maintenance costs for coastal beach and park administrators.

Other trash lost overboard may travel into the open ocean, or sink to the seafloor. Certain types of trash can be very harmful to certain marine organisms, such as clear or light colored plastic bags that are consumed by sea turtles which confuse them for jellyfish. Quite often, once consumed the plastic bags cause blockage in the digestive system, which can lead to death. Rope and cable that is lost overboard can become entangled on the fins or mouths of marine mammals, injuring them until the material falls off, or if not removed, can cause mortality through infected flesh wounds or inhibiting feeding.

### 5.1.1.1.8 Noise, Lights, and Vibration

All motorized vessels, including those involved in the construction and maintenance of the proposed action, transmit noise through both air and water. The primary sources of vessel noise are propeller cavitation, propeller singing, and propulsion; other sources include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al., 1995). Propeller cavitation is usually the dominant noise source. For vessels, noise and vibration are related, since both produce energy moving through the water in a wave or band motion. Vibrations associated with propulsion engines would be transmitted through the hull and into the water. The intensity of noise from maintenance vessels is roughly related to ship size, laden or not, and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. For a given vessel, relative noise also tends to increase with increased speed. Commercial vessel noise is a dominant component of manmade ambient noise in the ocean (Jasny, 1999). In the immediate vicinity of a vessel, noise could disturb marine mammals, fish, and sea turtles; with the intensity and duration of affect diminishing rapidly with distance from the source since the energy level associated with noise transmission diminishes with the cube of distance.

All vessels operating between dusk and dawn are required to have navigation lights turned on. In addition, temporary work lighting would illuminate work areas on vessel decks or service platforms of adjacent WTGs or ESP. In addition, cable laying may occur 24 hours a day during certain periods, and these vessels would be illuminated at night for safe operation. A number of factors can affect light transmission, both in air and water. In air, the transmission of light associated with deck and navigation lights on construction and maintenance vessels can be affected by atmospheric moisture levels, cloud cover, and type and orientation of lights. In water, turbidity levels and waves, as well as type of light, can affect transmission distance and intensity.

At least two types of vessels on station would generate noise and vibrations that do not occur with vessels in transit. The cable jetting vessel would create localized underwater noise and vibrations associated with the water jets employed on the jet plow. In addition, the barges involved in pile driving of the monopile foundation, would create noise and vibrations that are well known from other pile driving activities. The sound source level for barges or tugs, typical types of construction/maintenance vessels that may be used for the proposed action, is 162 dB re 1 µPa at 3.3 ft (1 m) (Malme et al., 1989). Marine biota would be able to hear the vessel, but would no physical harm or behavioral effects would occur.

Because the maintenance base(s) of the proposed action would be at existing industrialized port(s), there would not be a substantial increase in noise or lighting above what is normally expected. However, use of these facilities would result in some increase in noise levels and lighting for a period of time that if the proposed action were not constructed, may not occur (unless the facilities were utilized by another industrial tenant). The proposed action's use of these areas would generate noise from the operation of machinery, such as vessel engines as they arrive or depart, cranes used to load or unload equipment and construction materials and supplies, and other smaller pieces of machinery such as fork lifts or delivery trucks. Lighting would be necessary for illuminating the work area on land, at the berth, and on the vessels while at berth. Because the area is designed as an industrial port, much of this lighting already exists, and the changes to background conditions would be negligible.

#### 5.1.1.1.9 Bottom Disturbances and Anchoring

Operation of all vessels, including those expected to be used during construction, decommissioning, and routine maintenance of the proposed action would result in several sources of bottom disturbance. When operating in shallow water areas, typically waters less than 20 ft (6.1 m) deep, the propeller wash from large vessels could contact the bottom and cause some scouring and sediment resuspension. This can injure some types of benthic organisms, or make them more susceptible to predation. Most of the large construction vessels to be used are likely to be jacked up on hydraulic legs or utilize spuds for positioning, which would result in some direct impact to the seabed. In the case of the cable laying/jetting vessel, anchoring is the method used to move the barge along the cable route, and an anchor handling tug is employed to reposition anchors as the barge advances along the route. This vessel is positioned using a series of heavy anchors deployed in an array around the vessel. Winches on the barge or vessel adjust tension on the anchor cables to make adjustments in position. Anchors in the 10,000 lb (4,536 kg) range (the largest anchor estimated to be used on the cable installation vessels) tend to dig into sandy sediments to a depth of about 3 to 5 ft (0.91 to 1.5 m) depending upon sediment type (see Section 5.1.4.3 for more detail on jetting). When the anchors are retrieved, they are pulled out by the bottom and much of the sediment on the flukes falls back into the anchor scar area so that the anchor scar remains as only a shallow depression. Over time, the dynamic environment of Nantucket Sound would level the seafloor. In addition, as the vessel position is adjusted, a portion of the anchor cable nearest the anchor slowly drags across the seafloor surface, causing a shallow sediment disturbance. This action is minimized by the use of mid-line buoys on the anchor lines, which raise a greater amount of anchor chain off the bottom, reducing the amount of chain that is swept along the bottom as the vessel moves. The setting and repositioning of anchors in this manner has the potential to injure relatively sedentary benthic organisms, such as brittlestars, sand dollars, or whelks.

It is unlikely that direct bottom disturbance or anchoring would occur at the staging and maintenance bases since these vessels would use existing mooring structures. Prop wash might occur as vessels move in or out of berths, depending upon the draft of vessels relative to bottom depths, with the resulting resuspension of sediments and possible affects on benthos, fish, and water quality.

#### 5.1.1.1.10 Air Emissions

The operation of vessels, other than sailboats, requires engine power for movement, and the combustion of fossil fuels, whether it is gasoline or diesel, results in the production of exhaust gases that are released to the environment. Types of waste gases are described more fully in Section 5.3.1.5, but typically include carbon dioxide ($CO_2$), CO, nitrous oxides, sulfuric oxides, and water vapor. The release of these gases lowers air quality, and when compounds precipitate out of the atmosphere into the ocean or on land, can affect water quality, affect plant growth, and affect the health of animals and humans. The operation of vessels during construction, operation and maintenance, and decommissioning must be evaluated in the context of the other types and numbers of vessels that occur in areas to be transited by proposed action vessels.

#### 5.1.1.1.11 Visual Aesthetics

During construction, operation, and decommissioning of the proposed action, there would be an increased number and types of vessels operating in the site of the proposed action. The presence of the proposed action-related vessels would alter the visual characteristic of areas transited by these vessels. The Nantucket Sound area has a rich maritime history that includes considerable vessel activity in and out of area ports, whether it is fishing vessels, ferries, various types of cargo vessels, and numerous recreational vessels. Nevertheless, proposed action vessels would increase the number of occurrences of vessels, and this would alter the visual environment. A number of the vessels to be used would be quite large, such as derrick crane barges, which would be visible at greater distances, whether day or night, than some of the smaller vessels that would also be used, such as crew and supply vessels.

This impact would be of greater magnitude during construction and decommissioning than operations, because of the larger and greater number of vessels involved. Also, during the time period of construction and decommissioning, nighttime work would require lighting of work areas. Any visual impact from nighttime work lighting would be dependent upon the distance/location of the viewer and the intensity and orientation of the lighting. During daylight hours, the large derrick barge(s), jack up barges, and cable laying vessel would represent larger vessels than normally occur in this portion of Nantucket Sound. Depending upon the individual, some people would be intrigued with the construction and decommissioning activities and not characterize the presence of these vessels as negatively affecting the visual aesthetics. In contrast, others would feel that these vessels are out of place and represent a degradation of the view across Nantucket Sound. As described in more detail in Section 5.3.3.4, there are a number of factors that affect the nature and extent of how the visual resource would be affected by the proposed action, such as distance from shore or meteorological conditions.

#### 5.1.1.1.12 Channel Maintenance

Dredged materials from channels are often contaminated with toxic heavy metals, organic chemicals, pesticides, oil and grease, and other pollutants originating from municipal, industrial, and vessel discharges and nonpoint sources, and can result in contamination of areas formerly isolated from major anthropogenic sources. The vicinities around harbors and industrial sites are most noted for this problem. Hence, sediment discharges from dredging operations can be major point sources of pollution in coastal waters in and around Nantucket Sound. Given that the shore side facilities proposed for use have adequate channels to accommodate the necessary vessels during construction, operation and decommissioning, it is unlikely that any channel maintenance would occur in association with the proposed action. However, connecting the offshore transmission cable system to the onshore transmission cable system involves HDD which does require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the U.S. and replaced upon completion of the offshore transmission cable system. Testing of the sediments proposed for dredging has shown them to be classified as Category One, Type A, the least toxic and least restrictive of the three classifications in the MassDEP criteria. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the United States and replaced upon completion of the offshore transmission cable system. Samples from vibracores of these proposed dredged sediments were collected and analyzed to determine bulk chemical and physical characteristics and testing analyses were performed in accordance with the MassDEP Division of Water Pollution Control (MassDEP-DWPC) Regulations 314 CMR 9.00. This testing has shown the proposed dredged sediments are classified as Category 1, Type A, the least toxic and least restrictive of the three classifications in the MassDEP-DWPC criteria. Based upon these results the excavated material can and would be used to backfill the cofferdam following the completion of the HDD and offshore transmission cable installation. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours.

##### 5.1.1.1.13 Bottom Debris

While vessels would be required to avoid overboard loss of construction materials, supplies, or equipment, it is likely that some material would end up on the seafloor during the life of the proposed action. Based on experiences from the construction of offshore oil and gas rigs, some debris such as metal cuttings, wire clippings or strands, nuts and bolts, etc. would end up on the seafloor. In comparison, certain other marine activities result in bottom debris in quantities that exceed those expected on the proposed action. For example, commercial fishermen lose lobster traps, and trawlers, gill netters, and seiners also lose gear that comes to rest on the seafloor. However, unlike the oil and gas industry, there is very little on-site fabrication associated with the proposed action. Instead, the proposed action consists primarily of assembly of components brought to the site pre-fabricated.

### 5.1.2 Heliport Facilities

Helicopter sounds contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). Helicopters often radiate more sound forward than backward, and the underwater noise is generally brief in duration as compared with the duration of audibility in the air. From studies conducted in Alaska, a Bell 212 helicopter was 7 to 17.5 dB noisier (10 to 500 Hz band) than a fixed-wing Twin Otter for sounds measured underwater at 10 ft (3 m) and 59 ft (18 m) depths (Patenaude et al., 2002). Water depth and bottom conditions strongly influence the propagation and levels of underwater noise from passing aircraft. Lateral propagation of sound is greater in shallow than in deep water. Interestingly, the amount of sound energy received underwater from a passing aircraft does not depend strongly on aircraft altitude. However, characteristics such as more rapid changes in level, frequency, and direction of sound may increase the prominence of sound from low-flying aircraft to marine mammals (Patenaude et al., 2002). Reactions by marine mammals to aircraft are most commonly seen when aircraft are flying less than 500 to 600 ft (152.4 to 182.9 m). Helicopters, while flying offshore, generally maintain altitudes above 700 ft (213.4 m) except perhaps when traveling between WTGs or the ESP and WTGs where they may fly at between 200 and 500 ft (61 and 152.4 m) on occasion.

#### *5.1.2.1 Helicopter Activities During Construction*

Helicopter hubs or "heliports" are facilities where helicopters can land, load, and offload passengers and supplies, refuel, and be serviced. There are a number of local airports that are adequately equipped to support helicopter use during proposed action construction, operation and decommissioning. Increased helicopter activity could result in increased noise and engine exhaust emissions at the heliport or along flight paths out to the proposed action. No other impacts from helicopter use are anticipated. Helicopter use during construction would occur much more frequently than during operations, but for a much shorter timeframe.

#### *5.1.2.2 Helicopter Activities During Operations*

The same heliport facilities that were available during construction may be used during operations. Helicopter traffic is a primary source of OCS-related noise in coastal regions. Sound generated from this activity is transmitted through both air and water, and may be continuous or transient. The intensity and frequency of the noise emissions are highly variable, both between and among these sources. Helicopter sounds contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). The level of underwater sound detected depends on receiver depth and aspect, and the strength/frequencies of the noise source. The duration that a passing airborne source can be received underwater may be increased in shallow water by multiple reflections (echoes). Maintenance helicopters related to the proposed action may add noise to broad areas. Sound generated from maintenance helicopter traffic is transient in nature and variable in intensity.

The use of a helicopter would allow for maintenance crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers. The helicopter platform would also allow for emergency evacuation of any individuals who may become injured. Therefore, helicopter activity is expected to be fairly infrequent.

### 5.1.3 Construction and Maintenance Staging Facilities

There is an existing, underutilized, industrial port facility in Quonset, Rhode Island that has the attributes required for staging an offshore construction project of the magnitude of the proposed action. The Quonset Davisville Port & Commerce Park is located on Narragansett Bay in the town of North Kingstown, Rhode Island and is owned and controlled by the RIEDC. This site is a portion of what once was a much larger government facility known as the U.S. Naval Reservation – Quonset Point, part of which is still actively utilized as a civilian airport and base for an Air National Guard Reserve squadron. Following the downsizing of the U.S. Naval Reservation – Quonset Point, the Commerce Park was created in order to develop prime industrial sites, create job opportunities and to improve the economic conditions throughout the region. The potential staging of the proposed action from the Quonset Davisville Port & Commerce Park is consistent with the Park's stated purpose.

#### *5.1.3.1 Solid Wastes and Trash*

As with any large construction project, a variety of solid wastes would be produced at the staging area, ranging from paper and wood products to scrap metal, oily wastes, and garbage. Because much of the materials used for the facility would arrive pre-fabricated, rather than built on-site, the quantities of solid waste generated are likely to be less than an equivalent sized electric generating station. For example, the large structural components such as the turbine rotors, generators, monopiles, foundation piles and electric cables would most likely arrive via over-water shipment to Quonset for staging the work in Nantucket Sound. The applicant has stated that construction and maintenance activities would be performed by contracted firms and, as part of the contract agreements, these entities would have responsibility for the proper handling and disposal of solid waste and trash generated during construction and maintenance activities.

#### *5.1.3.2 Oily or Hazardous Wastes*

Since no substantive construction or fabrication is expected to occur at the staging area, the creation of oily or hazardous wastes is anticipated to be minimal. Typically, whenever machinery is used and equipment using hydraulic power is used on construction projects, there is the potential for generation of waste oil and fluids resulting from maintenance and repair activities on the machinery and equipment. Any oily or hazardous wastes that are produced would be properly disposed of in accordance with all applicable laws and regulations.

#### *5.1.3.3 Stormwater and Wastewater*

Staging areas to be used for the proposed action are most likely to be associated with existing facilities that accommodate these types of activities. As such, stormwater and wastewater handling systems would have been previously designed and operated by the site owner/operator and the use of these properties in association with the proposed action is not likely to measurably alter existing conditions. Any changes in the stormwater and wastewater collection, treatment, and disposal systems that are attributable to the proposed action would need to be dealt with in accordance with all applicable laws and regulations.

#### *5.1.3.4 Landfills*

The applicant would contract firms to construct and maintain the proposed action. Landfills likely to be used would be at the discretion of the entity producing the waste. As indicated in Section 5.1.3.1, contractors would be responsible for waste disposal at landfills in accordance with all applicable laws and regulations. Applicable disposal sites are described in Section 4.3.2.4.

#### *5.1.3.5 Noise, Lights, and Vibration*

Noise associated with the staging area would be typical for an industrial port, where cranes are used to load and unload materials from ships. Since the Quonset Davisville Port & Commerce Park is already approved for this type of activity, if utilized there would be no substantial increase in noise levels above what would be typically expected at this facility. Similarly, smaller industrial ports on Cape Cod, that could handle much of the maintenance support for the proposed action, already involve the loading and unloading of vessels at different times of the day, using cranes, winches, davits, etc similar to what would be needed to support maintenance vessels and activities. Therefore, the noise, lights, and vibrations associated with these types of activities already occur. Any increases in noise levels associated with increased equipment usage at the Quonset Davisville Port and Commerce Park are expected to be minimal and intermittent. Further, noise levels near the Port must be in compliance with local noise ordinances. MMS does not believe that a quantitative analysis is required. Negligible impacts are therefore anticipated.

### 5.1.4 Wind Turbine Generator, ESP, and Cable Installation

Installation (may also be referred to as construction) of the proposed action would involve a number of different activities requiring the use of specialized marine construction equipment and vessels, some of which would be operated in a portion of Nantucket Sound that has not historically been subject to construction activities. Impact producing factors associated with vessels are discussed in Section 5.1.1 and helicopters in Section 5.1.2, and are not repeated in Section 5.1.4. Other portions of the proposed action would involve construction using conventional construction equipment operating in areas that have already been developed. The WTGs would be constructed in a grid pattern with minimum 0.39 miles (0.6 km) by 0.63 miles (1 km) spacing. Inner-array cables would be installed in the seafloor between WTGs and between WTGs and the ESP. Lastly, two parallel transmission cables would be installed in the seafloor between the ESP and the south shore of Cape Cod, with on-land continuation to an existing substation.

#### *5.1.4.1 Visual Aesthetics*

The factors that could adversely affect the aesthetics of the coastline are oil spills and residue, tarballs, trash and debris, pollution, increased vessel and air traffic, and the presence of WTGs visible from land. Visibility is dictated not only by size and location of the structures and curvature of the Earth but also by atmospheric conditions. Social scientists added factors, such as the viewer's elevation (ground level, in a 2-story house, or in a 30-story condominium) and the viewer's expectations and perceptions. It should be noted that during the installation process, activities associated with construction that could affect visual aesthetics would consist of both relatively stationary (such as jack up barges) and mobile (cable jetting vessel) components. Vessels are discussed in Section 5.1.1. In contrast, as the construction proceeds, fixed components would become more prevalent until all 130 WTGs and the ESP are constructed and the proposed action goes into operation. Hence, the visual attributes of the proposed action would develop over time.

#### 5.1.4.2 Noise and Vibration

The monopiles would be installed into the seabed by means of pile driving ram or vibratory hammer and to an approximate depth of 85 ft (26 m) into the seabed. This would be repeated at all WTG locations. At Point Gammon in Yarmouth, the temporary sound of construction could be audible when pile driving is done for the monopiles in the northeast corner of the proposed action closest to shore (sounds up to 41 dBA when winds are onshore) when existing sound levels are very low (possibly as low as 35 dBA). At Cape Poge on the northeast tip of Martha's Vineyard, the temporary sound of construction could be audible when pile driving is done for the monopiles in the southwest corner of the proposed action closest to the Vineyard (sounds up to 40 dBA when winds are onshore) when existing sound levels are very low (possibly as low as 40 dBA). Even in these instances, however, the temporary short-term sound levels would be low and would not interfere with any activities. Generally, there will be no audible airborne sounds from pile driving at most land locations, and only minor noise impacts would be anticipated.

For the ESP installation, six piles would be driven through pile sleeves to the design tip elevation of approximately 150 ft (46 m). The piles would be vibrated and hammered as required. This would cause underwater noise and vibrations that could affect a variety of marine organisms, both in the water column and within the sediments.

The principal sound from construction would be temporary pile driving of the WTG monopiles. The anticipated duration of installing all of the monopiles from start to finish is expected to be approximately eight months, plus any delays due to weather. It would take 4 to 6 hours to drive each monopile. The driving rate would be in the range of 2 to 36 impacts per minute. The predicted construction impacts are 31 dBA to 76 dBA when the receiver is 1/3 to 1 mile (0.5 to 1.6 km) downwind of the pile driving activity and 7 dBA to 49 dBA when the receiver is 1/3 to 1 mile (0.5 to 1.6 km) upwind of the activity. Existing average sound levels ($L_{eq}$) at sea in the vicinity of the proposed action are approximately 46 to 51 dBA. These existing levels represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind in light wind conditions. For such boaters, the acoustic modeling results reveal that sometimes the temporary pile driving activity would be audible (i.e., above existing levels) and sometimes it would not, depending on a boater's distance from the monopile being driven and whether he is upwind or downwind of the activity. It should also be noted that occupants of sailboats tacking upwind or motorboats would experience higher baseline sound levels, and for these boaters it is less likely that temporary sound from proposed action construction would be audible.

Sound source data for construction effects underwater were provided by GE Wind Energy from recent tests at the Utgrunden and Gotland Projects (Report No. 4.1.2-1) which have similar environmental conditions to Nantucket Sound and provide the best available data. Data obtained during pile driving at the Utgrunden Project revealed underwater $L_{max}$ sound levels of 177.8 dB at 1,640 ft (500 m). Noise levels of pile driving at the SMDS were found to range from 145 dB to 167 dB at a distance of 1,640 ft (500 m). The higher Utgrunden pile driving sound level data were utilized in the modeling analysis because the monopile foundations for the proposed action would be similar in size to those used at Utgrunden, and because of similarities in environmental conditions between Nantucket Sound and the Baltic Sea. Baseline underwater sound levels under the design wind condition are 107.2 dB.

#### 5.1.4.3 Cable Jetting

The jet plow embedment process for laying submarine power cables with a cable barge produces no sound beyond typical vessel traffic in Nantucket Sound. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The offshore cables are deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, water pump systems are initiated, and the jet plow progresses along the pre-selected offshore cable route with the simultaneous lay and burial operation, creating a trench approximately 4 to 6 ft (1.2 to 1.8 m) wide (top width) to a depth of 8 ft (2.4 m) below the present bottom into which the offshore cable system settles through its own weight. Temporarily re-suspended in situ sediments are largely contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediment traveling outside of the trench. Any re-suspended sediments that leave the trench tend to settle out quickly in areas immediately flanking the trench depending upon the sediment grain-size, composition, and hydraulic jetting forces imposed on the sediment column necessary to achieve desired burial depths.

Other potential water quality impacts associated with fluidizing sediments during jetting include release of nutrients or sediment-bound contaminants into the water column. In areas of high organic content, resuspension of sediments can increase the oxygen demand in the water, thereby causing localized depression of DO levels.

The cable laying/jetting vessel would utilize a system of anchors as the method to move the barge along the offshore cable routes, and an anchor handling tug would be employed to reposition anchors as the barge advances along the routes. This impact producing factor is discussed in Section 5.1.1.1.9.

Another component of the cable jetting process that could cause impacts is the high pressure water jets cutting into the sediments, intended to loosen and liquefy sediments, but also potentially injuring or causing mortality of benthic organisms. Vibrations associated with the jetting would likely cause more mobile species such as lobsters, crabs, flounder and skates to move out of the way. However, infauna or slower moving epifauna, such as polychaete worms, razor clams, sand dollars, brittlestars, or hermit crabs may suffer tissue or organ damage, could become exposed and more susceptible to predation, or may suffer mortality. The jet plow embedment process will produce no audible sound for nearby marine life beyond the sound of rushing water and that from the surface vessel used to transport materials to the site.

### 5.1.4.4 Solid Waste and Trash Handling

Solid waste and trash generated during installation would be contained on vessels or at staging areas, and is discussed in the following sections.

### 5.1.4.5 Floating Trash and Debris

Floating trash and debris generated during installation would largely occur from vessels associated with the installation process, and is therefore covered in Section 5.1.1. One additional source of floating trash and debris could result from installation activities on the ESP. Once the ESP piles and base are constructed, installation of other equipment and components of the ESP would occur as a combination of fixed platform and vessel support. As transformers and other electrical components are installed, it is possible that material would fall off or blow off the ESP platform. Good housekeeping practices would be employed to minimize this occurrence.

### 5.1.4.6 Bottom Debris

Bottom debris is defined as material resting on the seabed (such as cable, tools, pipe, drums, anchors, and structural parts of platforms, as well as objects made of plastic, aluminum, wood, etc.) that are accidentally lost (e.g., during hurricanes) or tossed overboard from facilities. Bottom debris generated during installation would largely occur from vessels associated with the installation process, and is therefore covered in Section 5.1.1. One additional source of bottom debris could result from installation activities on the ESP. Once the ESP piles and base are constructed, installation of other equipment and components of the ESP would occur as a combination of fixed platform and vessel support. As transformers and other electrical components are installed, it is possible that material would fall off the ESP platform. Good housekeeping practices would be employed to minimize this occurrence.

Appropriate precautions would be taken to avoid the overboard loss of materials related to the proposed action and the quantity of bottom debris per operation would be kept to a minimum.

#### 5.1.4.7 Bottom Disturbance

Installation of the WTGs and ESP would involve the use of jack up barges and/or vessels that utilize spuds to secure their position. These vessels would have some direct temporary impact to the seabed from up to six jack up pads, which typically range from 10 to 20 ft (3 to 6 m) in length and width, respectively. Once the jack-up legs are deployed, the barge is raised out of the water to create a stable work platform that is not influenced by tides, currents, or waves. The vessels that are anticipated for the WTG and ESP installation would not utilize anchors. Spud moored barges typically use between 2 and 4 legs that can be raised and lowered along the sides of a barge to hold the barge in place. Depending upon the size of the barge, the spud legs tend to range between 2 and 4 ft (0.61 and 1.2 m) in diameter or width. Unlike jack up barges, spud barges remain floating and are subject to tides, currents, and waves. Deployment and retrieval of jack up legs and spud legs can result in resuspension of sediments, while the lowering of legs results in direct disturbance of the sediments and mortality of infaunal and slow moving epi-benthic organisms within the footprint of the legs. After the barge has been moved, the former locations of the legs remain as small depressions in the seafloor, with the depth dependent upon factors such as length of time the barge has remained in one location, the type of sediment, and the water depth.

Minimal disturbance of sand and sediment would take place as a result of pile driving activities. The piles are hollow, and would enclose bottom material that is displaced in the pile. After installation, some scour around the monopile foundations may occur, depending on the location of the WTG on Horseshoe Shoal and local sediment transport conditions. Scour control mats and/or rock armor would be installed for scour protection.

Connecting the offshore transmission cable system to the onshore transmission cable system involves HDD which does require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the United States and replaced near the end of the offshore transmission cable system installation process. Testing of the sediments proposed for dredging has shown them to be classified as Category 1, Type A, the least toxic and least restrictive of the three classifications in the MassDEP criteria. These criteria are the MassDEP-DWPC classification criteria found in 314 CMR 9.07 for dredging and dredged material disposal, based on both physical and chemical characteristics. Based upon these results the excavated material can and would be used to backfill the cofferdam following the completion of the HDD and offshore cable installation. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours.

#### 5.1.4.8 New or Unusual Technologies Deployed

While some of the equipment and methods may be specialized for the construction of the proposed action, they have all been used before in other locations such as Europe. The construction of an offshore wind energy project is in itself something that has not been proposed before in the United States, Canada, or Mexico and could therefore be considered new technology deployed in this location.

### 5.1.4.9 Displacement of OCS Space

There would be temporary restrictions to certain areas during the construction of the proposed action. Construction vessels would also temporarily utilize space that would restrict recreational and commercial fishermen. For example, the anchoring spread around the offshore cables installation spread requires that other vessels not enter the area between the anchors and the barge, but this temporary exclusion moves as the barge moves. With respect to construction impacts on navigational activity in channels, the proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities (estimated to be one to two WTG locations at any one time) for protection of public safety. The remaining areas of the site of the proposed action would be open to unrestricted navigational access. The WTG that is closest to the Main Channel is approximately 1,190 ft (362.8 m) from the charted Main Channel edge and approximately 6,900 ft (2103.7 m) east of the Main Channel's narrowest point. The work vessels used to construct the WTGs are approximately 400 ft (122 m) long. This leaves ample room for vessels to transit past any ongoing construction. These work vessels would not need to occupy or block the Main Channel during construction. Therefore no restrictions or closures of the Main Channel to transiting vessels are anticipated. The USCG routinely de-conflicts waterways and channels around marine construction activities and it is anticipated that such procedures could be implemented in Nantucket Sound during construction of the proposed action. The applicant would not prohibit vessels from entering or operating in the area of the proposed action and does not intend to establish exclusionary zones. Once the proposed action is constructed, the OCS space occupied by the WTGs, ESP, and scour protection (assuming rock armoring) is less than 50 acres (0.2 $km^2$). Cable installations would occupy over 80 linear miles (128.7 km) of seafloor but in an approximate 1 ft (0.3 m) width, and would be buried at least 6 ft (1.8 m) below grade. The installation of the cables would only preclude a few potential ocean uses while allowing many others to continue.

### 5.1.4.10 Displacement of Aviation Space

The presence of the construction equipment would require that aviators avoid the local area around the equipment, and as WTGs are erected, increasing numbers of obstacles would become present over the Horseshoe Shoal area. These areas would be added to aviation charts and FAA notices would serve to communicate the area of the proposed action to the aviation community. However, in most instances, air traffic in the middle of Nantucket Sound is flying at heights greater than the airspace occupied by the proposed action, and the occupation of this area has been determined by FAA to not be a significant issue or concern for aviation safety.

### 5.1.4.11 Post Lease Geological and Geophysical Field Investigations

Prior to the construction process, a post lease geological and geophysical field investigation would be conducted. The activity would require the deployment of a vessel to do mapping of the sea floor as well as require geological boring to collect subsurface geotechnical and sediment samples. The process of boring would result in minor localized turbidity near the bore hole.

## 5.1.5 Proposed Action Operations

Based on both offshore and onshore WTG operational experience, five days per year per turbine has been established as an anticipated maintenance requirement.

### 5.1.5.1 Discharges to the Sea

The structures associated with the proposed action would not produce discharges to the sea during operations. The only discharges to the sea that are anticipated are those associated with vessels performing maintenance, and these are discussed in Section 5.1.1. Accidental or unintentional discharges to the sea are discussed in Section 5.2.

### *5.1.5.2 Bottom Disturbances and Anchoring*

During normal operations, there are no activities anticipated to require disturbance of the bottom. Maintenance vessels are unlikely to anchor and it is not anticipated that any of the offshore cables would require exposure for maintenance during the life of the proposed action. The most likely scenario resulting in bottom disturbances would probably stem from work on the scour protection on any monopiles or ESP piles that appear to be experiencing scour. These disturbances should be localized and infrequent, but could result in disruption of nearby sediments.

### *5.1.5.3 Floating Trash and Debris*

During operation of the proposed action, the generation of floating trash and debris is likely to be limited, with a greater possibility at the ESP than at the WTGs. The overall quantity of floating trash and debris is likely to be small since the majority of maintenance activities are unlikely to produce much of this type of material.

### *5.1.5.4 Bottom Debris*

During operation of the proposed action, the generation of bottom debris is likely to be limited, with a greater possibility at the ESP than at the WTGs. The overall quantity of bottom debris is likely to be small, associated with maintenance activities, and consists of non-toxic materials such as nuts and bolts, small hand tools, pieces of wire, etc.

### *5.1.5.5 Air Emissions*

Any OCS activity that uses equipment that burns a fuel would cause emission of air pollutants. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. The only air emissions anticipated from the proposed action would result from the maintenance vessels. The vessel emissions represent a mobile source and would not result in a lowering of air quality in a specific location within Nantucket Sound or surrounding areas. However, the use of at least two maintenance vessels for a majority of the days each year does represent an overall, but incrementally small, increase in air pollutants being added to the Nantucket Sound area. The WTGs would utilize the wind as the fuel to generate electricity, and would emit no air pollutants.

### *5.1.5.6 Visual Aesthetics*

During operation of the proposed action, the presence of 130 WTGs and the ESP would be visible at different distances under different light and weather conditions. Nighttime or low light condition lighting would be employed as discussed in Section 5.1.5.8. The proposed action facilities would be visible from a number of locations along the shorelines of Cape Cod and the islands and therefore represent a change in the viewshed and an alteration of the aesthetics of the Horseshoe Shoal portion of Nantucket Sound. Opinions vary as to whether the facilities would have a noticeable or positive effect on the visual aesthetics. The monopile color has been selected to be as neutral as possible. The offshore cables would not affect the visual aesthetics, other than perhaps a slight reduction in some woody vegetation along the NSTAR transmission line ROW.

### *5.1.5.7 Noise and Vibration*

As discussed in Section 5.1.1, all vessels, including maintenance vessels for the proposed action, transmit noise through both air and water. The normal operational/maintenance activity is anticipated to include two vessel trips per working day (252 days/year), which would include one crew boat from Falmouth and the maintenance support vessel from New Bedford. In addition, an occasional second round trip from Falmouth could take place in times of fair weather or for emergency maintenance.

The WTGs would also produce sound when operating. Existing sound levels are 60 to 65 dBA and represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind when the average surface wind speed is 16 mph. Occupants of a sailboat tacking upwind or a motorboat would experience higher baseline sound levels. For such boaters, proposed action operational sound levels of 40 to 45 dBA are well below existing sound levels of 60 to 65 dBA, and the proposed action would not create a pure tone (ESS, 2007 and Table 6 in Report No. 5.1.5-1); therefore, again, the proposed action is expected to be largely inaudible to recreational boaters. As was the case with the cut-in wind speed condition, the frequency-specific modeling results (ESS, 2007 and Figures 14 and 15 in Report No. 5.1.5-1) also reveal that low-frequency sound from the proposed action is below the threshold of human hearing and would be inaudible regardless of the baseline sound levels. Accordingly, minimal noise impacts on recreational boaters are anticipated due to operation of the proposed action at either the cut-in or design wind speed conditions.

The proposed action would be equipped with foghorns for boating safety. Several different devices would be deployed around the perimeter of the proposed action, each with a different characteristic sound. The horns would operate only when fog is present, day or night, and would have a ½-mile audible range. Thus, boaters traveling near the proposed action in dense fog would certainly hear these warning devices, just as they now hear various gongs and bells in Nantucket Sound from fixed buoy locations. Persons on land (5+ miles [8+ km] away) would not hear the foghorns.

In Lewis Bay and onshore locations along the shore of Cape Cod and Martha's Vineyard the calculated maximum operational sound levels of 12 to 26 dBA are well below existing sound levels associated with cut-in to design wind speeds (41 to 71 dBA), and the proposed action would not create a pure tone. The proposed action is anticipated to be inaudible at shoreline locations.

The calculated maximum operational sound levels of 13 to 21 dBA are well below existing sound levels associated with cut-in to design wind speeds (46 to 60 dBA), and the proposed action would not create a pure tone (ESS, 2007 and Report No. 5.1.5-1), therefore the proposed action is also anticipated to be inaudible under these conditions. The frequency-specific modeling results (ESS, 2007 and Figures 16 through 37 in Report No. 5.1.5-1) also reveal that low-frequency sound from the proposed action is below the threshold of human hearing and would be largely inaudible regardless of the baseline sound levels. For example, at Lewis Bay, Yarmouth, the calculated cut-in sound levels for the low frequency of 16 Hz is only 50 dB, while the hearing threshold (the level of sound needed at this frequency in order for it to be heard) is 92 dB. At 250 Hz, the calculated cut-in sound level is only 6 dB, while the hearing threshold is 14 dB. Calculated project sound by frequency falls to 0 dB beyond 250 Hz, and would also not be audible. A similar example is found for Edgartown, Martha's Vineyard, where the calculated cut-in sound level at 16 Hz is 49 dB, and at 250 Hz is only 2 dB. Accordingly, negligible noise impacts are anticipated at any onshore locations due to proposed action operation for either the cut-in or design wind speed conditions.

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Existing underwater sound levels for the design condition are 107.2 dB. The calculated sound level from operation of a WTG is 109.1 dB at 66 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m).

An analysis of predicted underwater sound levels perceived by marine biota from proposed action operation show that no injury or harassment to sea turtles are predicted, even if an individual were to approach as close as 66 ft (20 m) to a monopile.

### 5.1.5.8 Wind Turbine Generator Navigation Lights

The WTGs have been designed with the required USCG Private Aids to Navigation lighting. Two flashing amber lights would be located on the lower access platform about 35 ft (10.7 m) above sea level. The flashing amber lights on the ESP and perimeter WTGs are designed to be visible within distances of 2.3 miles (3.7 km). WTGs located within the perimeter of the area of the proposed action would be equipped with ATON lights of lower intensity, visible between approximately 0.29 and 0.58 miles (0.4 and 0.9 km). This lower intensity lighting is adequate to allow a vessel within the area of the proposed action to navigate from WTG to WTG, a maximum distance of 0.63 miles (1 km). Lights would flash at a frequency of 20 flashes per minute (FPM). A description of navigational lighting is provided in the Visual Section in Section 5.3.3.4.

### 5.1.5.9 Monopile Stability and Foundation Scour

The estimated impact to the seabed was calculated to determine plan areas of the scour ellipses around the WTGs based on the dimensions predicted in the ESS revised *Scour Report, 2005* (Report No. 4.1.1-5). A combination of scour mats and rock armor is proposed (see Figure 2.3.2-4). As proposed, the total estimated impact to the seabed by the scour protection is 1.96 acres (7,946 $m^2$) for scour mats and 8.75 acres (35,417 $m^2$) for rock armor. If any of the scour mats should prove insufficient they would be replaced by rock armor. The worst case would be the replacement of all scour mats with rock armor. If the scour protection were entirely rock armor, the total impacted seabed area would be 47.82 acres (0.19 $km^2$).

### 5.1.5.10 WTG Blades in Motion

While in motion, the blades of the WTG have the potential to increase the risk of collision to birds. Refer to Sections 4.2.4.3 and 4.2.4.4 for further information. In addition, the rotating blades have the potential to contact the mast of any sailing vessels or superstructure of any large vessel that exceeds a height off the water of about 75 ft (22.9 m). However, given the water depths throughout much of the proposed action, vessels of this size are unlikely to transit through the proposed action. Navigation charts would be appropriately labeled to indicate the potential hazards associated with navigation within the area of the proposed action, so the probability of this occurrence is remote.

Under specific weather conditions, ice could theoretically form on the blades, and then become detached, striking vessels navigating under the area occupied by the blades. Because the WTGs have vibration sensors, it is likely that the automatic shutdown mechanism would be activated under ice formation, which would reduce the potential for flying ice to extend further than the rotor diameter. Since this is likely to be an infrequent occurrence it is discussed more in Section 5.2.2.3.

Blade throws are a potential danger as well. Turbine blades could become loose and fall off. Possible types of blade throws include root connection failure; partial failure from lightning; failure at outboard aerodynamic device; tower strike; partial failure due to defect; or extreme load buckling. Potential causes include unforeseen events out of the design envelope; failure of control system; human error; incorrect design for fatigue or ultimate loads; or poor manufacturing quality. The probability of a turbine blade throw is one-in-ten-thousand ($10^{-4}$) (Larwood, 2005). This study did not analyze the probability of impact of mobile targets; however, the likelihood of a mobile vessel sailing under the turbine at the time of a blade throw is even less.

### 5.1.5.11 Monopiles as Fish Attracting Devices (FAD)

The WTG monopile foundations and ESP piles may attract fish and fouling organisms, thereby acting as FADs. Bombace (1997) states that man-made submarine structures can serve to reduce the mortality rate during the critical recruitment phase, increase food availability, and provide shelter for reproductive adults. Bohnsack (1989) states that species most likely to benefit from artificial structures, are those with demersal, philopatric, territorial, and reef-obligate life histories. Several fish species within the proposed action area and other shoals in Nantucket Sound display these characteristics in some or all of their life history stages, and thus may benefit from the presence of the monopiles. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. However, the vertical structure that would be created from the installation of wind turbine towers is not anticipated to result in adverse impacts to the ecology of the immediate area of the proposed action or to Nantucket Sound. With the WTGs within the area of the proposed action being spaced approximately 0.39 by 0.63 (629 by 1,000 m) apart, the overall environment and fish species composition in the area of the proposed action is not predicted to substantially change from pre-proposed action conditions.

Should the monopiles function as FADs, a secondary affect could be realized, namely, the creation of both recreational diving and fishing opportunities. Given the general lack of offshore hard structure reefs within the relatively protected waters of Nantucket Sound, combined with the proximity to many small ports, the WTGs could become target recreation locations.

### 5.1.6 Proposed Action Decommissioning

#### *5.1.6.1 Discharges to the Sea*

Discharges to the sea resulting from decommissioning activities are associated with the operation of vessels performing the work, and as such are discussed in Section 5.1.1. No discharges of wastewater or liquids are anticipated to occur from the WTGs or ESP during the decommissioning process.

#### *5.1.6.2 Bottom Disturbances and Anchoring*

As with the proposed action construction, decommissioning activities would require the same kinds of vessels, resulting in similar types of bottom disturbances and anchoring as are discussed in Sections 5.1.1.1.9 and 5.1.4.7. Once the proposed action is decommissioned, there would no longer be any bottom disturbances resulting from the former facilities.

#### *5.1.6.3 Sea Bed Site Clearance*

The applicant has committed to removing offshore cables installed in the seabed, as well as the removal of piles to a depth of approximately 15 ft (4.6 m) below the natural sea bottom elevation. To the extent that scour control mats can be retrieved they would be, but depending upon how buried they are and the extent of deterioration, they may fall apart during removal with remnant fragments remaining commingled with sediments. Based on the decommissioning plans, the areas occupied by offshore cables would be cleared of proposed action materials, and each of the monopiles and the ESP, no aboveground materials would remain, other than the potential for a small amount of bottom debris that is too small to detect and recover, such as nuts and bolts, short pieces of wiring, etc.

Once the tower has been removed during decommissioning, the sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (4.6 m) below the existing seabottom in order to allow access for cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. Prior to the removal of the cut pile any adjacent scour protection (either scour mats or rock armor) would be removed. Armor stones would be removed using a clamshell dredge or similar equipment, placed on a barge, and disposed of at an upland location. Once the scour control has been removed, the pile would be cut from the inside and placed on a barge for removal. The assembly may be cut into pieces depending on the capacity of the crane available. The sediments from inside the monopile would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity.

It should be noted that any environmental impacts related to the removal of the armor stones would be avoided by leaving the rock armor in place following the removal of the WTG foundations. Over the operational lifespan of the proposed action it is possible that regulatory changes may allow for minimizing environmental impacts by leaving scour protection in place. However, if current regulations remain in effect and require the removal of the armor stones it can be expected that environmental impacts related to the removal of the stones would include temporary and localized impacts to benthics, sediments, fish, marine mammals, and navigation similar to those expected during offshore cables installation and/or decommissioning. It is estimated that removal of the rock armor stones would take approximately one half day per WTG site. The armor stones would be re-used at an off-site location (to be determined) pending all necessary approvals.

#### *5.1.6.4 Floating Trash and Debris*

As with most construction/removal activities that occur in the ocean or along the shoreline, the decommissioning of the proposed action has the potential to create floating trash and debris. Given the de-assembly nature of the decommissioning and lack of on-site fabrication that would require more destructive means of removal, the proposed action does not have the potential to create much in the way of floating material during decommissioning activities. Once the proposed action is decommissioned, there are no incidental materials that might unintentionally be left on site that have the potential to float.

#### *5.1.6.5 Air Emissions*

Air emissions during decommissioning would result from the operation of the construction equipment and vessels. For the period of decommissioning activities, air emissions of the combustion by-products of diesel fuel and gasoline would be increased in the local area over those occurring during operations, similar to those discussed in Section 5.1.1 for the construction period. Once the proposed action is decommissioned, there would be no air emissions resulting from the former proposed action.

#### *5.1.6.6 Visual Aesthetics*

Decommissioning consists of removing the proposed action's visual elements WTGs thereby removing any visual impacts to receptors within the proposed action’s APE and returning the seascape to pre-existing conditions.

During the actual decommissioning process, there would be an increase in vessel activity compared to the operational timeframe, including nighttime lighting of work vessels that would alter the visual aesthetics. This would be a temporary situation.

#### *5.1.6.7 Noise and Vibration*

Similar to, but to a lesser extent, decommissioning activities would result in a temporary increase in the amount of noise and vibration. The noise and vibration would primarily be associated with the operation of vessels and equipment involved in the decommissioning, and once all proposed action facilities are removed or decommissioned in place, there would be no noise or vibrations associated with the former proposed action. The biggest difference between construction and decommissioning noise and vibration is that during decommissioning there would be no pile driving noise, which avoids the higher intensity sound levels associated with pneumatic and vibratory pile driving.

#### *5.1.6.8 Navigation Lights or Beacons*

As with the construction timeframe, during decommissioning there would be a temporary increase in the amount of lighting present within the area of the proposed action in association with decommissioning work vessels, such as derrick barges. Once all proposed action structures are removed, all lighting would be removed and the area would become similar to pre-proposed action conditions.

#### 5.1.6.9 Essential Fish Habitat Degradation With Monopile and Cable Removal

Several fish species within the site of the proposed action and other shoals in Nantucket Sound may be attracted to the monopiles in some or all of their life history stages, and thus may benefit from the presence of the monopiles. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. However, because the proposed action is not predicted to substantially change the overall environment and fish species composition in the area of the proposed action, it is also predicted that the impacts of removing the WTGs would be minor.

#### 5.1.6.10 Restoration of Outer Continental Shelf Space

The 130 WTGs, the ESP, 115 kV offshore transmission cable system, 33 kV inner-array cables, and associated scour control devices (rock armoring) require approximately 115 acres of submerged land within Nantucket Sound. After decommissioning is complete, 104 acres (0.42 $km^2$) of OCS space would be restored, along with 11 acres (44,500 $m^2$ or 0.04 $km^2$) of seabed within state waters, encompassing 115 acres (0.47 $km^2$) of submerged land within Nantucket Sound.

#### 5.1.6.11 Restoration of Aviation Space

As the WTGs and ESP are removed from Horseshoe Shoal, the airspace formerly occupied by these structures would become restored to pre-proposed action conditions, and any restrictions or hazards associated with flying within the area of the proposed action would be removed.

### 5.1.7 On-shore Impact Producing Factors

From the landfall at the end of New Hampshire Avenue in the Town of Yarmouth, an approximate 4.0 mile (6.4 km) long onshore 115 kV transmission cable system would be installed in an underground conduit system within existing roadways until it intersects the existing NSTAR Electric ROW at Willow Street in Yarmouth. From this point, the onshore transmission cable system would proceed west and south for approximately 1.9 miles (3.1 km), in an underground conduit system, along the existing NSTAR Electric ROW to the Barnstable Switching Station. Impact producing factors associated with the onshore transmission cable installation, operation, and decommissioning are described below.

#### 5.1.7.1 Transmission Cable Installation

Construction of the onshore 115 kV transmission cable system would first include installation of ductbanks, conduits, and vaults and then installation of the onshore 115 kV transmission cable system. Construction of the onshore cable system would follow a set of sequential operations including vegetation removal, trenching, and backfilling. The entire process would be coordinated in such a manner as to minimize the total time a parcel of land is disturbed and therefore exposed to erosion and temporarily precluded from normal use.

##### 5.1.7.1.1 Vegetation Removal

Clearing and grading along the roadways and existing NSTAR Electric ROW would remove trees, large rocks, brush, and roots from the construction work area and level the surface of the ROW across its width to allow operation of construction equipment. Trees would only be removed when necessary for construction purposes. Timber and other vegetative debris may be chipped for use as erosion-control mulch, burned, cut and stacked along the ROW, or otherwise disposed of in accordance with applicable regulations. Burning of brush would be conducted in such a manner as to minimize fire hazard and prevent heat damage to surrounding vegetation. No open burning will be utilized as a method of on-site vegetation disposal.

The degree of impact on vegetation would depend on the type and amount of vegetation affected, the rate at which vegetation would regenerate after construction, and the frequency of vegetation maintenance conducted on the ROW during onshore transmission cable system operation. Clearing of trees would result in long term and permanent impacts to these vegetation communities given the length of time needed for the community to mature to pre-construction conditions. All trees within the permanent ROW would be permanently removed and prevented from reestablishing through the periodic mowing and brush clearing required for onshore transmission cable system operation. The cutting, clearing, and/or removal of existing vegetation would also affect wildlife by reducing the amount of available habitat. The degree of impact would depend on the type of habitat affected and the rate at which vegetation regenerates after construction. To minimize impacts on vegetation within the construction and permanent ROWs and to improve the probability of successful revegetation of disturbed areas, the ROW would be managed incompliance with NSTAR's vegetation management plan.

#### 5.1.7.1.2 Sedimentation and Erosion

Construction activities associated with the onshore transmission cable system including clearing, grading, trench excavation, backfilling, heavy equipment traffic, and restoration along the construction ROW may result in adverse impacts on soil resources. Clearing removes the protective vegetative cover and exposes soil to the effects of wind, sun, and precipitation, which could potentially increase soil erosion and the transport of sediment to sensitive areas (i.e., wetlands and waterways). Grading and equipment traffic can compact soil, reducing porosity and percolation rates, which can result in increase runoff potential.

Temporary erosion control measures such as sediment barriers (silt fences) would be installed during the clearing and grading phase. After onshore transmission cable system installation, temporary erosion control measures would be regularly inspected and maintained throughout the duration of construction or until permanent erosion control measures are installed and the temporary measures are no longer needed.

#### 5.1.7.1.3 Trenching and Soil Disturbance

A combination of trackhoes, backhoes, trenching machines, and mechanical rippers would be used to excavate the onshore transmission cable system trench. Little, if any, blasting is anticipated; however, any necessary blasting would be conducted in accordance with all applicable laws and company standards. Where rock substrates are found, the rock would either be segregated during trenching or during backfill activities using segregating machines. In residential areas, subsoil and rock would be stockpiled separately from topsoil. Ductbanks will be cast in place, rather than pre-cast structures requiring transport and lowering into place. After the ductbanks, conduits, and vaults are lowered into the trench and the 115 kV transmission cable system is installed, the trench would be backfilled. Previously excavated materials would be pushed back into the trench using bladed equipment, backhoes, or auger type backfilling machines. Following backfilling, a small crown of material may be left to account for any future soil settling that might occur over the trench.

As described above, onshore transmission cable system construction activities along the construction ROW, including trenching, may result in adverse impacts on soil resources. Impacts to terrestrial wildlife resulting from construction activities would be short-term and minimal because most terrestrial species are reasonably mobile and are expected to temporarily relocate to similar adjacent habitats during construction activities. Some smaller, less mobile wildlife, such as small mammals, amphibians and reptiles, would likely experience direct mortality during clearing, grading, and trenching activities. Impacts to wildlife resources would be minimized through restoration of the ROW and much of the area affected by construction would be allowed to revert to pre-construction conditions following construction.

#### 5.1.7.1.4 Noise and Vibration

Construction activity and associated noise and vibration levels would vary depending on the phase of construction in progress at any one time. These construction phases include site grading, clearing/grubbing, trenching, installation, etc. The highest level of construction noise and vibration is assumed to occur during earth work; however, these effects would be short-term and limited to the duration of construction. Since nighttime construction is not proposed there would be no alteration of nighttime ambient noise quality along the onshore transmission ROW route.

#### 5.1.7.1.5 Air Emissions

Construction impacts on air quality are mainly due to potential fugitive dust released during construction activities. Proper maintenance of construction equipment, watering of the construction sites for fugitive dust control, if necessary, and minimizing soil disturbances to areas necessary for construction are measure that would be implemented to minimize impacts in air quality during construction. In addition, because the construction equipment would only be operated on an as-needed basis and only during daylight hours, the emissions resulting from the operation of construction equipment should be further minimized.

Open burning during construction activities also has the potential to impact air quality. If required, open burning would be regulated through the local permitting processes. Any necessary local open burning permits would be obtained prior to conducting such activities and the local open burning ordinances would be followed during such activities. Emissions from construction-related activities would not significantly affect local or regional air quality and would not cause nor contribute to an exceedance of the ambient air quality standards.

#### 5.1.7.1.6 Dewatering Discharges

After the ductbanks, conduits, and vaults have been inspected and approved, they would be lowered into the trench using side-boom tractors and/or backhoes. Prior to lowering-in, the trench would be inspected to ensure that all foreign material has been removed. Trench dewatering may be necessary at certain times during the lowering-in process. Any trench dewatering would be accomplished in a manner designed to prevent heavily silt-laden water from flowing into wetlands or waterways.

#### 5.1.7.1.7 Traffic Management

Construction of the onshore transmission cable system across major paved roadways, railroads, and unpaved roads where traffic cannot be interrupted would be accomplished by boring under the roadbed. Most smaller, unpaved roads and drives would be crossed by open trenching and then restored to pre-construction or better condition. If an open-cut road requires extensive construction time, provisions would be made for detours or other measures to permit traffic flow during construction. Consultations with landowners would be conducted to determine the best way to cross privately owned roads. All road damage caused by construction of the onshore transmission cable system would be repaired. The onshore transmission cable system would be buried to the depth required by applicable road crossing requirements and would be designed to withstand anticipated external loadings. Railroad crossings would be installed (typically using a bore) in accordance with the requirements of the railroad.

### *5.1.7.2 Transmission Cable Operation*

#### 5.1.7.2.1 Vegetation Maintenance

Routine vegetation maintenance clearing could occur within the existing permanent ROW no more than once every three years. However, to facilitate surveys, a corridor no more than 10 ft (3 m) wide centered on the onshore transmission cable system could be maintained by mowing or a similar means on an annual basis, in accordance with NSTAR's vegetation management plan.

##### 5.1.7.2.2 Electro Magnetic Fields (EMF)

For electrical cables, EMF would be highest adjacent to the cable and decrease as the distance from the cable increases. Electric fields are attenuated by objects, and are completely shielded by electrically conducting material such as metal, the earth, or the surface of the body. Magnetic fields penetrate most materials.

Humans are exposed to a wide variety of natural and man-made electric and magnetic fields from sources including natural fields and overhead transmission and distribution lines. Electric and magnetic fields from different sources may partially cancel or be additive at a given location. A number of epidemiologic studies have reported a small degree of association between measures of EMF and several diseases (e.g., childhood leukemia) while other studies have failed to find an association. A causal basis for the EMF associations is not supported by laboratory and biophysical evidence, and the actual basis remains unexplained.

Terrestrial animals (e.g., birds and honeybees) likely use the earth's DC magnetic field for orientation, navigation and migration. Aside from orientation and navigation, other potential effects of low-frequency EMF on ecological systems have been investigated, but the findings have been uncertain and there is no consistent evidence to establish an adverse-effect level.

Because the electric field of the onshore transmission cable system would be contained within the body of each cable, by its grounded metallic shield, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by its grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines.

#### *5.1.7.3 Transmission Cable Decommissioning*

Decommissioning of the onshore transmission cable system components would be a reverse process of the construction activities and would include leaving in place the conduits, ductbanks and underground vaults beneath the roadways and the existing NSTAR Electric ROW.

During decommissioning, the onshore transmission cable system would be disconnected and pulled out of the underground conduit system. The onshore transmission cable system would be reeled and the reels would be transported to the staging area for further handling. It is expected that all material from the onshore transmission cable system would be reused via recycling.

## 5.2 IMPACT-PRODUCING FACTORS – NON-ROUTINE CONDITIONS

### 5.2.1 Maintenance or Construction Vessels and Crew Boats

#### *5.2.1.1 Oil or Fuel Spills*

Oil is a mixture of different hydrocarbon compounds that begin reacting with the environment immediately upon being spilled. Once spilled, oil begins to spread out on the water surface. There are several different types of oil or fuel that could be employed on vessels used for the project, ranging from diesel fuel used for vessel engines, generators, and cranes to transmission fluids, lubricants or gasoline.

The largest quantities will be those associated with diesel fuel for vessels such as tugs, self-propelled barges, or dynamically positioned vessels. Depending upon the exact oil or fuel spilled, a number of processes alter the chemical and physical characteristics of the original hydrocarbon mixture, which results in the original mass spilled being partitioned to the sea surface, the atmosphere, the water column, and the bottom sediments. Weathering, the type and amount of cleanup, and the existing meteorological and oceanographic conditions determine the length of time that the slick remains on the surface of the water, as well as the characteristics of the oil at the time of contact with a particular resource.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants; water quality through the release of toxic byproducts; benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor; intertidal habitats such as beaches and mud flats; and marine mammals and sea turtles.

#### 5.2.1.2 Vessel Collisions

Vessel collisions during any phase of the proposed action are a remote possibility, particularly given that proposed action vessels are unlikely to be operating during any phase under poor weather conditions, when risk of collision is greatest. However, engine or steerage failure could occur on any vessel at any time. Given that most vessels employed during construction and decommissioning would be moving slowly, less than 10 knots (5.1 m/s), the risk of collision is further minimized. Smaller crew and supply boats may travel at speeds up to 20 knots (10.3 m/s), but these vessels do not have the same momentum and are easier to bring to an emergency stop. Vessels operating during maintenance activities would generally be similar to the smaller crew and supply boats used during construction, and only when necessary to remove a generator, rotors or other large components in the nacelle would a derrick crane barge be used during operations.

The risk of a vessel colliding with a WTG is low, given the proposed action's location away from typical vessel routes, the small diameter of the towers (approximately 16.75 ft and 18 ft [5.1 m and 5.5 m] as described in Section 4.0) and the large spacing between the WTGs. The small diameter of the WTGs would prevent all but the smallest vessels (those with LOA of approximately 16 to 18 ft [4.9 to 5.5 m] or less) from being shielded from view of another vessel by a WTG. When the WTG blade is in its lowest position, it would be approximately 72 ft (21.9 m) above MHW, and approximately 23 ft (7.0 m) from the WTG tower. Therefore, vessels with mast or structure heights less than 72 ft (21.9 m) would pass under the WTG blade should they get within 23 ft (7.0 m) of the WTG.

The location of the site of the proposed action relative to established vessel routes, physical water depth restrictions on Horseshoe Shoal and the large WTG grid spacing combine to limit the potential for a vessel to collide with a WTG. Despite this, the possibility for damage in the unlikely event of a collision was studied, as presented in Report No. 3.3.5-1 and Report No. 5.2.1-1.

#### 5.2.1.3 Cable Repair

The potential for a fault occurring during the operational lifetime of a buried offshore cable systems is minimal, based on industry experience. Impacts associated with a cable repair would result from temporary turbidity and some deposition of sediments during the repair process. Specifically, turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments after the repaired cable is placed back into the seabed. Cable repair procedures are discussed in Section 2.4.6.

### 5.2.2 WTG in Operation

#### 5.2.2.1 WTG and Electric Service Platform Fluid Spills

The oil storage components of the ESP consist of four 115 kV power transformers. The 115 kV power transformers contain 10,000 gallons (37,854 liters) each of dielectric cooling oil (40,000 gallons [151,416 liters] total). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). Oil spill probability analyses are presented in Report No. 3.3.5-1 while oil spill trajectory analyses are presented in Report No. 4.1.3-1. It has a greater than 90 percent chance of impacting the shoreline somewhere. The directions of the potential spill movement in the winter and fall are more variable than in the spring and summer, with the spills equally likely to impact Cape Cod, Martha's Vineyard, or Nantucket. Martha's Vineyard has the highest likelihood of impacts from spills in the spring due to prevailing wind directions from the north and east. The south shore of Cape Cod has the highest likelihood of impacts during the spring and summer due to prevailing winds from the south and west, while the likelihood of impacts to Nantucket at all times of the year are far less (<10 percent). See Report No. 4.1.3-1 for further information.

In addition to the materials stored in the ESP, the turbines would house certain system components within the nacelle that contain smaller amounts of lubricants and cooling fluid. Total oil storage at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). The expected oil storage components are the drive train main bearing containing 19 gallons (71.9 liters) of Mobil SCH 632; the drive train main gear box containing 140 gallons (530 liters) of optimal synthetic A320; the drive train cooling system which holds 21 gallons (79.5 liters) of optimal synthetic A320; the hydraulic system brake and hydraulic system rotor lock that use 2 gallons and 19 gallons (71.9 liters) of Mobil DTE 25, respectively; the hydraulic crane cylinder containing 5 gallons (19 liters) of ATF 66; the yaw system, two pitch systems which contain 7 gallons (26.5 liters) of Mobil SHC 630, 0.25 gallons (1 liter) Mobil SHC XMP 220, and 1 gallon (3.8 liters) Mobil SHC XMP 460, respectively. The worst case scenario for a single incident is 42,000 gallons (158,987 liters) from the ESP; however, given the controls in place, this is an unlikely scenario. According to the Oil Spill Probability Analysis (Report No. 3.3.5-1 and Report No. 5.2.1-1), the estimated number of spills from both the ESP and WTGs over five, ten, and thirty years of operation are 0.31, 0.62, and 1.862, respectively. Furthermore, the analysis shows that only 7 percent of all spills expected in Nantucket Sound during a 30 year period could be attributed to the addition of the proposed action facility.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants, water quality through the release of toxic byproducts, benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor, intertidal habitats such as beaches and mud flats, and marine mammals and sea turtles.

#### 5.2.2.2 Monopile Collapse

Given the relatively sheltered nature of Horseshoe Shoal, compared to an open coastline setting, the probability of monopile collapse due to ocean conditions is remote. The proposed action has been designed with a margin of safety to allow for the conditions anticipated during the proposed action's lifespan. Similarly, the magnitude and frequency of seismic events likely to occur within Nantucket Sound are unlikely to result in monopile collapse, either from fluidization of sediments or stress on the structure resulting from ground motion.

#### *5.2.2.3 Wind Turbine Generator and Ice Build Up and Safety*

Although rotor blades would have a slick surface for aerodynamic efficiency, which would allow most ice to slide off prior to any significant buildup, ice may collect on the WTG structure and blades under certain meteorological conditions (i.e., a combination of high relative humidity, freezing temperatures, and overcast or nighttime sky). This ice usually takes the form of a thin sheet as it attaches to wind turbines (similar to how ice attaches to an airplane's wings during flight). Temporary icing of a rotor blade would activate vibration sensors causing turbine shutdown in order to prevent rotor damage or hazard to proposed action maintenance staff or others from falling ice. Conditions conducive to icing would be evaluated by continuous monitoring of meteorological conditions and by monitoring the WTGs remotely (via camera). If conditions warrant, manual shutdown of the WTGs experiencing icing conditions would be initiated. The ice would remain attached until meteorological conditions allow it to melt. If the WTG is no longer operating due to icing, the melting ice would break apart into fragments in the same manner as ice falls off buildings, trees, and power lines, and fall down to the water surface under the WTG. If the WTG is operating, it is possible that the ice sheet attached to the WTG blade could be thrown from the blade as it rotates. However, as the ice sheet pieces are thrown from the blade, wind resistance would work to break them into much smaller fragments as they fall.

### 5.2.3 Electrical Service Platform

#### *5.2.3.1 Oil or Fuel Spills*

Because the ESP would contain 40,000 gallons (151,416 liters) of dielectric cooling oil, there is the potential for a spill of some or all of this material into the waters of Nantucket Sound. A model was created to anticipate the full release of 40,000 gallons (151,416 liters) of fluid oil from the ESP which would represent a worst case scenario; more information on the inputs used to run the model are provided in Report Nos. 3.3.5-1, 5.2.1-1, and 4.1.3-1. If an oil spill were to occur, the model results indicate that oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent), while it has a large probability of impacting the shoreline somewhere (>90 percent). The directions of spill movement in the winter and fall are more variable than in the summer and spring, with the spills equally likely to impact Cape Cod, Martha's Vineyard, or Nantucket. Martha's Vineyard has the highest likelihood of impacts from spills in the spring due to prevailing wind directions from the north and east, the south shore of Cape Cod has the highest likelihood of impacts during the spring and summer due to prevailing wind directions from the south and west, and the likelihood of impacts to Nantucket is always small (<10 percent).

In addition, during construction and decommissioning there would be an increased number of vessels operating around Horseshoe Shoal, which leads to a potential increase in vessel collisions. Depending upon the severity of such a collision, and the type of vessels involved, oil or fuel could be released.

As described Section 2.0, during the 20-year operational life of the proposed action there would be boats or other motorized floating vessels used to support and perform ongoing maintenance activities.

The vessels used during the operating life of the proposed action would carry a variety of liquids. The crew transport, maintenance support vessels and the special duty supply vessel would be carrying sufficient diesel fuel to move back and forth from port as well as operate for an entire day with some additional capacity for contingency. These vessels may also carry some supplementary diesel fuel and gasoline for use in powered equipment that may be used during maintenance activities. The smaller boat used for crew movement would be gasoline powered and have sufficient gas on board to run for more than an entire day.

Other liquids to be carried would include machine oils and lubricants that would be used both for proposed action generating equipment and, as necessary, for the powered equipment used for maintenance activities. Paints and paint thinners would be transported and used in quantities appropriate for the periods of the touch-up or repainting of the proposed action's components warranted by aging over the lifetime of the operations. Antifreeze and water necessary for equipment and vessel maintenance would also be carried. Drinking water for the maintenance crews would also be carried on crew transport and movement boats.

While not expected, collisions or other failures of the vessels used during the proposed action's operations could cause the release of some or all of these fluids. In order to minimize the potential adverse impacts that may be caused by the release of these fluids, Cape Wind would address the liquids carried on work and crew vessels in its OSRP (see Appendix D), prior to the start of operations (see Table 5.2.3-1 for a list of vessels and use frequency).

The accidental release of oil or fuel may also occur during construction and decommissioning as a result of refueling operations that occur on the water. For instance, jack up or spud barges as well as the cable jetting vessel would not return to port to refuel, but would rather be serviced by a supply or fuel supply vessel, that would transfer fuel while the vessels are on station. This is a normal operation performed during offshore construction activities, and adequate safeguards should be in place to minimize the potential for accidental release, as well as to minimize the affects, should a release occur. Such safeguards include an OSRP (see Appendix D) and the Emergency Response Plan (ERP) (ESS, 2007-Appendix 2.0-D). Each of these safeguards, as well as others, is discussed in more detail in Section 9.3.2.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants, water quality through the release of toxic byproducts, benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor, intertidal habitats such as beaches and mud flats, and marine mammals and sea turtles. A discussion on potential impacts to wildlife within the area of the proposed action can be found in Appendix G, which provides information on T&E species and potential effects to T&E species. The spill probability for the proposed action has been broken down for transiting vessels and the WTG Array/ESP over a thirty-year period by spill volume. In the event of a spill from a transiting vessel there is a 90 percent probability that the volume of the spill will be one gallon (3.8 liters) or less, whereas the probability of a spill of 2,106 gallons (7,972 liters) or less from transiting vessels is one percent. The expected number of transiting vessel spill events over a 30 year period is 26.665. Likewise, a spill event occurring from the operation of the WTG/ESP has a 90 percent probability of having a volume of 50 gallons (189 liters) or less and a one percent probability of a spill of 10,198 gallons (38,604 liters) or less (Report No. 3.3.5-1 and Report No. 5.2.1-1). The expected number of WTG/ESP spills over thirty years is as much as 1.862 (Report No. 3.3.5-1).

Given the relatively sheltered nature of Horseshoe shoal, compared to an open coastline setting, the probability of ESP collapse due to ocean conditions is remote. The proposed action has been designed with a margin of safety to allow for the conditions anticipated during the proposed action's lifespan. Similarly, the magnitude and frequency of seismic events likely to occur within Nantucket Sound are unlikely to result in ESP collapse, either from fluidization of sediments or stress on the structure resulting from ground motion.

### 5.2.4 Electrical Transmission Cables

#### *5.2.4.1 Snagging or Severance*

While the design of the electric cable systems, both inner-array and the offshore transmission cable systems, are intended to adequately bury the cables to a depth where they would not become exposed or be located at a depth below the seabed surface where they could be snagged by anchors or mobile fishing gear, as described in the geology section, there are parts of Nantucket Sound where sand waves reveal the mobility of bottom sediments. In the event that a section of cable no longer remains at the design depth in the sediments, it is possible that an anchor or mobile fishing gear may snag the cable. It is possible that the results of a snagging may be no damage to the cable, damage to the cable but not loss of service, or sufficient damage as to make the cable inoperable. Since the cables would be marked on navigation charts with appropriate warnings, snagging of the cables is considered a remote occurrence.

Even more remote is the possibility that some future activity may occur over a cable that results in the cable being severed. Future placement of other utilities in Nantucket Sound would need to be sited and designed to either avoid the cables or cross them in a manner that avoids snagging or severing them. Future sand mining or dredging, if not properly located relative to the proposed action cables could result in snagging or severance of cables. There are several protective layers around the core of the cable, and the cable would have to be very stressed in order to be severed. Depending upon the circumstances, snagging of the cable may result in it being pulled out of the sediment for a short section and left on the seafloor surface until repair or reburial can occur.

In the event of cable snagging or severance, repair equipment would be mobilized to repair the cable and re-bury it. These activities would result in short term and localized sediment disturbance that could affect benthos and water quality.

#### *5.2.4.2 Exhumation*

It is anticipated that the uncovering of the offshore cables due to natural processes is unlikely due to the minimum 6 ft (1.8 m) burial depth below present bottom and because it would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the offshore cables would be reburied. To rebury an exposed section of cable, a jetting vessel would be deployed and the cable re-jetted to a target depth of 6 ft (1.8 m). These activities would result in short term and localized sediment disturbance that could affect benthos and water quality.

#### *5.2.4.3 On Land Cable Damage or Severance*

The electric transmission cable on land could be damaged or severed due to the actions of others, particularly if they fail to use Dig Safe during activities that involve excavation near the cable. The use of duct banks reduces the potential for damage as the concrete provides some protection for the cables. If the cables were to be damaged or severed, repair might include the need to expose the duct bank in that section, perform the repair, and then backfill and restore the area. If the repair is required along the NSTAR transmission line segment, then minor vegetation clearing may be required, and wildlife would be temporarily displaced from the location due to the construction activity and noise. If the repair is required along the street segment, then traffic may need to be re-routed and nearby residents would experience temporary noise and construction dust.

# 5.3 IMPACTS ON PHYSICAL, BIOLOGICAL, SOCIOECONOMIC, AND HUMAN RESOURCES – PROPOSED ACTION

## 5.3.1 Physical Resources

### *5.3.1.1 Geology*

#### 5.3.1.1.1 Construction/Decommissioning Impacts

**Description of Numerical Models and Engineering Analysis**

Numerical models and engineering analysis of site specific data related to oceanographic processes were used to assess, simulate, and predict potential impacts to geologic resources for construction of the proposed action. Analyses performed were as follows:

**Jet Plow Sediment Transport and Deposition**

Simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were completed using two models, HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations.

The SSFATE model was run for five offshore transmission cable system routes. One was a simulation of the jetting process to bury one of the 115 kV offshore transmission cable systems from the Yarmouth landfall in Lewis Bay to the ESP. Burial of four of the 33 kV inner-array cable routes from the ESP (Electric Service Platform) to their respective ends were also simulated. These four routes were chosen to be representative of the burial of the cable connecting the WTGs. The modeling and results are considered to be representative of sediment conditions throughout the area of the proposed action since they represent locations covering the range of water depths, wave conditions, currents, and sediment characteristics in the Horseshoe Shoal area.

The results of the analysis are discussed in the impact section and presented in Report No. 4.1.1-2.

**Seabed Scar Recovery and Possible Cable Exposure**

A slight depression, estimated to be between 0.5 and 2 ft (0.15 and 0.61 m) deep, is anticipated as a result of installation of the inner-array cables and the offshore transmission cable system. The applicant completed an evaluation to determine the seabed recovery time after jet plow installation of the offshore cable systems. Using the methodology of van Rijn (1993) to calculate bedload sediment flux on Horseshoe Shoal, estimated recovery rates for jetting scars along the cable routes were determined, and an analysis of the potential for localized scour was completed. The results of the analysis are discussed in the impacts section below and presented in Report No. 4.1.1-3.

**Scour Analysis for Wind Turbine Generator Piles**

Analysis of scour at the proposed WTGs was completed. Marine scouring methods developed by Sumer and Fresdoe (USACE, 2002) were used to predict the amount of scour based on wave, current, and sediment characteristics within the proposed turbine array. The analysis resulted in a predicted scour hole size at the wind turbine arrays that could be used to support scour mitigation analysis.

The results of the analysis are discussed in the impacts section and presented in Report No. 4.1.1-5.

**Post-Lease Geological and Geophysical Sampling**

Post-lease G&G investigations would be completed by the applicant to support final design. The sampling would include the following:

- Approximately 50 vibracores would be collected along the proposed 115 kV offshore transmission cable system routes (approximately 2 vibracores per mile [1.6 km]) and along the inner array 33 kV cable routes (1 vibracore approximately every 3 miles [4.8 km]). The diameter of the core barrel is approximately 4 inches (102 mm), and the cores are advanced up to a maximum of 15 ft (4.6 m). The vessel is anchored during coring.
- Approximately 20 borings would be advanced at selected WTG sites. The analytical program is designed to address liquefaction potential, gas concentrations in sediments, pressure regimes of gaseous sediments, and gas saturation versus shear strength properties of sediments. The borings would be advanced from a truck-mounted drill rig placed upon a jack-up barge that rests on spuds lowered to the seafloor. Each of the four spuds would be approximately 4 ft (1.2 m) in diameter. The barge would be towed from boring location to location by a tugboat. Borings generally can be advanced to the target depth (100 to 200 ft [30.5 to 61 m] depending on location) within one to three days, subject to weather and substrate conditions. Drive and wash drilling techniques would be used; the casing would be approximately 6 inches in diameter.
- CPT rig or an alternative subsurface evaluation technique (appropriate to site-specific conditions) would be used, as necessary, to evaluate subsurface sediment conditions. A CPT rig would be mounted on a jack-up barge similar to that used for the borings. The top of a CPT drill probe is typically up to 3 inches (76 mm) in diameter, with connecting rods less than 6 inches (152 mm) in diameter.

Detailed descriptions of the post-lease G&G investigation are presented in Section 2.0. Impacts to geological resources from G&G are expected to amount to temporary increases in turbidity and would be negligible.

**Sediment Deposition and Transport**

During installation of the inner-array cables and the offshore transmission system cables with a jet plow, some sediment would be mobilized and transported from the trench area by currents. Potential impacts to the sediment resource are the suspension and transport of sediments, formation of a seabed scar, and re-deposition of sediments at a distance away from the jet plow trackline, which would potentially include a sorting process whereby finer-grained sediments get transported and deposited at further distances.

In general, and assuming similar currents, the coarse sediments that predominate Horseshoe Shoal and Nantucket Sound would remain in suspension in the water column over a shorter duration than the finer-grained material found in Lewis Bay, and would not disperse as far. However, areas of higher currents could offset the differences in grain size/mass such that larger particles in higher currents may be transported distances equal to or farther than those of fine sediments in lower currents. At all locations along the offshore cables, the suspended sediment would return to the seabed.

An analysis was performed to estimate the amount of suspended sediment and subsequent deposition during the cable burial process. Two models were utilized for modeling, HYDROMAP for currents and

SSFATE for suspended sediments in the water column during jetting operations. Parameters included the following:

- Water Depth: Due to the complex nature of Nantucket Sound bathymetry, the hydrodynamic model domain was extended to relatively deep waters (approximately 660 ft [201.2 m]) in the south and east directions, to Block Island in the west direction and the north end of Massachusetts Bay to the north.
- Current Speed and Direction: Three tidal stations, Woods Hole, Edgartown, and Nantucket were used for tidal constituents in the hydrodynamic model, which is used to drive the sediment transport model simulations.
- Sediment Characteristics: Sediment characteristics were based on actual samples collected from vibracores on Horseshoe Shoal and along the proposed 115 kV offshore transmission system cable route.
- Operational Details: The SSFATE model was used to simulate jetting operations for burial of representative cables in trenches. Assumptions based on the proposed action estimates and past studies included a trench cross section of 32 square ft (3.0 $m^2$), a trenching speed of 91 m/hr (300 ft/hr), and that 30 percent of the trench volume was injected into the water column.

For the offshore cable routes located in the coarse sediment of Nantucket Sound from Yarmouth to the ESP and the WTGs to the ESP, the modeling results indicated that re-deposition of sediment would occur within a few hundred yards of the cable route. A larger portion would be deposited adjacent to the cable route, with a thickness estimate of 0.8 to 1.8 inches (20 to 46 mm) and a thin veneer of finer-grained sediment would extend within a few hundred yards of the trench at 0.04 to 0.2 inches (1.0 to 5.0 mm) (Report No. 4.1.1-2).

As a result, a seabed scar would form. It is estimated that the seabed scars would be 6 ft (1.8 m) wide and 0.75 to 1.7 ft (0.23 to 0.52 m) deep. The seabed scars are anticipated to recover naturally, through normal sediment migration and deposition through the scar area, from tidal and storm events. Seabed scars are estimated to recover within days on Horseshoe Shoal, within 1 to 38 days along the cable route, and over many months or possible years until a major storm occurs within Lewis Bay (Report No. 4.1.1-3).

The impact to the geologic resource from re-deposition of sediment and the formation of the seabed scar during jetting operations for offshore cable installation are considered minor as the resource would recover completely without mitigation.

Placement of the monopiles would result in circular areas of the sediment on the seafloor being enclosed within the hollow monopile. This would result in a loss of available sediments to the environment, which would become available upon decommissioning.

The total surface area affected by monopiles is estimated at 0.67 acres (2,711 $m^2$). The total estimated combined area of impacted seafloor by the inner-array cables and the offshore transmission cable system is 5.89 acres (23,836 $m^2$). Accordingly, geological impacts as a result of land and seafloor occupation would be expected to be minor.

Impacts related to decommissioning of proposed action-related structures including wind turbine towers, foundations, scour control mats, the ESP, inner-array cables and offshore transmission cable system would result in temporary seafloor impacts and temporary re-suspension of bottom sediments.

During decommissioning, the scour mats would be removed by divers and a support vessel in a similar manner to installation, and this is expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats. It is anticipated that the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material. Impacts to sediment from scour mat removal would be minor. In those locations where rock armoring has been used for scour protection, armor stones would be removed using a clamshell dredge or similar equipment and placed on a barge. It is estimated that removal of the rock armor stones would take approximately one half day per WTG site. The armor stones would be re-used at an off-site location (to be determined) pending all necessary approvals.

There would be no excavation around the outside of the monopile prior to the cutting, because the cutting would be done from inside the monopile following the removal of the sediments within the pile. Sediment removal to a depth of approximately 15 ft (4.6 m) below the seabottom would be accomplished hydraulic dredging/pumping with storage of the material on a barge. Once the cutting takes place, approximately 15 ft (4.6 m) below the mudline, the cut pile would be removed. Following the removal of the cut pile and any adjacent scour protection (either scour mats or rock armor) the sediments would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. Impacts to geologic resources are considered minor for the proposed decommissioning activities.

## Onshore

### *Transition from Lewis Bay*

At the Lewis Bay landfall, a temporary sheet pile cofferdam is proposed to support HDD activities. The dredging of approximately 840 $yd^3$ (642 $m^3$) of sediments to an elevation of approximately -10 ft (-3 m) MLLW would be required. Following installation of the offshore cables, the cofferdam excavation would be backfilled with originally excavated material. The dredged backfill material would be supplemented with imported clean sandy backfill material to restore pre-construction contours, if necessary. Once the dredged area is restored, the sheet pile cofferdam would be removed from Lewis Bay.

To transition from the nearshore to onshore route, HDD techniques would be utilized. The HDD is a trenchless method that is an alternative to traditional open-cut cable installations. The result is very little disruption to surface activities and less working space requirements.

The HDD method involves drilling a small pilot hole, using technology that allows the drill to be steered and tracked from the surface. The pilot bore is launched from the surface at an angle between 8 and 20 degrees to the horizontal, and transitions to horizontal as the required depth is reached. A bore path of very gradual curvature or near-straight alignment is normally followed to minimize friction and to stay within the allowable joint deflection and the allowable curve radius for the pipe. This minimizes the chance of getting the pipeline “hung up” in the soil or damaging the pipe.

The pilot hole is enlarged (usually approximately 1.5 times the largest outside diameter of the new pipe) by pulling back increasingly larger reamers, or reaming heads, from the pipe insertion point to the rig side. After the pre-reams, the pulling head and connecting product pipe are attached to the reamer using a swivel, a device that isolates the product pipe from the rotation of the HDD drill pipe. The product pipe is then pulled behind the final reamer back through the HDD path to the exit pit on the rig side.

Drilling mud is normally utilized to lubricate the cutting head during the drilling operation and stabilize the reamed bore path prior to and during pull-back. Drilling mud is primarily a mixture of water and bentonite clay. Bentonite is a naturally occurring clay mineral that forms a mud when mixed with water. The applicant has proposed a formal monitoring program to monitor for drilling fluid release and a contingency plan to stop and cleanup an unexpected release of drilling mud to Lewis Bay.

The potential impact to geological resources during the HDD transition from offshore to onshore is considered minor.

**Onshore Excavation**

The installation of onshore cable vaults would result in the excavation and offsite disposition of some surficial material. It is likely that much of the excavated material would be suitable for re-use as fill with a local recycler.

Onshore transmission cable ROW easements may result in certain restrictions on the unconsolidated geologic resource, such as sand quarrying, though no existing quarrying activity was identified. Certain portions of the ROW are proposed along existing transportation and utility corridor routes, such as the first 4 miles (6.4 km) of the onshore route below existing roadways.

The potential impact to geological resources from the installation and operation of the on-land cable route would be negligible.

**Conclusion**

Overall, the construction and decommissioning impacts to geologic resources would be minor, as they would be temporary, and relatively localized in Nantucket Sound. The minor impacts are largely reversible following decommissioning. Onshore excavation is targeted for existing roadways and a utility ROW. The onshore impacts to geologic resources would be negligible.

#### 5.3.1.1.2 Operational Impacts

**Description of Numerical Models and Engineering Analysis**

Numerical models and engineering analysis of site specific data related to oceanographic processes were used to assess, simulate, and predict potential impacts to geologic resources for operation of the proposed action. Individual analyses are presented below.

**Effects of Wind Turbine Generator Piles in Nantucket Sound**

The zone of influence of the WTG piles on currents, waves, and sediment transport was evaluated. The zone of influence experiences active sediment transport, dominated by the presence of coarse grain sediments and bedforms such as sand waves. The approach used was to assess the zone of influence of a single pile and then use the resultant information to evaluate the potential interaction of multiple piles to determine the cumulative zone of influence.

The results of the analysis are discussed below in the impacts section and presented in Report No. 4.1.1-4.

**Scour Protection**

Two scour mitigation methods were evaluated; scour mats and rock armor.

Two seabed scour control mats were installed on the SMDS' southwest batter pile in October 2003. No scour mats were installed on the SMDS' north and southeast batter piles to allow these piles to provide points of comparison for scour that occurred over time. In June 2005, an underwater inspection occurred to visually inspect the scour mats around the southwest batter pile and to compare the conditions at the other two unprotected SMDS piles with the protected pile. The presence of the scour mats enhanced the accumulation of sand around an installed pile suggesting the scour mats are effective at preventing scour around installed piles. Four additional SSCS mats were installed around the southeast pile in May 2006.

A conceptual rock armor design for scour protection was developed using methodologies presented in the Federal Highway Administration publication *Bridge Scour and Stream Instability Countermeasures – Experience, Selection, and Design Guidance* (FHWA NHI 01-003, March 2001) and the USACE engineering manual, *Coastal Engineering* (USACE, 2002). Using the same wave and current data as those used for the scour mat analysis, stone size and layer thickness were estimated for the environmental conditions anticipated.

The methods and results for this analysis are discussed in the impacts section and presented in Report Nos. 4.1.1-6, 4.1.1-7, and 4.1.1-8.

**Cable Repair**

In the event of a cable failure, the applicant would have a Cable Repair Plan in place to minimize or eliminate environmental impacts. The elements of the Cable Repair plan are detailed in Section 2.0.

Environmental impacts related to cable repair would include temporary and localized impacts to sediments and are expected to be similar to those during offshore cable installation and/or decommissioning, and would be dependent upon the amount and extent of cable damage and the duration that repair vessels are on site. The potential impact to geological resources from the repair of the cable offshore or on-land would be considered negligible.

**Sediment Scour**

Sediment scour would occur at the pile foundations for each WTG and the six 4 ft (1.2 m) diameter piles for the ESP, if mitigation measures are not employed. Sediment scour on piles in the marine environment is a result of the orbital motion of water produced by waves and currents and the resultant vortices produced as water flows past a pile. As water flows around a pile, the capacity of the local sediment transport system increases, sediment erosion occurs and a scour hole is formed. The sediment is suspended and transported away from the pile until the sediment transport system returns to equilibrium. At this point the sediment is deposited back to the seabed. This process would occur during the ebb and flood tides.

An analysis to predict scour factors and predicted scour depths and equilibrium conditions at the WTG and ESP was performed (Report No. 4.1.1-5). Site specific hydrographic surveys, physical analysis of sediment, and estimates of wave and current conditions across the site of the proposed action were inputs to scour prediction methods outlined by Sumer & Fredsoe in their 2002 publication titled *The Mechanics of Scour in the Marine Environment* and the USACE *Coastal Engineering Manual* (Sumer & Fredsoe, 2002; USACE, 2002). The methods and calculations described in these documents were used to create spreadsheets to predict the extent and depth of scour at each WTG location. The parameters used in the calculations included:

- Return period for wave events: 50 year;

- Wave height (locally generated average of highest 10th of waves): 13.2 ft (4 m);
- Spectral peak period (locally generated waves): 6.2 seconds;
- Current speed: 8.35 ft/s (2.5 m/s) (5.5 ft/s [1.67 m/s] wind-generated plus 2.85 ft/s [0.87 m/s] tidally generated);
- Current direction: not required for methodology used;
- Water depth: between 12 and 56 ft (3.6 and 17 m) (dependent on WTG location);
- Median sediment grain size: between 0.215 mm and 0.485 mm (0.008 inches and 0.02 inches) (dependent on WTG location and nearest vibracore sediment characteristics);
- WTG monopile diameter: 16.75 ft (5.1 m) or 18 ft (5.5 m) (dependent on water depth at WTG location);
- ESP pile diameter: 4 ft (1.2 m);
- Angle of internal friction for sediment: 27 degrees;
- Assumed angle for wake vortex shedding: 15 degrees;
- Slender pile regime used to estimate predicted scour depth if diffraction parameter (D/L) less than 0.1; and
- Large pile regime used to estimate predicted scour depth if diffraction parameter (D/L) greater than 0.1.

The predicted scour extent and depth presented are conservative estimates or a “worst case scenario” of the estimated maximum scour depth.

After reviewing trends and predictions on scour depth and distance at the 130 WTG locations, the 130 WTG locations were divided into two scour scenarios to develop a conceptual design for scour protection. A water depth of 40 ft (12.2 m) was selected as the dividing line between each scenario. At the WTG locations, the range of scour extent is predicted with widths of 42 to 45 ft (12.8 to 13.7 m), lengths of 88 to 94 ft (26.8 to 28.7 m), and depths of 13.7 to 14.7 ft (4.2 to 4.5 m) (Report No. 4.1.1-5). An illustration of this predicted scour extent at the monopiles, without scour protection, is presented in Figure 5.3.1-1.

At the ESP, six 4 ft (1.2 m) piles are proposed, in a two by three layout, 75 ft (22.9 m) apart. The same methods used to predict the WTG scour were used for the ESP, with a known water depth of 28 ft (8.5 m). At the ESP location, the scour extent is predicted with a width of 18 ft (5.5 m), a length of 55 ft (16.8 m), and a depth of 9.2 ft (2.8 m) (Report No. 4.1.1-5). Due to the distance between the piles, the scour footprints are predicted to overlap in the absence of any mitigation measures. An illustration of this predicted scour extent at the ESP, without scour protection, is presented in Figure 5.3.1-2.

The applicant evaluated and has requested the use of two engineered scour mitigation methods, scour mats and rock armor. The specific type of engineered scour mitigation method proposed for each location has been proposed. Where depths are shallow and current speeds are relatively faster, rock armor will be used. In relatively deeper water, where current speeds are relative slower, scour mats are proposed. The scour protection proposed, by location, is presented in Figure 2.3.2-4.

Final consideration for scour protection would be based on an assessment of potential environmental impact and scour performance. Scour mats have been used previously for scour protection and are anticipated to last the life of the project (Report No. 5.3.1-1). Long-term field monitoring of two types of scour mats are ongoing at the meteorological tower site. The multi-year pilot study is testing the effectiveness and durability of scour mats of different designs. Results would be incorporated in the final decision regarding which scour mitigation method is most effective and has the least environmental impact, and in the case of scour mats, which type is best for the particular application.

More precise qualitative and quantitative evaluations are proposed for the final design process. Scour tolerances will be calculated based upon final design, including factors such as pile diameter, length, and component weights. Ultimately, if post-installation inspections indicate the scour tolerance may be exceeded at a location with scour mats, and adjustments to the scour mat configuration is not successful at mitigating the scour at a specific monopile, the scour mats will be removed and rock armor will be installed.

Each scour mitigation method proposed, including information on the ongoing scour mat pilot study, is discussed below.

The scour mats proposed use synthetic fronds, made of buoyant polypropylene and polyester webbing designed to mimic seafloor vegetation. The fronds reduce particle velocity as suspended sediment passes over them. As the particle velocity decreases, sediment is deposited onto the scour mats. When they are attached to the bottom as a network, these synthetic fronds trap sediments and eventually become buried. The result of this sediment trapping mechanism forms a scour protection system that is of low bottom relief, similar to existing conditions.

The scour mats are placed on the seabed by a crane or davit onboard a support vessel. Final positioning is performed with the assistance of divers. To secure the scour mats to the seafloor, each scour mat section is fitted with pre-attached anchors spaced at regular intervals along the mat. The anchors are certified for one ton of anchor hold down capacity, with each providing 0.64 ton of hold down capacity per square meter of the mat. Additional anchors may be attached to the mats by divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. As the mats are anchored, there is some possibility that there may be some movement of the scour control mats if the anchoring systems should become loosened.

In October 2003, two scour mats were installed on the sediment surface around one of the three piles of the SMDS. During installation, the two scour mats were positioned such that their long axes were nearly north/south on both sides of the pile. The southern, near-side corners were placed closer together than the northern, near-side corners. The observed currents were nearly perpendicular to the long axis of the mats. The fronds used in the scour mats were 4.1 ft (1.2 m) long. At the time of scour mat installation, a ratchet strap was placed on the three piles at a distance of 48 inches (1.2 m) above the present sand bottom for use during future monitoring. No scour mats were installed on the SMDS' north and southeast piles to provide control points without scour control.

In June 2005, an underwater inspection was performed to visually inspect the scour mats around the southwest batter pile and to compare the conditions at the other two unprotected SMDS piles with the protected pile. Approximately 12 inches (0.3 m) of sand accumulated over a 20 month period at the scour mat protected pile. At the unprotected pile, approximately 13 inches (0.33 m) of sand was scoured away from this pile over a 20 month period.

In May 2006, four additional Seabed Scour Control Systems (SSCS) scour mats were installed around the southeast pile. These additional scour mats are of a modified design in web materials, manufacturing processes, and various frond lengths. The existing conditions of the first two scour mats were surveyed. Sediment scour was observed at each of the three piles. Portions of the nylon webbing on the existing mats were exposed above the seabed. The fronds appear to have separated longitudinally into many fronds of smaller width, though they appeared firmly attached to the mat webbing. Measurements were again taken (similar to monitoring in June 2005, described above). The measurements indicate a net accretion of 12 inches (0.3 m) at the southwest pile, and a net scour of 7 inches (0.17 m) at the previously unprotected southeast pile (Report No. 4.1.1-8).

In October 2007, a fall investigation was completed on the scour mats at the SMDS. Observations were made at the three piles and included the following observations (Report No. 5.3.1-2).

At the northern pile, a location with no scour mats, minor scouring was observed.

At the southwest pile, a location with two scour mats installed, portions of the nylon webbing that comprises the scour mats were exposed above the seabed. The fronds appeared to have separated longitudinally into many fronds of smaller width. The fronds appeared to be firmly attached to the mat webbing.

At the southeast pile, a location with four scour mats installed, the fronds were mostly covered by the seabed. The maximum measured height above the seabed was 10 inches (0.25 m). The edges of the mats were covered by sediment. A bed of mussels six to nine inches thick covered much of the area above the scour mats. The mats were verified as in-place, by digging down through the mussels and sediment to locate the fronds and mat beneath. The net accretion was 24 inches (0.6 m) of sediment and 6 to 9 inches (0.15 to 0.23 m) of mussels.

The October 2007 inspection concluded that the four scour mats at the southeast pile performed well, in accordance with expectations, and the fronds were intact. It was hypothesized that the fronds at the two scour mats located at the southwest pile, observed to be separated longitudinally into many fronds of smaller widths in May 2006, may have been vandalized

In the event a scour mat is damaged, the mat would be removed, hoisted to the surface, and brought to shore for recycling or disposal. A new mat would be installed similarly to the original.

Rock armor (large hard rock boulders) has also been proposed. A filter layer immobilizes the sand and one or more layers of rocks, capable of withstanding the energy of currents and waves, are used to stabilize the filter layer and protect the seafloor around the piles from erosive forces. The boulders would be large enough to deter removal by current conditions and wave effects and small enough for prevention of removal of stone fill material that is placed beneath them.

The rock armor and filter layer material would be placed on the seabed using clamshell bucket or a chute. By lowering the material into the water and placing the material on the bottom rather than dumping it, more control over the placement of the material can be achieved. Sediment suspended during the installation of the rock armor material is expected to be more than that associated with the use of scour mats. It is anticipated that the dominant sandy seafloor sediment would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments.

This would result in total scour protection area of 2,064,964 $ft^2$ (47.41 acres or 191,841 $m^2$) for all 130 wind turbine towers and 17,664 $ft^2$ (0.41 acre or 641 $m^2$) for the 6 ESP pilings. Thus, rock armor scour protection would alter approximately 0.3 percent of the site of the proposed action. The rock armor and filter material would be placed at elevations that were similar to pre-installation sea-bed elevations. It is anticipated the rock armor would not appreciably change the local seafloor topography, as this design would promote deposition of a sand/silt matrix in the interstices of the boulder framework with the eventual burial of all the rock armor. Tidal currents may expose portions of the rock armor for short periods of time, until the bi-directional currents lead to establishment of a dynamic equilibrium, allowing the average condition of the scour-protected zone to be buried by sand.

The proposed rock armor designs are based on three predicted scour conditions resulting from wave and current action, water depth, and diameter of the piles. The scenarios considered include (Report No. 4.1.1-6):

- **Scenario 1A (16.75 ft diameter WTGs; water depths 12 to 15 ft [3.7 to 4.6 m]):** Rock armor stones with a median weight of 125 lbs would extend 42 ft by 94 ft (12.8 by 28.7 m) from the WTG pile, four feet thick.
- **Scenario 1B (16.75 ft diameter WTG's & the ESP; water depths between 16 to 39 ft [4.8 to 11.8 m]):** Rock armor stones with a median weight of 50 lbs would extend 42 ft by 94 ft (12.8 by 28.7 m) from the WTG pile, three feet thick.
- **Scenario 2 (18 ft diameter WTG's; water depths between 39 and 56 ft [11.8 to 17.1 m]):** Rock armor stones with a median weight of 50 lbs would extend 45 ft by 88 ft (13.7 to 26.8 m) from the WTG pile, three feet thick.

The proposed rock armor design was reviewed against generally accepted methods along with the scour analysis parameters used for the modeled conditions to show that the design parameters in the Rock Armor Report were conservative when compared to observations from the SMDS and the hydrodynamic model predictions, and that the rock sizes would enable the scour protection to remain in place under the expected oceanographic conditions at the site of the proposed action (Report No. 4.1.1-7).

Scour protection would be installed around each foundation following the installation of the monopile. Some amount of scouring would take place around the pile prior to the scour mats or rock armoring being placed. Filter material, stones sized one-tenth the gradation and weight of the rock armor, would be placed on the bottom with a clam shell bucket to replace any scoured sediment and to help prevent the rock armor from sinking into the underlying material. In locations where monopiles are installed in sand waves and rock armoring is utilized, it is anticipated that the rock armoring would settle with the migration of the sand wave.

The impact to the seabed from sediment scour as a result of the pile foundation installation would be minor with the addition of the proposed scour controls.

**Sand Waves**

Sediment transport can be impacted by structures in a shallow marine environment as waves and current regimes create vortices that increase particle velocity at the seabed adjacent to a pile. This change in sediment transport at the seabed can result in scour around pilings. A site-specific study (Report No. 4.1.1-9) was completed to assess the effects of the WTGs on sediment transport and sand waves in Nantucket Sound.

The approach of the study followed those typically used to evaluate the effects of offshore structures. The key parameters in these analyses include the diffraction parameter, which indicates whether a wave would diffract behind a pile; and, the Keulagan-Carpenter (KC) number, which indicates whether flow around the pile would separate and shed vortices in the downstream direction. Since both parameters require wave length, analysis of one month (December, 2003) of wave data (wave height, wave period and water depth) was performed.

Diffraction effects were found to occur for 62 percent of the waves from the time series. However the largest diffraction occurred for waves with the smallest period with low induced bottom velocities. These waves cause insignificant sediment transport regardless of whether they diffract or not and so can be ignored. Larger waves, particularly ocean swells, are not affected by the presence of the piles (Report No. 4.1.1-4).

The calculation of the KC number, based on the wave data, found no value greater than 1.8, which is below the threshold for flow separation to occur. A potential flow analysis appropriate for this condition shows that the flow around the pile returns to within 89 percent of its undisturbed value within 1 pile diameter from the pile and to within 99 percent of its undisturbed value within 4 pile diameters. Using the same approach for the periodic tidal wave, a very long period shallow water wave, gave a large KC number over 5,000, indicating that vortex shedding would occur. The velocity defect created by this vortex street dissipates rapidly (Report No. 4.1.1-4).

Comparison to laboratory studies of multiple piles indicates that there is no anticipated wake interaction among the piles since interaction ceases when the piles are spaced greater than five pile diameters from each other and the spacing for this proposed action ranges from 120 to 190 pile diameters (Report No. 4.1.1.4). There is no evidence that the piles would impact the migrating sand waves as a group and the impact to these migrating bedforms should be localized and minor, essentially associated with the area of scour protection at each pile. A diffraction effect occurred for waves with smaller periods that reduced sediment transport ability. Larger waves and ocean swells were not affected by the presence of a pile (Report No. 4.1.1.4).

The impact to the surficial geologic resource from the placement of piles is considered minor and would be reversible following decommissioning.

Potential impacts to the offshore cables from migrating sand waves and bedforms were evaluated. The evaluation considered the site-specific geophysical data collected for the area of the proposed action; existing data from other locations with migrating sand waves, and modeled migration estimates (see Section 5.3.1.3). It was concluded that with modeled bedform migration rates of 3.3 to 9.8 ft (1 to 3 m) per year, the potential for cable exposure on Horseshoe Shoal where migrating sand waves are located is possible within 6 to 18 years if no mitigation measures are undertaken (Report No. 4.1.1-3).

The results indicate that the seafloor may be impacted locally if the offshore cables, set approximately 6 ft (1.8 m) below the seabed, are exposed (Report No. 4.1.1-3). If the cable is exposed during sand wave migration, increased flow would occur above and below the cable, resulting in localized sediment scour. The applicant has proposed a periodic diver inspection and monitoring program to assess cable exposure and scour.

Because of the small area affected and the lack of interaction between WTGs, the potential impact to sandwaves and migrating bedforms is considered minor for the life of the proposed action and would be negligible following decommissioning.

**Conclusion**

Because of the small area affected and the lack of interaction between WTGs, the potential impact to sandwaves and migrating bedforms would be minor for the life of the proposed action and would be negligible following decommissioning. Mitigation being considered at this time includes sediment scour control and post-construction monitoring of sediment scour with periodic diver inspections and a monitoring program to assess cable exposure and scour developed by the design engineer. A more detailed discussion of mitigation is provided in Section 9.0.

### 5.3.1.2 Noise

Noise impacts generally fall into two categories: temporary impacts resulting from operation of construction equipment, and long-term or permanent impacts resulting from operation of the proposed action. Construction-related noise would result from offshore monopile pile driving and barge and ship engines. Onshore construction noise would be generated by HDD activities at Lewis Bay and installation of the cable system. Operational noise would be associated with the wind turbines themselves plus noise associated with the operation of maintenance vessels.

#### 5.3.1.2.1 Construction/Decommissioning Impacts

**Construction**

***Construction Impacts on Onshore Locations During Installation of Monopiles***

The sound impacts during construction are associated with the installation of 130 16 to 18 ft (4.9 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, and vessel traffic for transporting equipment, piles, and workers to the site. The jet plow embedment process for laying offshore cables with a cable barge produces no sound beyond typical vessel traffic in Nantucket Sound. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles. Monopile installation for all of the WTGs is anticipated to require approximately 8 months from start to finish, plus any delays due to weather. It would take 4 to 6 hours to drive each monopile. The driving rate would be in the range of 2 to 36 impacts per minute. Measured sound data from installation of similar sized piles at the Utgrunden Project were used in the acoustic modeling. Noise levels of pile driving at the Utgrunden Project revealed $L_{max}$ sound levels of 177.8 dB at 1,640 ft (500 m) (see Section 2.3.1 in Report No. 4.1.2-1). The sound levels from monopile driving would depend on the distance from the receiver to the particular point in the proposed action array and whether the receiver is upwind or downwind of the location where the monopile is being driven. (In the former case, the wind shadow effect substantially reduces sound levels).

Calculated pile driving sound levels for the onshore noise modeling locations are presented in Table 5.3.1-1, along with the range of measured existing $L_{eq}$ sound levels. The data in this table indicate that for the vast majority of locations, pile driving noise would be below the minimum measured ambient levels, even with onshore winds, which would result in the highest pile driving noise. The only two locations where pile driving noise could at times be equal to or exceed minimum measured ambient conditions are at Point Gammon and Cape Poge. The maximum calculated pile driving sound level at any location is 41 dBA whereas the lowest ambient level measured is 35 dBA.

Any audible pile driving would be limited to brief periods and at only some locations. As such, minor noise impacts are anticipated at some onshore locations due to pile driving during construction.

**Post Lease G&G Investigation**

The post lease G&G investigation would involve vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus noise impacts are expected to be negligible with respect to G&G activity.

**Construction Impacts on Onshore Locations During Horizontal Directional Drilling (HDD) and Onshore Cable Laying**

Elevated noise levels would occur in association with the need to conduct HDD for the boreholes containing the offshore transmission cable system from Lewis Bay to the transition vault on nearby land and noise impacts associated with overland laying of cable from the transition vault to the Barnstable Switching Station. The HDD involves the use of a drilling rig, mud pump and crane, powered by diesel engines. Onshore construction activities would be temporary, lasting 4 to 6 weeks, and would be audible to persons near the cable corridor. Sound levels would be similar to roadway construction equipment. The exact temporary sound levels experienced by residents for the HDD and cable laying would depend on their distance from the construction activity. For example, a person standing 50 ft (15.2 m) from the equipment (HDD, excavator, backhoe) would hear sound levels ($L_{eq}$) in the range of 73 to 79 dBA, and at 200 ft (61 m) they would hear 61 to 67 dBA. Houses along New Hampshire Avenue where this construction would occur are generally 50 or more ft (15.2 or more meters) from the trench that would be dug. The nearest houses to the HDD area are Nos. 32 and 49 New Hampshire Avenue. The closest edge of the house at No. 32 New Hampshire Avenue is 16 ft (4.9 m) from the HDD pit and the closest edge of the house at No. 49 New Hampshire Avenue is 32 ft from the edge of the HDD pit. Noise barrier walls would be constructed at the edge of the HDD pit to shield these residences. The calculated $L_{eq}$ sound level at the nearest edge of the house, assuming a second-floor window exists at that point, would be 68 dBA at No. 32 and 61 dBA at No. 49 New Hampshire Avenue. Minor noise impacts would be expected for the most proximate residences to the HDD site.

To further facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes. The cofferdam would be approximately 65 ft (19.8 m) wide and 45 ft (13.7 m) long and would be open at the seaward end to allow for manipulation of the HDD conduits. The cofferdam would be constructed using steel sheet piles driven from a barge-mounted crane. The noise effects would be temporary and the calculated maximum sound levels are 79 dBA at the two closest residences to the cofferdam, Nos. 32 and 49 New Hampshire Avenue. The installation of sheet steel for the cofferdam would utilize a low-noise vibratory method and would not use impact pile driving. Minor noise impacts would be expected for the most proximate residences to the cofferdam construction area.

**Construction Impacts on Offshore Locations**

Predicted maximum ($L_{max}$) pile driving noise levels at the Buoy G5 and Buoy G20 locations are presented in Table 5.3.1-2. The lowest sound levels are associated with pile driving at the WTG location farthest away from the receiver, while highest sound levels are associated with pile driving at the WTG location closest to the receiver. The calculated construction levels are 31 dBA to 76 dBA when the receiver is downwind of the pile driving activity and 7 dBA to 49 dBA when the receiver is upwind of the activity. Existing average sound levels ($L_{eq}$) at sea in the vicinity of the proposed action are approximately 46 to 51 dBA. These existing levels represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind in light wind conditions. The range of calculated levels, which depend on location and wind conditions, is quite large. There would therefore be times when pile driving noise exceeds ambient conditions, and pile driving would be audible to boaters near the pile installation site. Other times, pile driving noise levels would be low, and likely inaudible. It should be noted that under high wind conditions or for boaters in motorized vessels, ambient levels would be much higher. Any construction noise impacts would be minor and temporary in nature.

**Underwater Construction Impacts**

The underwater sound effects of construction would be temporary and are associated with the installation of 130 16 to 18 ft (4.9 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of offshore cables. According to divers experienced in jet plow installations, the jet plow itself produces no audible noises other than the sound of water exiting the nozzles, which is only audible when immediately adjacent to the nozzles. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles using a drop hammer. Only one monopile would be driven at a time. The driving rate would be in the range of 2 to 36 impacts per minute. It is anticipated that the process of completing one string of WTGs (10 WTGs with associated inner-array cables and scour mats) would take up to approximately one month and installation of all 130 WTGs would occur over two construction seasons. Sound data from installation of similar sized piles at the Utgrunden Project were used in the acoustic modeling (see Section 2.3.1 in Report No. 4.1.2-1). Sound levels would depend on the distance from the underwater receiver to the monopile being driven. For a detailed analysis on underwater construction noise and the effects to protected marine species and fish, please refer to Section 5.3.2.6 and Section 5.3.2.7, respectively.

**Decommissioning**

The decommissioning proposed action would not require pile driving activities, which cause the highest sound levels of any activities associated with the proposed action. Pile driving only takes place during the construction phase of the proposed action. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities which approach the noise level of pile driving. During decommissioning, the monopiles would be cut off at 15 ft (4.6 m) below the seabottom. As such, the noise impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction. As such, negligible impacts are anticipated.

**Conclusion**

In summary, the analysis revealed that noise impacts are expected to range from negligible to minor for onshore and offshore receivers. Mitigation measures are proposed for HDD and cofferdam construction. No noise minimization control measures for any other activities would be required.

### 5.3.1.2.2 Operational Impacts

**Above Water Operational and Maintenance Noise Impacts**

***Operational Impacts on Onshore Locations***

A detailed noise modeling analysis of operational noise was conducted. The modeling results were evaluated in conjunction with measured ambient conditions. Modeling receptors were chosen at the same three onshore locations as where ambient measurements were conducted, and at eight additional locations along the shore. The location of the modeling receptors are: Bass River Beach, Yarmouth; Point Gammon, Yarmouth; Lewis Bay, Yarmouth; Hyannisport, Barnstable; Hyannis Point, Barnstable; Wianno Beach, Barnstable; Oregon Beach, Barnstable; New Seabury, Mashpee; Oak Bluffs, Martha's Vineyard; Edgartown, Martha's Vineyard; and Cape Poge, Martha's Vineyard. These locations are listed in Table 5.3.1-3. Ambient data for the eight additional locations were assigned from one of the three representative monitoring locations, where similar conditions were found to exist.

Industry standard methods and assumptions were utilized for the operational noise modeling analysis. This included: (1) geometric wave spreading (decrease of sound with distance); (2) absorption of sound by the atmosphere; and (3) excess anomalous attenuation (decrease of sound due to atmospheric turbulence, temperature gradients and ground characteristics). The sea surface was assumed to be a reflective surface and downwind conditions were included, essentially negating excess anomalous attenuation and resulting in a more conservative analysis. The assumptions in the construction noise analysis differed only in that calm to moderate winds were used to simulate conditions considered to be ideal for installation of the WTG piles.

Refraction of sound waves (re-direction due to changes in atmospheric conditions) can occur under certain meteorological conditions, and can cause sounds that would not normally be heard to be heard at large distances. Refraction of sound requires the presence of an atmospheric inversion (colder temperatures at the surface than aloft), which can occur under calm wind conditions. The presence of an inversion causes the sound waves from a source to bend back toward the ground at locations further away from the source. During calm wind conditions wind turbine operation would not occur. As such, the effect of sound refraction would not be a factor during operation of the proposed action. Regardless of the fact that this condition can not occur during proposed action operation, the analysis nonetheless considered potential refraction of sound by assuming a temperature inversion would exist during operation.

Research has shown that under high wind conditions (20 mph [8.9m/s] and higher), changes in wind with height can slow down sound reduction with distance for low frequency sounds below 20 Hz. This slower wave spreading (cylindrical spreading), was included in the analyses. Higher frequency sounds are not affected by this condition. Lastly, only onshore winds were considered, since these would produce the highest sound levels (sound levels are reduced during upwind conditions).

Operational noise modeling was further divided into two parts; one for the WTG cut-in speed (8 mph at hub height) and one for WTG design speed (30 mph [13.4 m/s] at hub height). Cut-in modeling represents conditions when ambient sound levels would be lowest, due to lighter winds, and design speed modeling represents maximum sound output from the WTGs. Detailed sound level data for the WTGs were obtained from recent tests conducted for a GE 3.6 MW[20] unit operating near Barrax, Spain.

The noise modeling results for cut-in wind speed conditions at onshore locations are presented in Table 5.3.1-4. Calculated levels are shown to be low, ranging from only 11.6 to 17.8 dBA. The calculated levels are also compared to the range of measured $L_{eq}$ sound levels (41 to 63 dBA), and shown to be well below these levels. The frequency-specific modeling results (ESS, 2007 and Figures 16 through 37 in Report No. 5.1.5-1) reveal that low-frequency sound from the proposed action is below the threshold of human hearing and would be largely inaudible regardless of the baseline sound levels. For example, at Lewis Bay, Yarmouth, the calculated cut-in sound levels for the low frequency of 16 Hz is only 50 dB, while the hearing threshold (the level of sound needed at this frequency in order for it to be heard) is 92 dB. At 250 Hz, the calculated cut-in sound level is only 6 dB, while the hearing threshold is 14 dB. Calculated project sound by frequency falls to 0 dB beyond 250 Hz, and would also not be audible. A similar example is found for Edgartown, Martha's Vineyard, where the calculated cut-in sound level at 16 Hz is 49 dB, and at 250 Hz is only 2 dB. Accordingly, negligible noise impacts are anticipated at any onshore locations due to proposed action operation for either the cut-in or design wind speed conditions.

Calculated levels for the design wind speed condition (the maximum sound output from the WTGs) are also shown to be very low, and are presented in Table 5.3.1-5. Proposed action sound levels are shown to range from 19.2 to 25.9 dBA at the onshore locations. A comparison of the calculated levels to measured existing ambient conditions (54 to 71 dBA) reveals that proposed action levels at the design wind speed would be well below ambient levels. Frequency specific modeling results indicate that low frequency sounds would be below the threshold of human hearing.

[20] For the noise analysis, a GE 3.6 MW turbine was modeled as representative of noise impacts from 3.6 MW turbines in general. The actual manufacturer of the turbines will be selected at a later date by the applicant.

Considering the very low calculated proposed action noise levels, wind conditions, and the ambient conditions that have been measured, it is anticipated that the proposed action would be largely inaudible at onshore locations. Accordingly, negligible noise impacts are anticipated with the proposed action operation under either the cut-in or design wind speed conditions.

***Operational Impacts on Offshore Locations***

The two noise modeling locations for the offshore analysis are the same locations as where ambient measurements were conducted (Buoys G5 and G20). Similar to the modeling for onshore locations, the offshore analysis considered both cut-in and design wind speeds. Calculated noise levels for the cut-in and design conditions are presented in Table 5.3.1-6 and compared to the measured ambient levels. Calculated levels (32 to 34 dBA) for the cut-in condition are shown to be well below measured ambient levels (46 to 51 dBA) at the Buoy locations. Calculated levels (42 to 45 dBA) for the design condition are shown to be well below measured ambient levels (60 to 65 dBA) at the Buoy locations. It is noted that the ambient levels presented are for non-motorized vessels, and ambient levels would be higher for those in motorized vessels. Accordingly, negligible noise impacts are anticipated at offshore locations.

***Maintenance Impacts***

Activities associated with maintenance, including crew boats, barges and small equipment (tools, utility generators, etc.) are similar to typical vessel usage of Nantucket Sound, and are not expected to measurably increase the ambient background noise levels. As such, negligible noise impacts are expected due to maintenance activities.

**Operational Noise on Underwater Locations**

Calculated sound levels from operation of a WTG would only be 1.9 dB above baseline sound levels at the close in distance of 65.6 ft (20 m) from a monopile. Proposed action operation is anticipated to be inaudible to most marine life at this close-in distance. Accordingly, negligible impacts are anticipated to marine life due to proposed action operation.

**Conclusion**

Operational noise impacts are expected to be negligible for onshore locations, offshore locations, and underwater impacts because of the limited noise associated with the turbine operations and maintenance activities as described above.[21]

### 5.3.1.3 Oceanographic Processes

Anticipated impacts on the physical oceanographic environment from installation of the WTGs, the inner-array cables, and the offshore transmission cable system would be minimal and localized. The nature and extent of these impacts and proposed mitigation measures are summarized below.

Minimal impacts in the form of sediment deposition and temporary increases in water column sediment concentrations would occur within the Massachusetts Coastal Zone as a result of jet plow embedment of the 115 kV offshore transmission cable system and the backfilling of the HDD cofferdam. The post lease G&G field investigations (refer to Section 2.7) would result in only temporary and localized turbidity as the result of drilling and vibracore activities. As described below, sediment

[21] The proposed action noise levels were also evaluated against the MassDEP noise policy for informational purposes (see Section 3.0) for both onshore and offshore areas. Proposed action noise levels were calculated to be well below the minimum measured ambient conditions at all locations. No increases in ambient noise levels would occur at onshore locations and minimal (e.g., 2 dBA or less) increases would occur at offshore locations. The proposed action would not produce pure tone noises. As such, the proposed action would be in compliance with the MassDEP noise policy, if it were applicable.

deposition amounts are expected to be small. Increases in water column sediment concentrations are expected to be short lived and significantly lower than those that result from storm events or routine commercial trawling activities.

#### 5.3.1.3.1 Construction/Decommissioning Impacts

**Currents**

There are no anticipated impacts to currents during construction/decommissioning of the WTG structures on Horseshoe Shoal other than the small and localized disruption of flow that occurs around the hull of moored vessels. Therefore, impacts on currents due to construction/decommissioning activity would be negligible.

**Waves**

There are no anticipated impacts expected on waves due to construction/decommissioning activities other than the small and localized reflection of waves that occurs around the hull of moored vessels. Therefore, the impacts on waves would be negligible during construction/decommissioning.

**Salinity**

There are no anticipated impacts from construction/decommissioning of the 130 WTGs, the ESP, or any of the cables on salinity. Construction/decommissioning activities would have negligible impacts on salinity.

**Temperature**

There are no anticipated impacts on water temperatures within Nantucket Sound or Lewis Bay from installation of the WTGs, the ESP or any of the cables. Therefore, impacts on temperature would be negligible during construction/decommissioning activities.

**Sediment Transport**

In addition to the SSFATE modeling completed on the 4,200 ft (1,280 m) segment of the 115 kV cable route in Lewis Bay that is presented, more complete modeling of sediment transport, including the entire 115 kV cable route and four representative stretches of the 33 kV inner-array cable are presented in Report No. 4.1.1-2. SSFATE modeling techniques were used to simulate water column sediment concentration and sediment deposition thickness and extent resulting from jet plow embedment of the offshore cable systems. The SSFATE model simulations were completed along a representative straight-line segment 4,200 ft (1,280 m) in length, presuming sand-sized sediment based on information from Vibracore VC01-L2, near the inlet to Lewis Bay. The results presented from the simulation can be considered typical and generally representative of the subsurface sediment types expected to be encountered along the offshore cable system routes, as those are also primarily sand-sized sediments. The modeling and results are considered to be representative of sediment conditions throughout the site of the proposed action.

The results of the model simulation indicate that sediment deposition ranges from zero to approximately 0.9 inches (23 mm) adjacent to the jet plow trench in sandy sediments. The majority of the sediment deposition is expected to remain within or immediately adjacent to the cable trench. The model simulation indicates that sediment deposition quickly tapers off to below 0.2 inches (5 mm) at approximately 100 ft (30.5 m) on either side of the cable trench in sandy sediments. These deposited sediments are anticipated to dissipate over time through natural tidal and storm-related sediment processes.

Special concern has been raised during the regulatory review process about the potential effects of the jetting operation on an eelgrass bed identified just west of Egg Island in Lewis Bay. In this area, the bottom sediments are relatively coarse. As a result, the sediments suspended by the jet plow are predicted to fall along the route with bottom deposition predicted to be in the range of 0.04 to 0.1 inches (1.0 to 3.0 mm) at the western edge of the eelgrass bed. The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations (Report No. 4.1.1-2).

In general, the deposition of sediments suspended by jet plow embedment operations was estimated to be minimal when compared to the active bed load sediment transport known to exist in Nantucket Sound (between 45 and 71 mg/L under natural tidal conditions). The modeling results show that the sediments suspended by the jet plow would generally fall along the route. In areas where the route is in a north-south orientation, which is perpendicular to the predominant east-west flow direction, the effects of the tides can be seen transporting the sediment slightly west or east of the route in an oscillating fashion. The actual location of these oscillations (but not the shape) would change since they are determined by the relationship between the time of the tide and the jetting start time. Generally, the sediment deposition thickness is predicted to be in the range of 0.04 to 0.2 inches (1.0 to 5.0 mm), depending on location along the route and horizontal distance from the trench. In some isolated locations, deposition is predicted to be in the range of up to 0.4 inches (10 mm), with a few locations up to 0.8 inches (20 mm) along the 115 kV offshore transmission cable system and between 1.0 to 1.8 inches (35 to 45 mm) peak along isolated locations of each 33 kV inner-array cable routes. These higher deposition areas are predicted to occur when the tidal currents are in slack water conditions, which allow the deposition to be concentrated in small areas since current velocities do not disperse the sediment material. Relatively narrow bands between 0.02 and 0.04 inches (0.5 and 1 mm) thick are deposited on the fringes of the patterns. The model predicts the following peak deposition thicknesses in isolated locations along the four representative 33 kV inner-array cable routes modeled.

- **Southwest of the ESP:** 1.4 inches (35 mm)
- **Southeast of the ESP:** 1.0 inches (25 mm)
- **East of the ESP:** 1.1 inches (27 mm)
- **Northwest of the ESP:** 1.8 inches (45 mm)

Any effects from construction/decommissioning on sediment transport would be temporary and localized, and therefore overall, construction/decommissioning impacts on sediment transport in Nantucket Sound would be minor.

### Water Depth/Bathymetry

Changes in seabed elevation around each WTG would be limited to localized scour around each WTG. The maximum estimated scour distance from a WTG is approximately 94 ft (28.7 m) (4.6 percent of the minimum distance between WTGs), with an associated estimated scour depth of approximately 14.7 ft (4.5 m). For the ESP, the predicted extent of scour was estimated to be 55 ft (16.8 m) with a predicted depth of 9.2 ft (2.8 m) for each of the six piles supporting the ESP. A slight depression, estimated to be between 0.5 and 2 ft (0.15 and 0.61 m) deep, is anticipated to result from installation of the inner-array cables and the offshore transmission cable system. This slight depression is expected to fill in over time through natural sediment resuspension, deposition, and consolidation. Although there is the potential for scour around each WTG and the ESP piles, the applicant has proposed scour mitigation measures and monitoring as described below, that would prevent substantial scour from occurring.

The recovery rate for jetting scars along the offshore cable routes on Horseshoe Shoal was estimated at between 0.2 and 38 days. It also determined that the presence of the jetting scar would not increase localized scour. In fact, it was estimated that the presence of the jetting scar would result in slightly decreased water flow over the scar, resulting in a decreased potential for sediment transport. These results are comparable to those for the two electric cables that have been installed by jet plowing between Cape Cod and Nantucket Island.

At the landfall in Lewis Bay, construction of the temporary cofferdam at the exit hole of the HDD to be used for cable installation under the Cape Cod Shoreline would include the dredging of sediments to a elevation of approximately -10 ft (-3 m) MLLW. After jet plow embedment of the offshore cable systems are completed, the dredged area would be restored with the original dredge material. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours. Once the dredged area is restored, the sheet pile cofferdam would be removed from Lewis Bay.

The impacts to water depth/bathymetry from construction/decommissioning activities would be minor as the trenches created by the jet plow are anticipated to fill naturally over a short period of time, while suspended sediments from the jet plow are predicted to be a short-term localized event. At the landfall site the temporary cofferdam would mitigate any impacts to the surrounding area.

During decommissioning, the foundation components (transition piece, monopile and scour mats, and rock armor) would be removed. Sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (5 m) below the existing seabottom in order to allow access for the cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. Prior to the cutting and removal of the monopile, any adjacent scour protection (scour mats and rock armor) would be removed. After the removal of the monopile to a barge, the sediments would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. The offshore cables would be disconnected and pulled out of the J-tubes on both the WTG and the ESP. Decommissioning of the submarine cables is not anticipated to require any cutting of the cables below the seafloor. The cables would then be reeled in after being water jetted free of bottom sediments, creating a shallow linear depression that would only last a short while. This would result in a negligible impact.

**Conclusion on Construction/Decommissioning Impacts**

Overall, construction/decommissioning impacts on oceanographic processes would vary from negligible to minor, as they would result in only temporary and localized effects.

### 5.3.1.3.2 Operational Impact

**Currents**

The calculation of the Keulagan-Carpenter (KC) number based on the wave data found no value greater than 1.8, which is below the threshold for flow separation to occur. A potential flow analysis appropriate for this condition shows that the flow around the pile returns to within 89 percent of its undisturbed value within one pile diameter from the pile and to within 99 percent of its undisturbed value within four pile diameters.

Comparison to laboratory studies of multiple piles indicates that there is no anticipated wake interaction among the piles since interaction ceases when the piles are spaced greater than five pile diameters from each other and the spacing for this proposed action ranges from 120 to 190 pile diameters. Using a single pile zone of influence of five pile diameters long (if not significantly shorter [87 ft; 27 m]) and two diameters wide (35 ft; 11 m) or 3,014 square ft (280 $m^2$), the total area for all 130 piles is 9 acres (36,421$m^2$). This area can be compared to the total area of the WTG pile array on Horseshoe Shoal of

15,800 acres (64 $km^2$) showing that only 0.057 percent of the area is potentially affected. In reality, only a very small portion of this area is really affected since all these impacts decrease quickly away from the pile. The large spacing between the WTGs and the small WTG pile diameter would prevent the effects of each WTG pile on current conditions from affecting adjacent piles. Therefore, the WTGs would not act as a pile group. Operational impacts on currents would be minor.

**Waves**

Due to the proposed spacing of the WTGs of 0.39 miles (0.63 km) from northwest to southeast, and 0.63 miles (1 km) from east to west, the proposed action would not be expected to have significant large-scale impacts on wave conditions. At the smaller scale, a pile's influence on wave propagation in the immediate vicinity of each WTG would depend on the ratio between the diameter of the pile and the wavelength of the incident wave. Piles with diameters less than one-tenth of the incident wavelength do not have an impact on waves, since the waves pass the pile without reflection or diffraction. Piles with diameters greater than one-tenth of the incident wavelength do have an impact on incident waves in that the waves are reflected by the pile and diffracted around the pile. So, as wavelength increases, the effect the pile has on wave propagation decreases (USACE, 2003).

The proposed diameter of monopiles that would be used for WTGs is either 16.75 or 18 ft (5.1 or 5.5 m), depending on the water depth at the WTG location. Each of these pile diameters is greater than one-tenth of the average locally-generated ocean wavelengths. Thus, only small-scale reflection and diffraction of locally-generated and ocean waves would be expected to occur in the immediate vicinity of each WTG location.

A study on effects of the WTG pile array in Nantucket Sound determined that diffraction effects were found to occur for 62 percent of the waves from the time series. However, the longest diffraction occurred for waves with the smallest period with low induced bottom velocities. These waves cause insignificant sediment transport regardless of whether they diffract or not and so can be ignored. Larger waves, particularly ocean swells, are not affected by the presence of the piles.

Based on the WTG pile diameter and wave characteristics in the area, the piles are essentially invisible to the waves. Therefore, the presence of the WTGs would not affect wave conditions in the area and therefore operation impacts on waves would be negligible.

**Salinity**

The proposed action is anticipated to have no impacts to salinity in Nantucket Sound because there would be no intake or discharge of seawater associated with the operation of the proposed action, no new sources of freshwater due to the proposed action, nor any other mechanism by which salinity would be altered. Therefore, operational impacts on salinity in Nantucket Sound would be negligible.

**Temperature**

The offshore cable systems would generate a limited amount of heat immediately around the cables; however, the proposed action is anticipated to have no measurable impacts to water temperature in Nantucket Sound because the cables would be buried a minimum of 6 ft (1.8 m) below present bottom. This absorption of the generated heat into the sediments is essential for proper operation of the cables, and the temperature change at the sediment surface would be no greater than 0.19ºF while the increase in water temperature immediately above the cables would be approximately 0.000006ºF. There would be negligible operational impacts on water temperature within Nantucket Sound during operation.

### Sediment Transport

Localized effects to sediment transport patterns may occur immediately around each WTG foundation base. However, it is expected that a localized sediment transport equilibrium condition would be reached shortly after construction of the proposed action given the cyclical nature of both the tidal regime and scour. Laboratory studies have shown that interaction among piles ceases when piles are spaced greater than five pile diameters from each other. The WTG array on the proposed site has spacing from 120 to 190 pile diameters. Although local sediment transport and scour would occur around individual piles, no cumulative or interactive effects of the pile array on currents or waves would occur and therefore no effects on large scale sediment transport would occur. The greatest diffraction (bending) of waves occurred for the smallest period waves which cause insignificant bottom velocities and cannot affect sediment transport.

Sand waves on Horseshoe Shoal have amplitudes of up to 12 ft (3.7 m) and wavelengths of up to 200 ft (60 m) (Report No. 4.1.1-3). More than 26 miles (42 km) of the total proposed 33 kV inner-array cable route occurs in areas of active sand wave migration on Horseshoe Shoal. Assuming bedform migration rates of 3.3 to 9.8 ft/year (1 to 3 m/yr) and cable burial depths of 6 ft (1.8 m), it is possible that cable exposure could occur within 6 to 18 years after the burial if no mitigation measures are employed. Mitigation measures for offshore cable burial are described in Section 9.0.

There would be minor impacts on sediment transport due to operation of the proposed action, however, all impacts would be localized.

### Water Depth/Bathymetry

A June 2005 underwater inspection was performed to visually inspect the scour mats around the southwest batter pile to allow comparison with the conditions at the other two unprotected SMDS piles. Results are discussed in Section 4.1.3.1.6. The divers performing the inspection observed that approximately 12 inches (0.3 m) of sand had accumulated over a 20 month period as a result of the presence of the scour mats. At the southeast pile, the divers' measurements revealed that approximately 13 inches (0.33 m) of sand has been scoured away from this pile over a 20 month period. Similar measurements were not obtained from the north pile. Based on these observations, the presence of the scour mats resulted in the accumulation of sand around an installed pile and therefore appears to be effective at preventing scour around installed piles as long as the scour mats remain intact and in place.

In keeping with the purpose of gathering additional data pertinent to the proposed action, four additional SSCS scour mats were installed around the southeast pile in May 2006 to test the efficacy of modifications to the web materials, manufacturing processes, and various frond lengths (Report No. 4.1.1-8). Measurements were again taken (similar to monitoring in June 2005, described above). The measurements indicate a net accretion of 12 inches (0.3 m) at the southwest pile, and a net scour of 7 inches (0.18 m) at the previously unprotected southeast pile, indicating that the existing mats are helping to prevent scour.

Based on the predicted scour conditions, three scenarios were developed to evaluate rock armor for scour protection around the WTGs, which are discussed in Section 4.1.3.1.6. The scenarios were developed based on the findings from the *Revised Scour Report* (Report No. 4.1.1-5), ranges of water depth, and the diameter of the WTG.

- **Scenario 1A** was developed to evaluate rock armor around the 16.75 ft (5.1 m) diameter of the WTGs located in water depths between 12 and 15 ft (3.7 and 4.6 m). Under Scenario 1A, rock armor would extend to a distance from the WTG pile of 94 ft (28.7 m) at the longest and 42 ft (12.8 m) at the narrowest parts of the ellipse. The rock armor stones would have a median weight of 125 lbs and the armor layer would be 4 ft (1.2 m) thick.

- **Scenario 1B** was developed to evaluate the rock armor around the 16.75 ft (5.1 m) diameter WTGs located in water depths between 16 and 39 ft (4.9 and 11.9 m). Under Scenario 1B, rock armor would extend a distance from the WTG pile of 94 ft (28.7 m) at the longest and 42 ft (12.8 m) at the narrowest parts of the ellipse. The rock armor stones would have a median weight of 50 lbs and the armor layer would be 3 ft (0.9 m) thick. The Scenario 1B conceptual design was also used for evaluating the rock armor requirements for the ESP.
- **Scenario 2** was developed to evaluate the rock armor around the 18 ft (5.5 m) diameter WTGs located in water depths between 39 and 56 ft (11.9 and 17.1 m). Under Scenario 2, rock armor would extend a distance from the WTG pile of 88 ft (26.8 m) at the longest and 45 ft (13.7 m) at the narrowest parts of the ellipse. The rock armor stones would have a median weight of 50 lbs (22.7 kg) and the armor layer would be 3 ft (0.9 m) thick.

Under all the scenarios, the remaining predicted scour depth beneath the rock armor would be filled with a filter material to minimize the potential for the larger armor stone material to settle into the sediment below.

The rock armor and filter material would be placed so that the final elevations approximate pre-installation bottom contours to the extent practicable such that mounds of material would not be created. The estimated impact to the seabed from the presence of the rock armor for each WTG was multiplied by the number of WTGs in each scenario. The total estimated impact to the seabed from the rock armor for all the 130 WTGs and the ESP is approximately 47.8 acres (0.2 $km^2$). Operational impacts on water depth/bathymetry would be minor as final elevations associated with scour protection would approximate pre-installation bottom contours.

**Conclusion on Operational Impacts**

Overall, operational impacts on oceanographic processes would vary from negligible to minor and would result in only temporary and localized effects.

### *5.3.1.4 Impacts on Climate and Meteorology*

#### 5.3.1.4.1 Construction/Decommissioning Impacts

The post lease geological and geophysical sampling activities (see Section 2.0) would have negligible impacts on the climate and meteorology, while the construction and decommissioning of the proposed action would have minor impacts on climate and meteorology. Greenhouse Gas (GHG) (e.g., $CO_2$) emissions would result from use of geological and geophysical sampling (e.g., drilling) and construction equipment and the vessels used to transport the equipment. Decommissioning work would also involve the use of fossil fuel-fired equipment, as well as vessels to transport the equipment; and thus, the emissions of GHGs. The post lease geological and geophysical sampling activities and construction emissions would be temporary (approximately two years for construction and less for decommissioning) prior to the operation of the proposed action, while the decommissioning activities would also be temporary (approximately two years) after the shutdown of the proposed action.

**Conclusion on Construction Impacts**

Based on the limited amount of $CO_2$ emissions that would result from the G&G investigations and construction and decommissioning work, climate and metrological impacts would be minor.

#### 5.3.1.4.2 Operational Impacts

The turning of the WTG rotors, which react to the wind rather than create or modify it, would not affect the wind speed and/or wind direction in the waters of Nantucket Sound. The WTGs operate due to the force of the passing wind on the blades. After passing through the area of the proposed action there is some additional turbulence in the wind stream as a result of the wind's passage through the WTGs. At a distance of several rotor diameters beyond the proposed action, site winds return to laminar flow similar to that prior to encountering the site of the proposed action. Conditions such as the formation or dissipation of fog would not be affected by the WTGs operation because fog is formed during specific psychrometric (atmospheric temperature and moisture) conditions.

As discussed in Section 4.1.4.5, nearby onshore seasonal average mixing heights (4,662 ft [1,421 m]) are substantially above the top of the rotor swept zone (440 ft [134 m]). It is unlikely that the WTGs would entrain air above the mixing height to the layer below the mixing height.

During the operation of the proposed action, the only anticipated emissions of GHGs would be from the vessels used to transport the maintenance workers and any equipment necessary for possible offshore cable repair activities (see Section 2.4). These emissions would be during the life of the proposed action and the vessels and equipment would undergo regular maintenance, which would assist in minimizing the amount of GHG emissions.

**Benefit Analysis for Climate**

Operation of the proposed action would result in the potential to provide benefits in terms of lowering emissions of greenhouse gases and ozone precursors attributed to power production in the New England area. Emissions of $CO_2$ from fossil fuel combustion in New England have increased by 10 percent over the period between 1990 and 2004 (based on data from http://www.epa.gov/climatechange/emissions/state_energyco2inv.html). The total $CO_2$ emissions from fossil fuel combustion in 2004 were 190.8 million tons. Electric power generation contributed 24 percent to the total. The largest contributor was transportation with 40 percent of the total. The annual rate of $CO_2$ emissions from fossil fuel combustion in Massachusetts have increased by 4 percent over the period between 1990 and 2004.

The total generating capacity in the New England power system in the year 2004 was 30,940 MW (ISO New England, 2005). Of this total, southeastern Massachusetts has a capacity of 3,362 MW, or about 10 percent of the total New England capacity. The ISO New England Inc. (ISO-NE) predicts that the net energy need for New England will increase from 134,085 gigawatt hours (GWh) in 2005 to 152,505 GWh in 2014, a rate of about 1.4 percent per year. The peak summer and winter loads are expected to increase at a rate of 1.5 percent per year (ISO-NE, 2005). The annual growth rate in summer and winter peak loads for southeastern Massachusetts is projected to be 1.7 and 1.5 percent, respectively.

The proposed action would generate 1,600 GWh of power annually. The ISO-NE has calculated marginal emission rates for $CO_2$ (ISO-NE, 2004). The marginal emission rates provide an estimate of the additional emissions that would result from increased power consumption during periods of higher energy demands. For $CO_2$ the annual average marginal emission rate is 1,102 lb/MWh. Thus if the amount of energy produced by the proposed action would have to be produced by fossil-fuel powered plants instead, it would result in about 0.88 million tons of $CO_2$ emitted per year. The projected increase in energy needs in New England between 2005 and 2014 would result in an increase of about 84 tons per year of $CO_2$ if the power were to be produced by fossil-fuel power plants. The potential reduction in the growth of $CO_2$ emissions due to operation of proposed action would be about 1 percent of the total projected increase. Thus the proposed action would have the potential to very slightly reduce the growth in $CO_2$ emissions in the New England area.

**Conclusion on Operational Impacts**

The operation of the wind turbines would have negligible impacts on climate and meteorology; however, the maintenance activities associated with the proposed action, and any potential cable repair activities, would have a minor impact due to GHG emissions from the vessels transporting the maintenance workers and equipment necessary for cable repairs. Operation of the proposed action would potentially have some beneficial effects in terms of greenhouse gas emissions from power production in the region as discussed above because it would somewhat reduce the reliance on the use of fossil fuels. These benefits would outweigh the very small emissions resulting from operation of the proposed action, so the net impacts would be positive.

### *5.3.1.5 Impacts on Air Quality*

**Introduction**

This section discusses applicable regulatory requirements and potential air quality impacts associated with the proposed action. It describes the proposed action compliance with the CAA during post lease geological and geophysical sampling activities, construction/decommissioning and operation. The information contained in this section was obtained from review of existing data available for the area of the proposed action.

**Regulatory Analysis**

The 40 CFR Part 55 – OCS Air Regulations, was promulgated by USEPA in 1992 in order to apply Section 328(a)(1) of the CAA to OCS sources of air pollution located outside of the Western Gulf of Mexico. At the time of promulgation, the regulations were intended to apply to oil and gas development, production, and extraction facilities. The regulations did not contemplate projects involving alternative energy resources or non-extractive sources of energy. However, some activities associated with the proposed action are considered an OCS source, as defined in the regulations. Thus these activities are subject to the same requirements as those applicable to the nearest onshore area, the “Corresponding Onshore Area,” and USEPA Region One would conduct a consistency review and incorporate the relevant state rules (as described at 40 CFR Parts 55.12, 55.14, and 55.15).

The EPAct amended the OCS Lands Act of 1953 (OCSLA) (43 U.S.C. 1331 et seq.) to grant authority to the DOI to manage alternative energy projects on the OCS. As a result of the EPAct, the proposed action’s construction activities became subject to Section 328 of the CAA (42 U.S.C. 7627) relating to air emissions from OCS sources for activities regulated or approved under the OCSLA.

Section 328 (a)(4)(c) of the CAA defines an OCS source to include any equipment, activity, or facility: (1) which emits, or has the potential to emit, any air pollutant, (2) is regulated or authorized under the OCSLA, and (3) is located on the OCS or in or on waters above the OCS. This definition also includes emissions from any vessel servicing or associated with an OCS source, including emissions while at the OCS source or en route to or from the OCS source within 25 miles of the OCS source. The proposed action has three distinct time periods during which OCS sources and the vessels servicing them would emit, or have the potential to emit, air pollutants: preconstruction G&G data gathering stage, the two-year construction period and the decommissioning period.

USEPA considers vessels to be exempt from the definition of an OCS source unless they are attached to the ocean bottom or are en route to a structure or facility defined as an OCS source. The OCS sources for the proposed action would be the vibracore boat and diesel powered boring equipment, the jack-up barges and the diesel powered cranes or hydraulic rams on those jack-up barges that are directly attached to the ocean bottom using jack-up legs or spud piles and the support vessels servicing these OCS sources while en route to or from the OCS source within 25 miles of the OCS source. Figure 5.3.1-3 shows the 25 mile area around the proposed action. The following equipment and activities are subject to permitting by USEPA as OCS sources:

1. During the post lease geological and geophysical sampling, gathering stage, the equipment associated with the seafloor boring program (vibracore boat and diesel powered boring equipment) would be considered to be OCS sources.

2. During the two-year construction period, OCS sources include the following activities: pile installation, installation of scour protection, offshore cable laying, installation of the ESP, and installation of the WTGs. OCS sources include the following vessels: crane barges (if attached to the ocean bottom), and attendant barges (if attached to the ocean bottom). Finally, OCS sources include the following equipment: hydraulic rams and diesel powered cranes.

3. During the 20-year operational period, a diesel-powered crane would be in place on the ESP. The ESP would therefore be an OCS source.

4. During decommissioning, the removal of the WTGs, piles and scour protection would require the use of jack-up barges that would be attached to the ocean bottom, diesel powered cranes to handle the piles, diesel powered dredgers for the removal of rock armoring, and diesel powered hydrologic dredgers to remove material from inside the monopile prior to cutting of monopile under the surface of the sea floor, and then to replace the dredged material back into the hole. These barges and cranes and dredging equipment would be considered OCS sources.

5. During construction and during decommissioning, emissions from crew boats, tugs and support vessels en route to or from these OCS sources identified in items 1 through 3 would also be regulated by the USEPA permit when they are within 25 miles (40 km) of the respective OCS source. During the operational phase, crew boats, supply vessels, and maintenance vessels servicing the ESP would be regulated under the EPA permit. It us also assumed that vessels servicing the WTGs also would be included in the EPA permit.

Emissions during post lease geological and geophysical sampling activities, construction, operations, and decommissioning in the waters and on land designated as non-attainment areas regulated by Massachusetts and Rhode Island would also be reviewed to determine whether they meet the requirements set forth in the USEPA's General Conformity Regulations as codified in Section 176(c) of the CAA. This section prohibits Federally funded entities from taking actions in nonattainment or maintenance areas which do not conform to the SIP for the attainment and maintenance of the NAAQS. The purpose of conformity is to:

(1) ensure Federal activities do not interfere with the budgets in the SIPs;

(2) ensure actions do not cause or contribute to new violations; and

(3) ensure attainment and maintenance of the NAAQS.

The regulations provide that conformity determinations are required when the total of applicable direct and indirect emissions exceed specified *de minimis* levels. Both Massachusetts and Rhode Island are located in an ozone transport region and were designated "moderate non-attainment" for 8-hour ozone on June 15, 2004 by the USEPA. According to 40 CFR 93.153, the applicable *de minimis* level for triggering a Conformity Review in a moderate non-attainment area inside an ozone transport region is 100 tons per year for $NO_x$ and 50 tons per year of VOC. Based on preliminary emission estimates, a General Conformity analysis was determined to be required in Massachusetts and Rhode Island. Working with Cape Wind, MMS has undertaken a conformity analysis, which is summarized below, with the full analysis presented in Appendix I.

#### 5.3.1.5.1 Construction/Decommissioning Impacts

Air quality impacts due to post lease geological and geophysical sampling activities, including a marine shallow hazards survey and a supplemental geotechnical program (see Section 2.7.1), would occur offshore and would be conducted prior to construction. Construction air quality impacts would result from offshore and onshore (onshore) activities. The offshore activities are anticipated to take approximately two years to be completed and the onshore activities are anticipated to take one year to complete. Offshore activities would consist of pile installation, scour protection installation, offshore cable laying, turbine installation, and ESP installation. Table 5.3.1-7 shows the potential emissions by major activity: preconstruction, construction, operations, and decommissioning, and Table 5.3.1-8 shows the potential emissions by location. Potential emissions of CO, $SO_2$, $PM_{10}/PM_{2.5}$, $NO_x$, VOC, $CO_2$, and HAPs range from a minimum of 7.6, 2.5, 0.6, 19.6, 0.8, 919.0, and 0.0 lb/hr, respectively, during preconstruction activities to a maximum of 214.8, 130.2, 29.4, 984.7, 30.5, 46,905, and 0.4 lb/hr, respectively, during decommissioning activities. Most of the potential emissions will occur within OCS areas and will be regulated by the EPA. The applicant has submitted an NOI to EPA for authorization for the above referenced emissions. EPA will review the NOI and determine whether air modeling is required, and coordinate the establishment of an appropriate air quality modeling protocol as necessary.

Onshore construction activities would rely on substantially less powered equipment than that involved with the offshore construction phase. The onshore work can be broken down into three general categories: HDD, duct bank construction, cable pulling and termination. The HDD at the landfall would take between two and four weeks with emissions resulting primarily from the diesel powered drilling rig. The duct bank would be excavated, constructed and backfilled using a diesel powered bulldozer and excavator. Diesel trucks would deliver duct bank materials to the onshore work site. It is expected that the duct bank would take five months to complete. Once the duct bank is constructed, the onshore cable would be pulled to its connection with the Barnstable Switching Station, again using diesel powered equipment. Cable pulling, splicing and termination would also take approximately five months to complete. Emissions of fugitive dust from onshore cable construction would occur from time to time depending on the area of exposed soils, the moisture content of those soils and the magnitude and direction of ground level winds. Fugitive dust emissions would be minimized by limiting the amount of exposed soils at a given work area and by spraying water for dust control when weather conditions warrant it.

Decommissioning activities are anticipated to take approximately two years and include the removal of the piles, the scour protection, and the underwater cable and the decommissioning of the turbine, ESP, and meteorological tower. Table 5.3.1-8 shows that approximately 39 percent of the decommissioning emissions will potentially occur in waters regulated by Rhode Island, approximately 39 percent will occur in OCS areas regulated by the EPA, approximately 15 percent will occur in waters regulated by Massachusetts, and an additional approximately 7 percent will occur in OCS waters but are not emission sources regulated by a permit.

The activities associated with post lease geological and geophysical sampling, construction and decommissioning of the proposed action would result in air emissions over Nantucket Sound due to the use of fossil fuel fired mobile sources (e.g., ships, cranes and other powered construction equipment). The proposed action would need to comply with all Federal and State general conformity requirements during these activities. Furthermore, the proposed action would be required to apply all mitigation measures imposed by any Federal or State regulations and permit conditions to minimize the air quality impact of these activities.

A determination of the potential air quality impacts due to the proposed construction activities was conducted to ensure compliance with the applicable State and Federal air quality standards during these activities (Report No. 5.3.1-3). The air quality dispersion modeling analysis used the Mineral Management Service's (MMS's) Offshore and Coastal Dispersion (OCD) model version 5 (Chang and Hahn, 1997). A complete description of the model formulation is given by DiCristofaro and Hanna (1989). The model provided estimates of the air quality impacts from constructing 130 wind turbine generators (WTGs) and the electrical service platform (ESP), installing the 33 kV cables connecting the WTGs to the ESP, installing the 115 kV cable connecting the ESP to land, and vessels while at the construction site and while travelling within 25 miles of the project. It was conservatively assumed that all of the WTG and ESP construction, cable installation, and vessel travel occurred simultaneously for the short-term averaging periods (i.e., 1-hour, 3-hour, 8-hour, and 24-hour). For individual pieces of equipment, emissions were scaled according to the number of hours of use per day. For the annual averaging period, all construction activities were assumed to be completed in one year even though construction of the proposed action is expected to take two years. Thus, the annual emissions were conservatively based on the total potential emissions due to construction activities.

To locate the maximum air quality impacts due to the construction activities, a polar receptor grid was used that was centered at the ESP. Receptors were placed along radials every 10 degrees from 10 degrees through 360 degrees (north). The receptors were spaced every 100 meters starting from just outside the perimeter of the wind park area out to 9 kilometers from the center of the grid, every 200 meters from 9 kilometers to 10 kilometers, every 500 meters from 10 kilometers to 15 kilometers, and every 1 kilometer from 15 kilometers to 46.3 kilometers (25 nautical miles).

The OCD model requires five concurrent meteorological datasets to determine the potential air quality impacts due to a source. These five datasets are: over-water hourly meteorological data, over-land hourly surface meteorological data, over-water mixing height data, over-land mixing height data, and sea surface temperature data. The modeling analysis used data from March 2004 through February 2005 from the following locations:

1. Over-water hourly meteorological data: Cape Wind on-site meteorological tower;
2. Over-land hourly surface meteorological data: Nantucket Airport, Massachusetts;
3. Over-water mixing height data: Default value of 500 meters;
4. Over-land mixing height data: Chatham, Massachusetts; and
5. Sea surface temperature data: Buoy No. 44018 (SE Cape Cod) located 30 nautical miles east of Nantucket.

State and Federal air quality standards require that the modeled air quality impacts be summed with the existing representative background air quality concentrations to estimate the total air quality impact due to the proposed source. Thus, the modeled air quality impacts due to the construction activities were summed with the representative background concentrations. The highest annual average concentrations of $NO_2$, $SO_2$, and $PM_{2.5}$ occurred over Nantucket Sound just outside the boundary of the wind farm project area. The highest 24-hour average concentrations of $SO_2$, $PM_{10}$, and $PM_{2.5}$ and the highest 3-hour average concentration of $SO_2$ occurred along the 115 kV cable installation route just offshore Hyannis Port, MA. The highest 8-hour and 1-hour average CO concentrations also occurred in this same area.

Results of the air quality dispersion modeling analysis indicate that construction activities related to the proposed action will comply with all State and Federal air quality standards. Table 5.3.1-9 presents the results of the modeling analysis. Provided in Table 5.3.1-9 are the modeled air quality impacts due to the proposed construction activities, the representative background concentrations, the total air quality impacts (i.e., sum of modeled and background concentrations), and the State and Federal air quality standards. As shown in Table 5.3.1-9, all of the total air quality impacts are below their respective air quality standards even with the conservative assumptions made in the analysis.

Potential emissions due to the decommissioning activities are lower than the potential emissions due to the construction activities. Thus, the potential air quality impacts due to the decommissioning activities would be lower than estimated for the construction activities; and therefore, demonstrate compliance with all of the State and Federal air quality standards.

**Visibility Impacts**

Reduced visibility in the local area and the Class I areas (e.g., Arcadia, Presidential Range-Dry River, Lye Brook, and Great Gulf) in the region is a concern for the public and regulatory agencies. In the *Particle Pollution Report, Current Understanding of Air Quality and Emissions through 2003* (USEPA, 2004), the USEPA states "In the East, reduced visibility is mainly attributable to sulfates, organic carbon, and nitrates. Poor summertime visibility is primarily the result of high sulfate concentrations, combined with high humidity. Sulfates, which dominate the composition of these visibility-impairing particles, have been found to contribute even more to light extinction than they do to fine particle concentrations." The post lease geological and geophysical sampling, construction and decommissioning activities would have emissions of $SO_x$ and $NO_x$, which directly contribute to the formation of sulfates and nitrates in the atmosphere, and PM, of which a percentage would be organic carbon. Therefore, these activities have the potential to impact the local and long range (i.e., Class I areas) visibility.

The local and long range (> 31 miles [50 km]) visibility impacts due to the post lease geological and geophysical sampling, construction and decommissioning activities and the mobile sources used during these activities would be temporary. Thus, the "pollutant loading" in a certain area due to these activities would be minimized. However, diesel exhaust plumes may be visible from vantage points somewhere around the area of the proposed action for an extended period of time. Overall impacts on visibility would be negligible.

**Emissions Impacts**

The activities associated with post lease geological and geophysical sampling, construction and decommissioning of the offshore and onshore cables would result in air emissions due to the use of fossil fuel fired mobile sources (e.g., trucks, ships, cranes and other powered construction equipment). In addition, the construction of the onshore cable would generate fugitive particulate emissions resulting from land alteration activities (e.g., clearing, excavation, backfilling and grading, etc.). Other construction activities, such as welding, cleaning and degreasing, painting, etc. may also result in air emissions.

Regulated by the State and Federal agencies depending on the location of the emissions, the offshore emissions would be required to comply with all regulations and mitigation requirements enforced by these agencies. As a result of complying with these various regulations, the potential emissions due to the offshore post lease geological and geophysical sampling, construction and decommissioning activities should be minimized to the extent possible. The onshore construction and decommissioning activities would be regulated by the local and State agencies and the proposed action would be required to comply with all permit limits and mitigation measures imposed on these activities. In summary, emission impacts would be minor.

**Public Health Impacts**

The proposed action would result in temporary and low levels of fossil fuel emissions associated with equipment used in the offshore post lease geological and geophysical sampling, construction and decommissioning activities for the proposed action. These emissions would comply with the appropriate air regulations to ensure the health and safety of the onshore area. Onshore construction and decommissioning activities would be regulated by the local and State agencies, which would also ensure that the emissions are sufficiently controlled to protect the public health. In summary, public health impacts would be negligible.

**Conclusion**

Overall the post lease geological and geophysical sampling, construction and decommissioning air quality impacts are expected to be negligible to minor as these impacts would be for the most part temporary in nature and localized. The proposed action would be subject to various regulations, which may require mitigation measures to reduce the emissions from the post lease geological and geophysical sampling, construction and decommissioning activities. The proposed action would be required to comply with all of the local, State, and Federal regulations. Mitigation being considered at this time includes the use of water sprays on exposed soils when weather conditions are likely to raise dust. A more detailed discussion of mitigation is provided in Section 9.0.

#### 5.3.1.5.2 Operational Impacts

The actual wind turbines in the site of the proposed action would not have any emissions when in operation. However, maintenance work for each turbine has been anticipated to be 5 days per year. Two of these days would be scheduled maintenance work and three days are estimated for emergency maintenance work. Emergency maintenance work would be such work as cable repair activities in the event that a cable is damaged. Emergency cable repair is not expected to require anywhere near the same frequency as the three day per turbine estimate for emergency repairs. The scheduled maintenance work would be planned for the summer months when weather conditions are more favorable. Emissions from the vessels used to transport the work crews and emissions from any welding, cleaning and degreasing, painting, etc. may also result during these maintenance work periods.

The maintenance work emissions that are anticipated would be minor and could be emitted anywhere within the 25 square miles (64.7 $km^2$) proposed action site depending on the turbines being serviced. The vessels used to transport the work crews would be subject to regular maintenance to enhance fuel economy and to minimize their emissions. Furthermore, the vessels would be required to apply all mitigation measures imposed by any Federal or State regulations and permit conditions to minimize the air quality impact of these activities. Finally, it should be noted that the proposed action would result in a new clean source of electricity thus reducing a considerable quantity of local emissions that would occur if a fossil fuel facility were constructed instead of the proposed action (Refer to Section 3.3.6.4, the No-Action Alternative, for a cost benefit analysis that evaluates the likely environmental consequences that would occur if the proposed action were not constructed).

Except for routine maintenance activities and the vessels used to transport the maintenance workers, the proposed action would have no emissions during operations. Potential emissions associated with the maintenance activities are lower than the potential emissions due to the construction activities, for which an air quality dispersion modeling analysis was performed and demonstrated compliance with all of the

State and Federal air quality standards. Thus, the potential air quality impacts due to the maintenance activities would be lower than estimated for the construction activities; and therefore, demonstrate compliance with all of the State and Federal air quality standards.

**Visibility Impacts**

Emissions from the maintenance activities would contribute to visibility degradation. However, because the maintenance activities are dispersed throughout a 25 square miles (64.7 $km^2$) area, it is unlikely that the maintenance activities would significantly contribute to visibility degradation. Moreover, regular maintenance of the vessels and compliance with all of the operating requirements imposed on the vessels by the Federal and State agencies should minimize the amount of PM and other visibility degrading pollutants emitted by the vessels during maintenance activities. Overall, visibility impacts would negligible.

**Emissions Impacts**

Maintenance activities during normal operations of the proposed action would occur within the offshore proposed action. Vessels used to transport the maintenance workers would have emissions from the port of departure to the offshore proposed action and within the site of the proposed action. Maintenance activities and vessel emissions would be regulated by Federal and State agencies and would be required to comply with all of the permit conditions imposed by these agencies. The permit conditions would ensure that the emissions from the maintenance activities and vessels would be minimized to ensure local air quality impacts are minor.

**Public Health Impacts**

The proposed action operation would not generate fossil fuel emissions. However, maintenance of the facility would result in temporary and low levels of fossil fuel emissions ($SO_x$ and $NO_x$) associated with maintenance vessels. These emissions would comply with the appropriate air regulations to ensure the health and safety of the onshore area. Onshore construction and decommissioning activities would be regulated by the local and State agencies, which would also ensure that the emissions are sufficiently controlled to protect the public health. Overall, public health impacts would be negligible.

**Benefit Analysis for Air Quality**

Operation of the proposed action would have the potential to provide benefits in terms of lowering emissions ozone precursors attributed to power production in the New England area. The total generating capacity in the New England power system in the year 2004 was 30,940 MW (ISO New England, 2005). Of this total, southeastern Massachusetts has a capacity of 3,362 MW, or about 10 percent of the total New England capacity. The ISO-NE predicts that the net energy need for New England will increase from 134,085 GWh in 2005 to 152,505 GWh in 2014, a rate of about 1.4 percent per year. The peak summer and winter loads are expected to increase at a rate of 1.5 percent per year (ISO-NE, 2005). The annual growth rate in summer and winter peak loads for southeastern Massachusetts is projected to be 1.7 and 1.5 percent, respectively.

The proposed action would generate 1,600 GWh of power annually. The ISO-NE has calculated marginal emission rates for nitrogen oxides ($NO_x$) and sulfur dioxide ($SO_2$) (ISO-NE, 2004). The marginal emission rates provide an estimate of the additional emissions that would result from increased power consumption during periods of higher energy demands. Massachusetts and Rhode Island are classified moderate non-attainment area for ozone. The proposed action has the potential of reducing emissions of $NO_x$, which is an ozone precursor. The proposed action could slightly reduce the need for added capacity for fossil-fuel generating plants in the New England area. In addition, during periods of peak demands associated with spells of hot weather in the summertime, the proposed action could supply power that would otherwise have to be produced by fossil-fuel plants that generate $NO_x$ and other air pollutants. Warm spells are usually associated with high ozone levels and thus air quality impacts would be mitigated somewhat. The marginal emission rate for $NO_x$ for on-peak hours in the ozone season (May through September) is 0.48 lb/MWh. If we assume that the proposed action output would be 182.6 MW, typical of an average day, the potential amount of $NO_x$ reductions would be about 1 ton/day. In the year 2002 inventory for Massachusetts, the total $NO_x$ emissions for all sources on a summer day is 771.8 tons/day. The amount of potential reduction would thus be very slight.

**Conclusion**

The proposed action would have no emissions during operations except for maintenance activities and the vessels used to transport the maintenance workers. Maintenance activities could occur anywhere within the 25 square miles (65 $km^2$) proposed action. Therefore, it is anticipated that the operational impacts from the proposed action would be minor as the vessels used during the maintenance activities would be required to comply with all of the Federal and State permit requirements to minimize the potential emissions impact. The proposed action would have the potential of providing some beneficial effects in terms of air quality and climate change in the region as discussed above because it would reduce somewhat the reliance on fossil fuels for power production. These benefits would outweigh the very small emissions resulting from operation of the proposed action, so the net impacts could be positive.

### *5.3.1.6 Water Quality*

**Introduction**

Projects involving a discharge of dredged or fill material to a waterbody or wetland require a permit from the USACE under Section 404 of the CWA (33 U.S.C. 1344); and a 401 WQC from MassDEP under the Federal CWA (33 USC 1341; Massachusetts CWA; MGL Chapter 21§§26-53; and 314 CMR 4.00 and 9.00). The Federal CWA allows States the authority to review projects that must obtain a Federal license or permit and that result in a discharge to state waters. Please refer to Section 5.1.1 for discussion on vessel withdrawal and discharge as well as discussion of grey and black water, trash and debris, etc.

This proposed action would be subject to both Section 401 and Section 404 due to the volume of sediment to be dredged for the HDD offshore exit point and for the discharge of dredged or fill material back to Lewis Bay to backfill the cofferdam location. Section 401 and 404 jurisdiction extends to the 3.5 miles (5.6 km) State territorial limit. The only proposed action activity proposed within this 3.5 miles (5.5 km) limit is installation of a portion of the electric transmission cable interconnection between the ESP and the Barnstable Switching Station. A recent determination by MADEP defines jet plowing as dredging, thus requiring a 401 Water Quality Certification for embedding of the two (2) submarine cable circuits from landfall to the 3.5 miles (5.5 km) limit. In the nearshore area at the proposed offshore transmission cable system landfall, the cable system is proposed to be placed in a conduit to be installed using HDD installation techniques. As discussed in detail below, HDD would require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the U.S. and replaced upon completion of the offshore transmission cable system installation.

Dredging of the offshore exit point pit, placement of a temporary cofferdam, installation of the conduit by HDD, cable installation via hydraulic jet plow, and construction of the WTGs and ESP are subject to the jurisdiction of Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403) since these represent activities involving the placement of structures in Waters of the U.S. Installation of the offshore cable systems within the 3.5 mile (5.6 km) limit would also require permits under the Massachusetts WPA and local wetland bylaws. Each of these programs involves consideration of water quality issues.

The WTGs and the ESP do not require the use of water for any part of their operations. Neither the WTGs nor the ESP require the use of water to complete scheduled maintenance activities on the proposed action's equipment. Temporary living accommodations would also be provided on the ESP. These would only be intended for use during emergency periods when crews cannot be removed due to weather or sea state issues. These accommodations would utilize waste storage holding tanks for domestic waste that would be pumped to the service vessel for proper disposal. All equipment would be contained within an enclosed weather-protected service area. Runoff of rainwater from the WTGs and ESP would also not affect water quality. All oil and grease bearing components would be covered and contained such that storm water would not come into contact with oil and grease during periods of rainfall.

#### 5.3.1.6.1 Construction/Decommissioning Impacts

**Suspended Sediments/Dredge**

The offshore cables would be installed using hydraulic jet plow equipment, and disturbance associated with submarine foundation structures would be minimized through use of a monopile system (see Section 2.3). Potential marine water quality impacts would be limited to temporary and localized sediment disturbance along the offshore cable corridors and at monopile locations from construction vessel anchoring, anchor line sweep, and installation of the scour protection, foundation and cables. The temporary disturbance would typically last for a few hours after operations have ceased at the specific locations. Chemical analysis results indicate that constituents of concern were present in sediment samples from Lewis Bay and Nantucket Sound and were determined to be at concentrations below the levels that would cause either chronic or long-term biological impacts and should pose little or no risk to water quality or aquatic life.

**Lewis Bay**

The transition of the interconnecting 115 kV offshore transmission cable system from water to land would be accomplished through the use of HDD methodology in order to minimize disturbance within the intertidal zone and near shore area. The HDD borehole length between the entry point, which would be on New Hampshire Avenue near its intersection with Shore Road, and the exit point pit in Lewis Bay would be approximately 200 ft (61 m). Four 18 inch (45.7 cm) High Density Polyethylene (HDPE) conduit pipes (one for each of the three-conductors in the 115 kV offshore transmission cables) would be installed via HDD between the vaults and the pit. To further facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes located within Lewis Bay approximately 90 ft (27.4 m) seaward of the landfall location. The cofferdam would be approximately 65 ft (19.8 m) wide and 45 ft (13.7 m) long and would be open at the seaward end to allow for manipulation of the HDD conduits. The area enclosed by the cofferdam would be approximately 2,925 $ft^2$ (0.067 acre or 271.7 $m^2$) and would involve the removal of approximately 840 $yd^3$ (642 $m^3$) of material. The cofferdam would be backfilled after completion of the cable installation.

The dredged material would be removed using mechanical dredging equipment (i.e., clam-shell bucket). The dredged material would be temporarily placed on a barge for storage. The dredged area of the cofferdam would be backfilled with the dredged material. If necessary, the dredged material backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours. No removal of sediment outside of the cofferdam would be required.

To minimize the release of the bentonite drilling fluid into Lewis Bay during HDD, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. It is possible that some minor residual volume of bentonite slurry may be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater "silt fence." This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

In Lewis Bay, elevated suspended sediment concentration levels would remain considerably longer, as a result of weak tidal currents. Suspended sediment concentrations of 10 mg/L are generally predicted to remain for less than 24 hours after the jet plow has passed a given point along the route (Report No. 4.1.1-2). However, near the Yarmouth landfall concentrations of 10 mg/L are predicted to remain for up to 2 days after the jet plow passes as a result of very weak currents and fine bottom sediments. In places along and immediately adjacent to the offshore transmission cable system route (near the Yarmouth Landfall and south of Egg Island), suspended sediment concentrations are predicted to remain at 100 mg/L for approximately 5 hours (Report No. 4.1.1-2).

In the area of the eelgrass bed south of Egg Island, suspended sediment concentrations are predicted to be in the range of 50 to 500 mg/L, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/L are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route. At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/L are predicted to remain for up to 6 hours. The eastern portion of the bed may experience maximum concentration levels of less than 50 mg/L (Report No. 4.1.1-2).

**Horseshoe Shoal**

The installation of WTG foundations, inner-array and the offshore transmission cable system routes would physically displace sediment at specific locations through sediment suspension, transport, and deposition. In sandy sediments, such as those in the area of the proposed action, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation. A small depression may remain over the cables after installation, depending on localized sediment depositional processes. As with other projects involving submarine cable embedment in the seabed using jet plow technology, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (Connecticut Light & Power Company, 2002; Bohlen, pers. comm., 2002). The Connecticut Light & Power Company (2002) study contains information based on project-specific sediment types, jet plow information from a selected vendor, and modeling for the Long Island Replacement Cable Project (Norwalk, CT to Northport, NY). Bohlen (pers.comm., 2002) provided support to information on submarine cable embedment with information on project-specific sediment types, jet plow information from a selected vendor, modeling, and verification through direct observation and preliminary field data results during jet plow embedment in the New Haven, CT portion of the Cross Sound Cable Project in Long Island Sound (New Haven, CT to Brookhaven, NY).

The scour mats are placed on the seabed by a crane or davit onboard the support vessel. Final positioning is performed with the assistance of divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. Sediment suspended during the installation of the mats is expected to be minimal and expected to result from mat placement on the bottom and actions of the divers. The mats are removed by divers and a support vessel in a similar manner to installation, and are expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats. However, the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments.

The rock armor and filter layer material would be placed on the seabed using clamshell bucket or a chute. By lowering the material into the water and placing the material on the bottom rather than dumping it, more control over the placement of the material can be achieved. Sediment suspended during the installation of the rock armor material is expected to be more than that associated with the use of scour mats. However, the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments. In those locations where rock armoring has been used for scour protection, it would remain in place following the proposed action's decommissioning.

The SSFATE model also predicts that, in sandy sediments, suspended sediment concentrations from the jet plow are estimated to occur in a limited area in close proximity to the cable trench and exist for short durations of minutes to less than one hour at any fixed location (Report No. 4.1.1-2). In addition, the amount of suspended sediment injected into the water column from jet plow embedment is estimated to be approximately 0.36 $yd^3$ (0.28 $m^3$) for every linear foot of cable installed.

It is important to note that the suspended sediment concentration levels are short lived due to the tides flushing the plume away from the jetting equipment and the sediments rapidly settling out of the water column. Within Nantucket Sound, suspended sediment concentrations away from the offshore cable route of 10 mg/L are predicted to largely remain for approximately three hours after the jet plow has passed a given point along the route. In places along and immediately adjacent to the cable route, suspended sediment concentrations are predicted to remain at 100 mg/L for approximately two to three hours.

For the four representative inner-array cable routes modeled (Report No. 4.1.1-2), suspended sediment concentrations away from the cable route of 10 mg/L are predicted to largely remain between less than three and 12 hours, with one area being up to 18 hours, after the jet plow has passed a given point along the route. In places along and immediately adjacent to the cable route, suspended sediment concentrations are predicted to remain at 100 mg/L for approximately two to six hours, where as the active bed load sediment transport known to exist in Nantucket Sound is approximately 45 to 71 mg/L. (Report No. 4.1.1-2). The longer time durations associated with construction related turbidity occur in areas where the inner-array cable alignments run in an east-west direction, which is in the same direction as tidal currents in the area (see Table 5.3.1-10).

The volume and extent of sediment disturbance as well as the biological impacts associated with the jet plow are less than those associated with both one tidal cycle and one commercial trawling event. In addition, it is important to note that use of the jet plow is an isolated event whereas commercial trawling takes place routinely over large areas during the fishing season and two tidal cycles generally occur each and every day. The near bottom suspended sediment concentrations associated with the jet plow are within the range of natural variability resulting from tidal currents, waves, storms, trawling, and vessel propulsion, and as a result are lower compared to concentration associated with other natural and man-made occurrences in Nantucket Sound (Cape Wind, 2003). Potential impacts to surface water resources would be minimized to the greatest extent practicable through the use of appropriate cable installation techniques, and by limiting the area of seabed disturbance. Therefore, minor short-term and negligible long-term impacts are anticipated.

In addition to the water quality impacts discussed, the post lease G&G field investigations (Refer to Section 2.7) would require drilling and vibracore activities to assess geological conditions on the sea floor. Impacts associated with this would include temporary and localized turbidity, which would have a minor impact on water quality.

**Inland Waters**

Once the offshore transmission cable system makes landfall, the transmission cable system would be transitioned to the onshore transmission cable system in two below-grade transition vaults. The transition vaults would be located at the land boreholes with the dimensions of approximately 7 ft (2.1 m) wide by 34 ft (10.4 m) long by 7.6 ft (2.3 m) high (see Figure 2.3.7-1). The transmission cable system transition vault would be installed within the pavement using conventional excavation equipment (e.g., backhoe). This work would result in no impacts to wetland resource areas. Work may be required within the 100 ft (30.5 m) Buffer Zone of six wetlands in Yarmouth. No work is proposed in inland jurisdictional areas or 100 ft Buffer Zones in Barnstable.

The transition zone between freshwater and saltwater in the permeable layers of the Cape Cod aquifer is determined by the hydraulic pressure of freshwater outward and the movement of seawater landward (Olcott, 1995). Typically, saltwater incursion is caused by drought or over withdrawal of fresh water from the aquifer, which lowers the water table and decreases the seaward movement of freshwater. Since the flow of fresh groundwater within the Cape Cod aquifer occurs from outwash deposits underlying Cape Cod seaward towards Nantucket Sound (Olcott, 1995), offshore construction would not affect the freshwater aquifer.

The proposed upland transmission cable would not result in changes to surface or groundwater hydrology. As such, the proposed action is not expected to result in any impacts to the aquifer from the upland cable installation. Portions of the proposed cable route would be located near public water supply wells and within Zone I and II wellhead protection areas. Based on conversations with MassDEP staff regarding the proposed installation of subsurface utilities along the proposed cable route (MassDEP, 2002b; MassDEP, 2003), MassDEP would typically prefer that the utilities were installed outside of the Zone I areas. However, the MassDEP staff stated that they would allow the installation of utilities along existing roadways as long as alternative routes have been evaluated and the areas affected were minimized to the extent practicable. It is also important to note that the cable installation within Zone I areas would be installed using conventional open trench excavation and installation techniques, and that the transmission cables would not contain any fluids, petroleum, oils, or lubricants. The trenchless technology proposed for the Route 6 area would not be located within a Zone I area. The MassDEP Drinking Water Program staff indicated that the MassDEP would allow the installation of the proposed transmission cables within the Zone I area (MassDEP, 2002b; MassDEP, 2003).

The proposed action would not result in the addition of impervious surface areas, nor would it change the infiltration of surface water. The MassDEP regulations (310 CMR 22.21(2)(a) and (b)) outline the restrictions for the siting of various land uses within the delineated Zone II area. None of these restrictions would affect the proposed action along the proposed route. Based on these findings, it does not appear that the MassDEP Zone I and Zone II regulations would affect the proposed action along the proposed route. Regional standards for portions of the proposed action under the jurisdiction of the Cape Cod Commission do limit the quantities of hazardous materials and hazardous wastes within Zone I and II areas. Although the transmission cables would not contain lubricants, fluids, petroleum or oils, other materials, such as fuel for vehicles and construction equipment could contaminate groundwater in the case of an accidental spill. The applicant will prepare and implement a SPCC plan to detail procedures to minimize and mitigate any spills of hazardous materials.

One known culvert is located along the proposed route on Higgins Crowell Road at Wetland 2. During final design, it would be determined whether the ductbanks and transmission cable systems would pass above or beneath these culverts. No impacts to the culverts or adjacent waterways or wetlands are proposed.

The proposed action would not alter any freshwater wetlands or regulated culverts that would trigger Section 401 review. However, the proposed action would result in minor impacts to paved Riverfront Area and Buffer Zones, as regulated under the Massachusetts WPA and would, therefore, require an approval from the town Conservation Commission via an Order of Conditions. Work within Riverfront Area and the 100 ft (30.5 m) Buffer Zone is limited to temporary construction on paved roadway surfaces for the installation of the proposed transmission cable system route.

Proposed work in Yarmouth would result in temporary alteration of locally-regulated Lake and Pond Recharge Areas. In addition, the Yarmouth Wetlands Protection Regulations establish a 35 ft (10.7 m) Vegetated Buffer, 50 ft (15.2 m) No-Structure Zone, and 100 ft (30.5 m) Buffer Zone to certain resource areas, including any Bank or Vegetated Wetland. Direct impacts to these resource areas would be avoided by installing the transmission cable system beneath existing paved roadways and onshore portions of the NSTAR Electric ROW.

**Conclusion**

Overall, the construction and decommissioning impacts on water quality are expected to be minor, as disturbance to marine sediments would be only temporary and localized. Mitigation measures considered at this time include silt fences and other erosion control. A more detailed discussion of mitigation is provided in Section 9.0.

### 5.3.1.6.2 Operational Impacts

Operation of the proposed action and cable system is not anticipated to impact wetland resource areas.

There was some concern regarding frond deterioration from the scour mats and its impact on water quality. The fronds are stitched to the webbing material in a manner that prevents them from dislodging. Degradation could result from exposure to ultraviolet radiation; however, this is not possible in this situation because the fronds are installed on the sea-bottom where direct exposure to sunlight for extended periods of time does not occur. Frond degradation, as a result of excessive heat, is not possible because temperatures in excess of 100ºF are required for such thermal degradation to take place. As previously stated, year-long temperature readings at the SMDS did not record temperatures over 72ºF. During a June 2005 observation, no fronds were missing from the webbing material. During a May 2006 investigation of the fronds, they were observed to have separated longitudinally into many fronds of smaller widths; however, the fronds appeared to have remained firmly attached to the webbing material. Therefore, there is a very low probability that fronds would dislodge and impacts to water quality would be minor.

**Risk Characterization for Oil or Fuel and WTG Fluid Spills**

The only components of the proposed action that would come into regular contact with seawater and would be subject to potential interactions between water, encrusting organisms, and sediment are the welded steel monopile foundations. The transition piece of the WTGs, which would be located on top of the monopile at the water line/splash zone, would be coated with a product equal or similar to Interzone® 954 (the Materials Safety Data sheet for Interzone® 954 is provided in Appendix E). The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower (above the transition piece), would be coated with an epoxy-polyamide. In addition, cathodic protection using sacrificial anodes made of pure aluminum would be employed on the piles. The limited area of contact between the coated transition piece and seawater, and the protective anodes on the monopile, would minimize the potential for undesirable interactions between water, encrusting organisms, and sediment. The selected coating is not anticipated to degrade substantially or leach materials into the water column over the life of the proposed action. Interzone® 954 is approved for use within the United States by the EPA. Interzone® 954 is used nationally and internationally on various marine structures (e.g., hulls, bridges, oil rigs, mooring and wharf piles, pontoons, etc.) and has been approved for use in ecologically sensitive marine environments (e.g., Interzone® 954 was used on mooring piles within Cairns Harbor, part of the Great Barrier Reef World Heritage Site in Australia**)**. Therefore, no measurable change in these interactions is expected after proposed action installation.

The WTGs would contain lesser amounts of the following materials in the nacelle or hub: bearing lubrication (Mobil SCH 632), gear lubrication & cooling (Optimal Synthetic A320), break and hydraulic fluid (Mobil DTE 25), transmission fluid (ATF 66), gear lubrication and heat dissipation (water/glycol). Total storage of these materials at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibility of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system. During WTG operation small leaks could occur as a result of broken gear oil hoses/pipes, and/or broken coolant hoses/pipes. Gear oil leaks would be contained within the hub and main bed frame and/or tower as described above. Coolant leaks could occur on a number of locations within the nacelle fiberglass covers.

Analyses were performed to estimate the trajectories of oil spills and calculate probable estimates of area coverage and minimum travel time. The study used two models: HYDROMAP to calculate currents, and OILMAP to calculate oil spill trajectories and resulting oiled areas and travel times.

The OILMAP model was used to simulate spill trajectories and determine probabilities of areas being oiled and oil travel times for an instantaneous release of 40,000 gallons (151,416 liters) of electrical insulating oil at the ESP site in Nantucket Sound. This scenario (instantaneous release of entire tank contents) is highly unlikely and therefore conservative (Report No. 4.1.3-1).

The model results indicate that oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 to 30 percent). The likelihood of a spill impacting Nantucket is consistently small (less than 10 percent), while the chance of a spill impacting a shoreline somewhere within Nantucket Sound and the immediate surrounding areas is greater than 90 percent. Typically, the central and western areas of the Cape Cod coast and the east and northeast coasts of Martha's Vineyard are most vulnerable to a spill. The shortest time to reach shore for each of the scenarios ranges from 4.8 to 11.3 hours.

Some calculations were made that showed at 10 hours the percent evaporated ranged from less than one percent to slightly over 2 percent for the range of winds (5 to 20 knots [2.6 to 10.3 m/s]) typically seen in Nantucket Sound. After 24 hours, approximately three to six percent of oil had evaporated. In light wind conditions (less than 10 knots) greater than 90 percent of the oil remained on the surface. Less than 50 percent of oil remained on the water surface after 24 hours when winds exceeded 10 knots (5.1 m/s).

In addition to the oil spill trajectory modeling, an analysis has been performed of the probability that an oil spill might occur at the site of the proposed action (Report No. 3.3.5-1 and Report No. 5.2.1-1). The analysis involved the determination of the probability of the theoretical occurrence of an instantaneous release of 40,000 gallons (151,416 liters) of electric insulating oil and 2,000 gallons (7,571 liters) of diesel and other oils from the ESP[22] and up to 200 gallons (757 liters) of turbine and other lubricating oils from each of the 130 WTGs (for a total worst case of 68,000 gallons (257,408 liters) of oil). The analysis involved two major components: (1) determining the probability that any spill might occur from the ESP and WTGs; and (2) analyzing the range of spill sizes (and associated probabilities) that might be expected if a spill was to occur from the ESP and WTGs. The analysis involved a four-step process:

(1) Evaluate and describe the events that might cause damage to the ESP and/or WTGs;

(2) Estimate or qualitatively analyze the probability of each of these events occurring;

(3) Estimate or qualitatively analyze the probability that for each of these events that damage occurs to the ESP and/or WTGs; and

(4) Estimate or qualitatively analyze the probability for each of these events to cause damage sufficient to cause an oil spill from the ESP and/or WTGs.

The analysis shows that the highest possibility of an oil spill occurring in the area in and around Nantucket Sound is related to vessels transiting the area, regardless of the presence of the proposed action structures and related work vessels. Over the course of 30 years, transiting vessels alone may result in 21 spills in and around Nantucket Sound. These spills are unrelated to the presence of the facility and would occur whether or not the facility was in place. The presence of the facility may very slightly increase the risk of spills from vessels colliding with one of the proposed action structures. When the presence of the proposed action components are combined with transiting vessels, the possibility for a spill over the 30-year period increases slightly to 22.443 spills. The oil spill probability analysis shows that only 7 percent of all spills expected in Nantucket Sound during a 30 year period could be attributed to the addition of the proposed action facility. It is possible that 2 spills attributable to the proposed action itself could occur during the same 30 year period. Of these spills, there is a 90 percent chance that they would involve 50 gallons (189 liters) or less, and a 1 percent chance they would involve volumes of 10,000 gallons (37,854 liters). The probability of a spill in the same 30 year period involving the entire 68,000 gallons (207,408 liters) of oil contained within the 130 WTGs and the ESP is less than one in a million (Report No. 3.3.5-1).

**Conclusion**

Based on the temporary and localized impacts to water quality, and the very small probability of a major oil spill, the proposed action's operational impacts on water quality are expected to be negligible.

#### *5.3.1.7 Electric and Magnetic Fields (EMF)*

This section assesses impacts of the proposed action on EMFs. The information contained in this section was obtained from review of existing data available for the area of the proposed action, EMF monitoring and modeling, and review of the scientific literature on EMF.

Research has been conducted for over 20 years in the United States and around the world to examine whether the use of electricity and the associated exposure to electric and magnetic fields poses a health risk. In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID) in the EPAct (PL 102-486). The National Institute of

[22] The applicant formerly had proposed use of emergency diesel generators on the ESP, which involved the storage of up to 2000 gallons of diesel and other oils. The emergency generators have since been replaced by battery backup. While Report No. 5.2.1-1 includes the diesel fuel in the spill trajectory and risk analyses, the EIS does not include an analysis of the environmental impacts of a diesel fuel spill from the ESP.

Environmental Health Sciences (NIEHS), National Institute of Health (NIH) and the DOE were designated to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to EMF (NIEHS, 1999).

Over the course of this program, the DOE and NIEHS managed more than 100 cellular and animal studies, exposure assessment, and engineering studies. No additional epidemiology studies were conducted; however, analysis of studies already conducted was an important part of the assessments (EMF-RAPID Program Report, 2002). In 1998, the NIEHS completed the review of a comprehensive body of scientific research on the potential health effect of EMF. The NIEHS organized several technical symposia meetings and a Working Group meeting to review EMF research. The Working Group was made up of scientists representing a wide range of disciplines including engineering, epidemiology, cellular biology, medicine, toxicology, statistics and pathology to review and evaluate the RAPID program research and other research. The results of the Working Group's evaluation were published in the report *Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields* (August 1998).

In June 1999 the NIEHS submitted the report, *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, to Congress. In part, the report concluded the following:

> The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults…. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although some sporadic findings of biological effects have been reported. No indication of increased leukemia in animals has been observed.... Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiological findings.

NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. However, virtually all of the population in the United States uses electricity, and therefore, is routinely exposed to power frequency EMF. As a result passive regulatory action is warranted, such as a continued emphasis on educating both the public and the regulatory community on way in which to reduce exposure. NIEHS also suggested that the power industry continue the current practice of siting power lines to reduce exposure and encourage technologies that lower exposures from neighborhood distribution lines provided they do not increase other risks such as those from fire or accidental electrocution. The NIEHS does not believe that other cancers or non-cancer outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS, 1999, 9-10).

### Human Health Effects Associated with EMF

The likelihood for power line EMF to cause adverse health impacts in humans has been reviewed by many and various scientific groups. Hazard is identified by a standard process that considers data from epidemiologic, laboratory, and biophysical studies. Several epidemiologic studies have reported a small degree of association between measures of EMF and several diseases, e.g., childhood leukemia. Other studies have failed to find an association. A causal basis for the EMF associations is not supported by laboratory and biophysical evidence, and the actual basis remains unexplained. Nonetheless, in 2002, the International Agency for Research on Cancer (IARC) (IARC, 2002) designated EMF as a class 2B carcinogen ("possibly carcinogenic"), based on "consistent statistical associations of high-level residential magnetic fields with a doubling of the risk of childhood leukemia." Also, in 2002, the California Department of Health Services (CADHS, 2002) issued a report concluding that: "EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage."

Despite considerable research directed toward the topic, the direct health risks result from exposure to EMF has not been established. The epidemiologic association reported between EMF and some diseases have been the subject of continued statistical analysis (Greenland et al., 2000; Ahlbom et al., 2000; Wartenberg, 2001). When Greenland et al. (2000) pooled their epidemiology studies of childhood leukemia, they found evidence of increased risk at low magnetic flux densities, but not at the upper-end of the magnetic fields range used in the study, to which a small proportion of United States residents are exposed. The authors estimated a relative risk of 1.7 (95 percent confidence interval [CI], 1.2 to 2.3) for exposures above 3 mG, and a population attributable fraction of three percent (95 percent CI, –2 percent to +8 percent) for exposures above 0.5 mG. Another pooled analysis by Ahlbom et al. (2000) produced similar results for a 4 mG cutpoint. The possibility that the EMF associations are due to bias or confounders, however, has not been ruled out (Hatch et al., 2000; Ahlbom et al., 2001; Savitz, 2003).

Extensive investigations of animals exposed at much higher levels of EMF (up to 50,000 mG) have not demonstrated adverse health effects (Mandeville et al., 1997; McCormick et al., 1998 and 1999; Boorman et al., 1999 and 2000). The elevated levels of EMF exposure in occupational settings likewise do not show a consistent pattern of increased risk (Kelsh and Sahl, 1997; Kheifets et al., 1999; Sahl et al., 2002). Laboratory studies of cells and tissues do not support the hypothesis that EMF exposure at ambient levels is a significant risk factor for human disease (NIEHS, 1999). The failure to observe biological effects from EMF exposure may be due to the fact that, mechanistically, effects of EMF on biology are very weak (Valberg et al., 1997). Cells and organs function properly in spite of many sources of intrinsic chemical "noise" (e.g., stochastic, temperature, concentration, mechanical, and electrical noise), which exceed the effects caused by EMF by a large factor (Valberg et al., 1997).

If power line EMF initiates or modulates physiological dysfunction or onset of disease in humans or animals, then a mechanism by which EMF alters molecules, chemical reactions, cell membranes, or biological structures in a functionally significant manner should exist. Mechanistic models begin with the recognition that EMF is a physical, not chemical, agent as illustrated in the following causal chain:

EMF ⟶ Physics ⟶ Chemistry ⟶ Biology ⟶ Disease or Behavior

A necessary condition for EMF impact on human or ecosystem biology is that the EMF-induced changes must exceed chemical changes from natural or background influences. Changes in biology are coupled to EMF through changes in forces on charged structures, which in turn, must be coupled to metabolically important chemical processes (reaction or transport rates). The size and direction of the electric field predicts the size and direction of force on electric charges. Likewise, the magnetic field predicts force on moving charges. Thus, any EMF bioeffects must solely and ultimately be the result of forces. There are no other actions of EMF. The possibility of a biological effect depends on whether EMF forces can significantly modify biological processes having electrically responsive elements (for example, ions, charged proteins, neural electric currents, magnetic molecules (free radicals), and magnetic particles).

The EMF impacts can be evaluated by asking how the forces and energies conveyed by EMF compare to forces and energies endogenous to biological systems. Energies and forces exerted by typical 60 Hz EMF are well below those present in biological systems. That is, normal living cells operate under conditions of energy and force "noise" such that 60 Hz EMF effects would be lost in this background. Aside from specialized sensory systems, fundamental force and energy considerations preclude disruption of biology by weak EMF. Mechanisms by which EMF might alter biologic function are found to be small compared to the endogenous energies and forces characteristic of the living system (Valberg et al., 1997). Table 5.3.1-11 shows that in terms of energy or force on the whole-body scale or on the molecular scale, the effect of "large" EMF is many orders of magnitude below the typical forces and energies that accompany life processes. For example, the energy of a 60 Hz EMF photon is vastly less than that of ionizing radiation, and EMF is too weak to alter molecular structures. The level of the electric field *per se* could be increased to levels where it accelerates individual free electrons to electron-volt energies, exceeding those needed to break a chemical bond (as for example, in corona discharge). However, electric-field levels required for this type of molecular damage is far greater than what any organism would be exposed to with power line EMF. Likewise the force required to distort the shape of complex biological molecules, for example DNA or enzymes, is far larger than what the electric component of EMF can provide. The magnetic component of EMF can potentially rotate magnetic particles (which would act like compass needles) or single-molecule magnetic moments (e.g., free radicals) as described in the following section.

The failure to observe laboratory effects from EMF exposure (NIEHS, 1999) is likely due to the fact that typical power line EMF does not affect biology in a manner detectable above the many sources of noise in biological systems, and this inability to detect EMF effects in bioassay systems suggests that EMF itself does not play a causal role in the epidemiologic associations. In summary, a large number of blue-ribbon panels and public health review groups have examined the issue of the public's exposure to power line EMF. The overall conclusion of these groups is that available data do not establish a cause-and-effect relationship between exposure to typical environmental levels of EMF and elevated risk of disease.

**Ecological Health and Exposure Effects Associated with EMF**

Both terrestrial (e.g., birds and honeybees) and marine animals (e.g., finfish, eels, sharks, and sea turtles) likely use the earth's DC magnetic field for orientation, navigation and migration (Kirschvink, 1997; Kirschvink et al., 2001; Lohmann and Johnsen, 2000; Phillips et al., 2001; Ritz et al., 2000; Wiltschko et al., 2002). The mechanism underlying this magnetic sense is primarily limited to slowly-varying fields, and is not expected to respond to rapidly-varying (e.g., 60 Hz) AC fields. Aside from orientation and navigation, other potential effects of low-frequency electric and magnetic fields on ecological systems have been investigated, but the findings on ecological effects have been equivocal (NRC, 1997; Levin and Ernst 1997; Pagnac et al., 1998), and there is no consistent evidence to establish an adverse-effect level. In fact, the RAPID research program mentioned above was carried out on laboratory animals, and the lack of consistent findings for EMF effects in those species also supports this conclusion.

Weak electric fields can be detected by certain fish (rays, sharks) for use in orientation and prey location. For example, sharks are capable of responding to extremely weak, slowly-changing electric fields in sea water. The shark's electric sense organ (*ampullae* of Lorenzini) is complex, containing a large number (~10,000) of receptor cells, in which small interactions are integrated to generate a change which stands out against noise (Adair, 2001; Adair et al., 1998).

Data on the Nysted Offshore Wind Farm (Nysted) Project have documented some effects from offshore cable routes on fish behavior indicating avoidance of the cable as well as attraction, depending on species. However, the observed phenomena were not significantly correlated with the assumed strength of the EMF (Danish Energy Authority, 2006).

The specifications of the proposed cable systems require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the offshore cables. Magnetic fields on the other hand cannot be easily shielded because the magnetic field lines do not stop on objects they form continuous loops around conductors carrying currents.

The physics of power line EMF interactions with matter are universal, and the constituents of non-human living organisms share many similarities with human cells and tissues. Hence, the following parallels can be drawn between the potential for EMF health effects in humans and the potential for ecological effects in non-human species:

- Due to similar electrical properties (conductivity, permittivity, polarizability) of human and animal tissues, similar electrical interactions can be expected. Some differences may arise due to geometrical and size factors.
- Due to the universal structure and properties of cell membranes, the threshold field strengths for biophysical (thermal and non-thermal) effects on cell membranes can be expected to be high both for human and non-human species.
- Animals and species with special sense organs (i.e., endogenous magnetic particles, ampullae of Lorenzini) may require special consideration of possible EMF effects on behavior.

With regard to potential impacts of the EMF from submarine cables on living organisms, the following summary supports an absence of impacts (ICNIRP, 2000; NAS, 1993; VNTSC, 1994):

- Power line EMF has not been reported to disrupt land-based, freshwater, or marine organism behavior, orientation, or migration.
- Special sense organs, such as a "compass-needle" type of receptor for steady magnetic fields, are known to exist for some animals (Kirschvink et al., 2001) [23], but such a receptor would not be affected by power line, 60 Hz magnetic fields, which alternate in direction, and average to zero over 1/60$^{th}$ of a second (Adair, 1994; Valberg et al., 1997). [24]
- The actual magnitude of typical 60 Hz magnetic fields in the vicinity of the submarine cables is, in most locations, many fold below that of the steady geomagnetic field (~ 500 mG).

[23] In the abstract of his 2001 article, Dr. Kirschvink states that: "All magnetic field sensitivity in living organisms, including elasmobranch fishes, is the result of a highly evolved, finely-tuned sensory system based on single-domain, ferromagnetic crystals."

[24] As illustrated in Table A, the potential effects of EMF on any organism can be evaluated in the context of fundamental physics and chemistry. Such an analyses power line EMF mechanisms has been reported in a series of articles by Dr. Robert Adair, professor of physics at Yale University. Dr. Adair showed that the effective biological EMF "signal" (relative to biological "noise") is not of sufficient strength to alter biological processes. Dr. Adair considered a wide variety of possible interactions of EMF with biological systems, and he concluded that typical EMF field strengths are "much smaller than the smallest fields that have been known to affect chemistry."

- The very low energy content of 60 Hz EMF means that the amount of thermal energy absorbed by nearby sea creatures is extremely small.
- The volume of ocean or on-land habitat with any measurable EMF levels is a tiny fraction of overall available habitat.

In summary, the primary consideration is for organisms that may have magnetic sense organs. The current opinion as to how animals use the earth's magnetic field for magnetic orientation is that such sensing is due to a "compass needle" mechanism. Although magnetite particles are plausible geomagnetic field sensors (Adair, 1994; Kirschvink et al., 1992 and 2001), functional biogenic ferromagnetic material has been established only in a limited number of organisms (for example, magnetotactic bacteria) (Blakemore, 1982). The "compass needle" mechanism would not be expected to respond to power line magnetic fields which rapidly change in size and direction, and have a time-average magnitude of zero. Even for an optimized hypothetical biological sensor, the minimum 60 Hz magnetic flux density detectable by microscopic particles in marine organisms would have to exceed 50 mG (Adair, 1994; Polk, 1994). However, no one has demonstrated an effect on animal orientation by AC fields. Moreover, any expected levels above the 60 Hz magnetic field occurs only directly over the 115 kV offshore transmission cable system on the sea floor and in the immediate vicinity of the ESP within 10 ft of five convergent heavily loaded inner-array (33 kV) cables. In all other locations, the 60 Hz magnetic fields are below this value.

Based on the body of scientific literature examined there are no anticipated adverse impacts to the marine environment from the 60 Hz magnetic fields associated with the operation of the proposed action.

### 5.3.1.7.1 Construction/Decommissioning Impacts

No significant electric or magnetic fields are anticipated during construction other than possible small fields associated very close to construction equipment. As a result electric and magnetic fields impacts from construction/decommissioning are expected to be negligible.

### 5.3.1.7.2 Operational Impacts

**Electric and Magnetic Fields at Landfall Area**

***Electric Fields***

Calculated existing electric field levels in and adjacent to the streets along the onshore route range between 0.01 and 0.09 kV/m. Because the electric field of the proposed underground 115 kV cables would be effectively contained within the body of each cable by its grounded metallic shield, the addition of the transmission cable system would not change these electric field levels.

***Magnetic Fields***

At the transition vault located at the end of New Hampshire Avenue, the HDD conduits would converge to a more compact configuration in order to facilitate the transition from offshore transmission cable to duct type cable. The calculated peak magnetic flux density at an elevation of 3.3 ft (1 m) above grade at the vault is 11.3 mG for the 168 MW output and 30.8 mG for the 464 MW output.

The calculated peak magnetic flux densities produced by the proposed underground 115 kV cable in the streets is 7 mG at an annual average output of 168 MW, and 20 mG at maximum output of 454 MW. The field level falls off fairly rapidly with distance from the center of the duct bank.

The net magnetic flux density produced by the combination of the existing overhead and new underground cable system is a complex function of the relative geometry and loading of the overhead and underground circuits. The net magnetic flux density depends on the following:

- The relative position of the lines with respect to each other (i.e., whether the overhead and underground lines are on the same or opposite sides of the street);
- The phasing of the overhead conductors, which may vary along the route; and
- The north-south location along the route, since the loading on the overhead lines generally decreases along the line as it travels south toward the landfall location due to lessening loads.

Mathematical models were run for several representative laterals across the street at different points along the route. The resultant peak field strength, with the overhead lines at peak load, ranged between 8 and 36 mG with the proposed action at average output, and between 19 and 36 mG with the proposed action at maximum 454 MW output.

With the proposed action generating at either 168 MW or 454 MW, the magnitude and profile of the resultant magnetic fields on either side of the road are unchanged from a distance of approximately 20 to 30 ft (6.1 to 9.1 m) from the edge of pavement and beyond. Therefore, the magnetic flux densities experienced by residential or other properties along this section of the route would be the same as experienced with the existing overhead distribution lines. Likewise, the resultant magnetic fields on the side of the road closest to the Marguerite E. Small School are unchanged from those experienced under current peak loading on the existing overhead distribution lines as shown in Report No. 4.1.7-1.

### Electric and Magnetic Fields at NSTAR Electric ROW

#### *Electric Fields*

The electric field would be effectively contained within the body of each new underground 115 kV cable by its grounded metallic shield and therefore, no external electric field would be produced. As a result, upon completion of the new underground transmission cable system the electric fields within the ROW are anticipated to be approximately the same as the existing condition, which is due to the presence of the overhead 115 kV lines.

#### *Magnetic Fields*

To connect to the Barnstable Switching Station, 115 kV underground transmission cable system would be installed in the NSTAR Electric ROW. Calculations were performed to determine the net magnetic field due to this duct bank and the overhead 115 kV lines (with load flows as predicted by NSTAR Electric). At an average proposed action output of 168 MW, this resulted in 127 mG directly under the lines, a localized peak of 23 mG directly over the duct bank, 56 mG at the north edge of the ROW, and 12 mG at the south edge of the ROW. At the maximum proposed action output of 454 MW, these values become, respectively, 127 mG, 49 mG, 56 mG, and 12 mG, which are a small change from the 168 MW case. These results indicate that the predominant fields within the ROW are those generated by the existing overhead lines, whose loading under this interconnection option is not changed by the addition of the proposed action. The predicted impact of adding the underground transmission cable system is a negligible change from existing conditions within the ROW and no change in field strength at the ROW edges would occur.

Report No. 4.1.7-1 provides additional detail regarding the measurement of existing magnetic fields and calculations to predict future expected field levels for the onshore portion of the proposed action and for the 115 kV offshore transmission cable system.

**Electric and Magnetic Fields in Marine Environment**

No existing sources of power frequency fields are present in the offshore area of the proposed action. Projections were developed using the "ENVIRO" computer program to determine the magnetic flux density expected from both the 33 kV inner-array cables and the 115 kV offshore transmission cable system. Calculations were performed with the proposed action generating at a maximum delivered output of 454 MW and at the annual average output of 168 MW. Anticipated magnetic flux density was determined for the area directly above the cables (buried 6 ft [1.8 m] below the surface) at the sea floor and at varying water depths above the sea floor. In the horizontal plane, magnetic flux density was calculated approximately 20 ft (6.1 m) on either side of the offshore, at which point the magnetic flux densities had significantly decreased due to distance.

The magnetic flux density associated with the 33 kV inner-array cables is proportional to its electrical current and would, therefore, vary widely depending on the location of the cable segment in relation to the turbine string, and on the power output of the turbines. To account for this variation, calculations were performed for the most lightly loaded cable segment, which would be located at the end of a string and carry the output of only one WTG, and for a "homerun" cable segment, located between the closest turbine on a string and the ESP, carrying the output of 10 WTGs, the maximum number of WTGs on a cable string.

In the immediate vicinity of the ESP, the homerun cables become more closely spaced. Within approximately 20 to 30 ft (6.1 to 9.1 m) of the ESP, the cables begin to rise up in the subsurface trench such that they would be buried approximately 2 ft (0.61 m) deep under the scour control mats prior to rising vertically from the sea floor to the ESP in J-tube conduits secured to the ESP support structure. While this design has not been finalized, some reasonably conservative assumptions can be made to serve as a basis for magnetic field calculations at this singular location. It was assumed that a maximum of five 33 kV inner-array cables would be grouped on a single riser, spaced 6.5 inch (16.5 cm) (one cable diameter) apart, edge to edge. Magnetic flux density was then calculated at varying distances from the surface of the cables.

Calculations for the 115 kV offshore transmission cable system were performed which represent the two methods of installation proposed. The first method is appropriate to the majority of the submarine route, where the cable would be laid 6 ft (1.8 m) below the sea floor in two trenches with two cables per trench. The second method is for the transition to landfall where each of the four 115 kV offshore transmission cable system would be routed in its own 18 inch (45.7 cm) diameter HDPE conduit, installed using HDD construction techniques.

As with the onshore cable, no electric field calculations were performed because the electric field of the 33 kV and 115 kV offshore cables would be effectively contained within the body of each cable (i.e., shielded) by its grounded metallic shield.

Any fields produced by the generating equipment in the nacelle of the WTGs would be greatly attenuated at sea level (MLLW is 257 ft [78 m] below the nacelle). Fields produced by the electrical equipment within the ESP can be expected to be comparable to or less than those found in conventional land based substations. The principal sources of magnetic fields in a substation are the exposed high voltage buses (the magnetic field of a transformer is largely contained within the transformer). In the compact gas-insulated design proposed for the ESP, the bus bars are more closely spaced than in an outdoor air insulated substation, so the magnetic flux density is expected to be less. Moreover, any fields experienced on the ESP would be attenuated at sea level (MLLW is 40 ft [12.2 m] below the ESP deck). Lastly, because the ESP electrical equipment is effectively contained in a grounded metal enclosure, no external electric field is produced. Because of these considerations, the focus of the analysis was on the magnetic flux densities associated with the offshore cables, rather than on the fields generated by the electrical equipment.

***Electric Fields***

The proposed offshore cables would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cable system. Since the electric field would be completely contained within those shields, there is no perceptible electric field created by the cable system.

***Magnetic Fields***

The 115 kV offshore transmission cable system would consist of four 3-conductor cables configured as two circuits of two cable sets each. Each circuit would carry half the electrical output of the proposed action at any given moment. Throughout most of the submarine route (all but the HDD), the cables would be laid 6 ft (1.8 m) below the sea floor in two trenches, with two cable sets per trench. The trenches would be spaced approximately 20 ft (6.1 m) apart horizontally.

Calculations were performed to predict the magnetic flux density above the trenches on the sea floor, and at varying water depths above the trenches. The calculations predicted peak magnetic flux densities on the sea floor directly above each cable trench. The field strength decreases rapidly moving horizontally on the sea floor away from the trench. At elevations of 10, 20, and 30 ft (3, 6.1, and 9.1 m) above the sea floor the field strength also decreases as a function of vertical distance. The calculated peak value at the sea floor is (3 mG) and the corresponding field levels above the cable trenches are 0.4 mG at 10 ft, 0.2 mG at 20 ft, and less than 0.1 mG at 30 ft (see Table 5.3.1-12).

The 33 kV inner-array cables would also consist of 3-conductor solid dielectric cables. The cables would be arranged in strings, each of which would connect approximately 7 to 10 WTGs radially to a 33 kV circuit breaker on the ESP. Some strings may be bifurcated. The electrical current in the cable segments within each string would vary depending on location within the string: cable segments closer to the ESP would carry the output of more WTGs. Three different cable sizes would be used to accommodate this variation. The cables would be buried approximately 6 ft (1.8 m) below the sea floor, one per trench.

Calculations were performed to predict the magnetic flux density over the inner-array cables on the sea floor, and at varying water depths above them. The results are similar to what was found for the 115 kV offshore transmission system cables. Predicted peak magnetic flux densities on the sea floor, directly above the cable, decrease rapidly with distance from the cable and with vertical distance above the sea floor. Magnetic flux density around a cable is proportional to its electrical current, and therefore, the field strength would vary widely depending on the location of the cable segment within a string of turbines and on the output of the turbines. Accordingly, calculations were performed for the most lightly loaded cable segment located at the end of a string and carrying the output of only one WTG, and for a homerun cable segment located between the closest turbine on a string and the ESP (carrying the output of 10 WTGs). The calculated peak value at the sea floor is 28 mG and field levels at the cable trenches are 4 mG at 10 ft, 2 mG at 20 ft, and 1 mG at 30 ft (see Table 5.3.1-13).

Calculations were also performed to predict the magnetic flux density generated by the 33 kV inner-array cables in the immediate vicinity of the ESP, where they converge. The calculations conservatively assumed five homerun cables, each carrying the maximum load of 10 WTGs separated by one cable diameter. Magnetic flux densities were calculated at a distance of 2 ft (0.61 m) from the cables, which would represent the maximum exposure to marine organisms on the surface of the scour protection. Magnetic flux densities were also calculated at a distance of 10 ft (3 m) from the cables, which would be the closest reasonable approach of a boater to the cables at the point where they rise vertically out of the water up to the ESP. In fact, most responsible sailors or boaters would maintain a much greater distance from this structure. Because the cross-bracing on the ESP support structure would block vessels from passing under the ESP, this was considered the maximum exposure possible for the public at this singular location. While maintenance and construction workers may be briefly exposed to higher levels, such as when in direct contact with the J-tube conduits or in the cable spreading room on the ESP, their exposure would be comparable to that experienced by workers in conventional substations and generating stations. The calculated peak values directly in line with the cables at the 2 ft (0.61 m) and 10 ft (3 m) distance are 473 mG and 51 mG respectively. The calculated values a short distance to the side of the cables are 26 mG at the 2 ft (0.61 m) distance and 18 mG at the 10 ft (3 m) distance (see Table 5.3.1-14).

Report No. 4.1.7-1 presents additional detail regarding calculations performed to predict future expected magnetic flux densities for the marine portion of the proposed action.

With respect to the cable's landfall, the transition to landfall would change the configuration so that each of the four sets of cables is routed in an 18 inch (45.7 cm) diameter HDPE conduit, installed by HDD. It is expected that the conduits would be spaced 10.5 ft (3.2 m) apart at their seaward end. Peak magnetic flux densities calculated for this configuration directly above the offshore cables at the sea floor, at MLLW and at MHW are 29.2 mG, 18.8 mG, and 11.5 mG respectively (see Table 5.3.1-15).

***EMF Exposure in the Marine Environment***

For all of the proposed offshore circuits, the high-voltage conductors are enclosed in a shielded cable, and no external electric field is produced. Therefore, the proposed action would not produce or add to any electric-field exposures in either near shore or offshore waters.

Aside from the exposure to maintenance and other workers, the only possible magnetic field exposure scenarios for humans involve boaters in the proximity of the ESP or divers on the sea floor in the vicinity of the buried offshore cables or in the vicinity of cables that rise from the sea floor to the ESP. Potential exposures for marine organisms would be the same as for divers. The maximum levels of exposure occur over a narrow area along the cables, and decrease rapidly within a few feet of such locations as shown in Table 5.3.1-16. Magnetic flux densities directly over the offshore cables at peak load and in the vicinity of the ESP drop off rapidly with lateral and vertical distance from the cable and with distance from the ESP. Given the small area occupied by the offshore cables and ESP, and because divers or mobile marine species would likely not spend a large amount of time directly over the cables, exposure to magnetic fields would be minimal.

Marine species that may frequent the area around the ESP would be mobile, and therefore, their exposure would be dependent on the amount of time they were in the vicinity of the ESP. Marine benthos such as bi-valves and worms may spend more time in the vicinity of the buried offshore cables and therefore experience more exposure. These organisms are also mobile and have the ability to move horizontally and vertically within the sub bottom sediments. Overall, only a very small fraction of the available habitat would have potential exposure to the higher fields in the vicinity of the ESP.

A recent report on EMFs generated by offshore windfarm cables found that burial of the cable was generally ineffective in "dampening" the magnetic field, but that burial does provide some mitigation for the possible impacts of the strongest magnetic field and induced electric fields that exist within millimeters of the cable (Centre for Marine and Coastal Studies, 2003). The study also found that increased permeability or conductivity of the material around cable reduced the induced electric field.

There are no anticipated EMF impacts associated with the construction staging/laydown activities at Quonset Rhode Island because it is an existing facility and there would be no or minimal changes to the existing electric infrastructure.

**Conclusion**

As electric and magnetic field levels would be small, and the exposure to humans and marine life limited largely due to the depth of cable burial, impacts on humans and marine life from electric and magnetic fields during operation of the proposed action would be negligible.

## 5.3.2 Biological Resources

### *5.3.2.1 Terrestrial Vegetation*

#### 5.3.2.1.1 Construction/Decommissioning Impacts

The terrestrial resources impacted from this proposed action would be located along the onshore transmission cable system starting near the landfall location in Yarmouth and heading to Barnstable Switching Station. The proposed onshore transmission cable system route runs north from the landfall at New Hampshire Avenue in Yarmouth for approximately 4 miles (6.4 km) within roadway and road shoulder along Berry Avenue, Higgins Crowell Road, and Willow Street, and then the route leaves the roadways for approximately 2 miles (3.2 km), heading west and then south along the existing NSTAR Electric ROW to the Barnstable Switching Station. The NSTAR Electric ROW is actively managed in accordance with NSTAR's routine vegetation management program.

The proposed onshore transmission cable route within the NSTAR Electric ROW would consist of an excavated trench a minimum of 8 ft (2.4 m) wide and approximately 36 manholes. The manhole covers would be flush with the surface of the ground. For terrestrial work, traditional construction equipment such as backhoes and cable trucks would be utilized. The excavation would be backfilled to the original grade, with topsoil replaced on the surface, and the area would be seeded with an erosion control seed mixture for stabilization. The total width of workspace disturbance would be approximately 25 ft (7.6 m), including construction access, laydown areas, and the 8 ft (2.4 m) wide trench. This work would require the temporary disturbance of approximately 5.8 acres/252,648 square ft (23,471.6 $m^2$) of vegetation within the maintained ROW. The existing Barnstable Switching Station property can accommodate the addition of the proposed transmission cable with no additional land required.

Decommissioning of the onshore transmission cable system components would involve leaving in place the conduits, ductbanks and underground vaults beneath the roadways and the existing NSTAR Electric ROW but disconnecting and removing the underground conduit system. The onshore transmission cable system would be reeled and the reels would be transported to the staging area for further handling. The decommissioning of the onshore transmission cable system would be much shorter in duration then the installation because less work would occur since the conduit and vaults are being left in place. The vegetation impacts from the decommissioning activities would be reduced compared to construction since the entire route would not be disturbed, only the areas at the vaults or where reel up occurs.

Spills during equipment refueling, hydraulic line leaks or ruptures, or sloppy application of lubricants and greases could result in contamination of soils. The applicant would construct and operate the proposed action with an approved SPCC Plan, which should serve to minimize the potential adverse affects of such unintentional releases on the environment, including vegetation and vegetated habitats.

**Impacts on Terrestrial Flora**

The proposed action was designed to avoid impacts to previously undisturbed landscapes. The proposed transmission cable system route from the landfall location to the Barnstable Switching Station includes work within existing paved roadways and the existing maintained NSTAR Electric ROW. Although no disturbance of natural woodlands is planned, there may be some minor tree removal (if needed) along the ROW and road shoulders of the proposed transmission cable system. By planning the proposed action to use existing disturbed and managed areas, the proposed action would not result in extensive vegetation removal, especially of woody species, and would not directly impact freshwater wetlands.

To limit possible impacts to the surrounding landscape the following protocol would be used to facilitate revegetation along the undeveloped portions of the disturbed ROW. Sedimentation and erosion control devices would be installed as needed in uplands and near wetland areas along the edge of the construction ROW to prevent sediment flow into adjacent waterbodies and wetlands. Erosion and sediment control devices would be installed following vegetative clearing operations, but prior to grading and trenching in order to insure proper installation.

Although it is unlikely that there would be any trees taller then 15 ft (4.6 m) in the ROW, any trees 15 ft (4.6 m) in height or greater would be cleared and stockpiled for later wildlife habitat use. The understory vegetation and topsoil would then be stripped and stored along the trench. After the transmission line installation, topsoil would be re-spread, since separate topsoil stockpiling and replacement is important for successful vegetation re-establishment. The topsoil would be replaced as quickly as possible to minimize drying soils, germinating seeds, leaching nutrients, and declining microorganisms.

After the topsoil is re-spread, any trees that were cleared before would be placed evenly across the construction ROW (horizontally). The logs provide an effective erosion barrier and act as sediment traps. The logs provide habitat for pioneer animals such as insects and later, small mammals. The logs would also add organic material to the soil as they decompose.

Finally, the construction ROW would be seeded to ensure soil stabilization. A typical seed mix used for ROW revegetation might be composed of the following species: Creeping Red Fescue (*Festuca rubra*), Annual Rye-grass (*Lolium multiflorum*), Timothy (*Phleum pratense*), White Clover (*Trifolium repens*), Little Bluestem (*Schizachyrium scoparium*), Red Top (*Agrostis alba*), and Side-oats Gramma-grass (*Bouteloua curtipendula*). It is an appropriate seed mix for road cuts, pipelines, detention basin side slopes, and areas requiring temporary cover during the ecological restoration process. The mix would be applied by hydro-seeding or by mechanical spreader at a rate of 35 lbs per acre (3.4 kg per hectare). The soil would be raked to create grooves and provide a seedbed. After applying the seed, the soil would be lightly raked over and organic fertilizer (Neptune's Harvest Fish/Seaweed Fertilizer Blend 2-3-1 at a rate of 20 gallons mix per acre [190 liters mix per hectare] or equivalent) would be applied. A slow release and low nitrogen organic fertilizer is being used since the site of the proposed action is within a Significant Natural Resource Area for the presence of public water supply wellhead protection area. If seeding is by mechanical spreader, the construction ROW would be covered with a light mulching of certified weed free straw to conserve moisture and to aid in slope stabilization.

Following soil stabilization, pre-existing seeds within the re-spread topsoil would begin to sprout. The shrub and tree roots remaining in the disturbed but untrenched areas of the ROW are expected to further enhance revegetation of the ROW within two growing seasons. Based on the applicant's previous project experience on Cape Cod, scrub oak would resprout and grow to 2 to 3 ft (0.61 to 0.91 m) after one full growing season.

According to the NHESP, the proposed terrestrial cable route intersects mapped areas of habitat for the Plymouth Gentian (*Sabatia kennedyana*) a species of special concern. These mapped areas are: PH 88, EH178, PH 40, EH 680, and EH 188. Because these locations occur along the roadway portion of the onshore cable route, with construction occurring in the roadway or road shoulder, the impact to the Plymouth Gentian would be negligible. The proposed terrestrial route intersects PH 88 and EH 178 in the existing utility ROW portion of the route. The area where this occurs is in the buffer zone for Wetland 6 (see Figure 4.2.1-1). Plymouth Gentian is list as an obligate wetland plant for Region 1 according to the USDA plants database (NRCS, 2007). Because the proposed route is in the buffer zone of Wetland 6 and not in Wetland 6, the Plymouth Gentian is unlikely to occur in the work areas along the proposed route. Through the proper implementation of construction BMPs, the potential for indirect impact to the Plymouth Gentian would be negligible.

During decommissioning, impacts to the terrestrial flora would be greatly reduced compared to the installation impacts by limiting the activity to reel locations and not excavating the entire onshore transmission route. The erosion controls and revegetation procedures that are discussed in the construction impact sections would also be employed during the decommissioning phase of the proposed action to reestablish disturbed areas created during the proposed action's decommissioning. It is possible that there could be some tree removal in the reel up locations to create a safe working environment. Since this would represent a small fraction of the proposed route, these impacts are considered negligible to minor.

**Conclusion**

During construction and decommissioning, impacts to the terrestrial flora are expected to range from negligible to minor as these impacts would be temporary in nature, and localized. During decommissioning there could be some tree removal in the reel up locations to create a safe working environment. This represents a small fraction of the route and these impacts would be negligible to minor in nature. The impact to the Plymouth Gentian should be negligible. With the Plymouth Gentian being an obligate wetland plant and the proposed route being located in the buffer zone of a wetland and not in the wetland, there should be no Plymouth Gentian in the direct path of the proposed route, and implementation of construction BMPs would further help to ensure impacts would be negligible.

#### 5.3.2.1.2 Operational Impacts

During the proposed action's operations, regular vegetation maintenance would be performed along the proposed route along the NSTAR ROW. The vegetation maintenance schedule and procedures would be the same vegetation management plan that is currently employed along the ROW. The vegetation management along the roadway portions of the proposed route would also follow the current vegetation management being employed along the roads of the proposed route. In the event that repairs are needed and the cable system needs to be excavated, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter and the disturbance localized to the repair location. The erosion controls and revegetation procedures that are discussed in the construction impact sections would also be employed during any repair needed along the terrestrial route.

**Conclusion**

The operations of the proposed action are expected to have negligible to minor impact on terrestrial flora, largely because of the already developed and cleared or maintained characteristic of the route.

Impacts from repairs would be similar to the installation impacts, although the duration and extent of the impact would be shorter and smaller and would be considered negligible to minor depending on the repair location and the time of year. A discussion of mitigation is provided in Section 9.0.

### *5.3.2.2 Coastal and Intertidal Vegetation*

#### 5.3.2.2.1 Construction/Decommissioning Impacts

Once the offshore transmission cable system makes landfall at the proposed location, the transmission cable system would be transitioned to the onshore transmission cable system in two below-grade transition vaults. The transition vaults would be located at the land boreholes with the dimensions of approximately 7 ft (2.1 m) wide by 34 ft (10.4 m) long by 7.6 ft (2.3 m) deep (see Figure 2.3.7-1). The transmission cable system transition vaults would be installed within the pavement using conventional excavation equipment (e.g., backhoe).

In an attempt to minimize the release of the bentonite drilling fluid into Lewis Bay during HDD operations, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. It is possible that some minor residual volume of bentonite slurry may be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater “silt fence.” This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

Cable jetting operations would result in the creation of elevated suspended sediment concentrations that could reduce photosynthetic activity in seagrass beds. Jet-plow operations, as modeled for the proposed action, are not likely to produce sufficient sediment concentrations over a long enough duration that would smother or otherwise harm any eelgrass beds. As discussed below, the applicant has undertaken studies of this potential occurrence and taken measures to minimize adverse impacts.

While sedimentation from the trenching process could affect nearby seagrass beds, direct disturbance impacts have been minimized by routing the offshore cables outside of known locations of seagrass. Anchors associated with the jetting vessel positioning would result in localized disturbance to seagrass, if they are deployed within areas of seagrass. The Proponent has committed to not anchoring within eelgrass beds. Anchor cable sweep would increase the disturbance of seagrass from any anchoring occurring within the seagrass beds.

**Impacts on Coastal Wetland Resources**

Portions of the proposed transmission cable route are located in coastal wetland resource areas and their designated buffer zones. This includes navigable waters and waters of the United States which are under federal jurisdiction, as well as coastal beach, saltmarsh, land under the ocean, coastal bank, land subject to tidal action, land subject to coastal storm flowage and land containing shellfish, which are under state and local jurisdiction. Additionally, coastal watershed areas have local jurisdiction under Yarmouth WPR. Jurisdiction and impacts for coastal wetland resource areas are summarized in Table 4.2.2-1.

No work is proposed within saltmarsh, and only temporary work is proposed within paved areas of the 100-foot (30.5-m) buffer zone subject to state and local jurisdiction. Direct impacts from the proposed action to coastal bank, coastal beach, and land subject to tidal action will be avoided by use of the HDD method for cable installation at landfall along the proposed cable route. However, construction would occur within the state and local jurisdictional 100-foot (30.5-m) buffer zone for these resources. Additionally, a transition vault would be located within the 100-foot (30.5-m) buffer zone for coastal bank and also within the 100-year floodplain (land subject to coastal storm flowage), which includes a V-zone. Impact to coastal areas could occur if new hard structures or impervious areas resulted in a redirection of coastal zone flooding during storm events, or an alteration in patterns of sediment transport. Because the transition vault is a below-grade structure and no fill or elevation changes within the V-zone is planned as part of the proposed action, the proposed action is not expected to result in alterations to the V-zone or to coastal bank.

**Impacts on Coastal Flora**

Since the landfall location is devoid of vegetation (made up of intertidal sand and mud flats and concrete) and the transmission cable route immediately heads under an existing paved road, the impact to any coastal flora would be negligible. Inside the proposed action's buffer zone, there are residential properties directly east and west with associated yards with riprap and concrete walls towards the water. There are no known significant populations of coast flora at the landfall location. A salt marsh is located approximately 200 ft (61 m) west of the landfall location, but would remain unaffected by the proposed action due to the distance from the cable landfall and use of HDD technology for transmission cable installation.

**Impacts on Seagrass Beds**

In order to address special concerns about the potential effects of the jetting operation on an eelgrass bed identified just west of Egg Island in Lewis Bay, simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were performed. These simulations, which used two models (HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations), estimated the suspended sediment concentrations and deposition that could result from jet plow embedment of the cables. The full analysis is included in Report No. 4.1.1-2 and summarized below.

In the area of the eelgrass bed in Lewis Bay, the bottom sediments are relatively coarse. As a result, the sediments suspended by the jet plow are predicted to fall along the route with bottom deposition predicted to be in the range of 1.0 to 3.0 mm (0.04 to 0.1 in) at the western edge of the eelgrass bed. The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations. Suspended sediment concentrations in this area are predicted to be in the range of 50 to 500 mg/liter, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/liter are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route. At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/liter are predicted to remain for up to four hours. Concentrations at that level are not predicted to occur at the bed's eastern end, which experiences maximum concentration levels less than 50 mg/liter (Report No. 4.1.1-2).

Eelgrass beds typically experience some level of sedimentation under natural conditions as a result of tidal currents, waves, and storms. As a result, eelgrass has morphological, physiological, and reproductive means of dealing with exposure to a certain amount of deposited sediments. Regrowth of seagrasses such as eelgrass can occur if sediment deposition only results in a light covering of sediment material and if the rhizome system is not damaged (Duarte, 1997). Since the majority of the eelgrass bed is expected to experience little or no deposition as a result of jet plow operations, it is anticipated that the natural means of seagrass adaptation to changing sedimentation conditions would allow the eelgrass bed to withstand the short-term jet plow operations that would pass by the eelgrass bed (Report No. 4.1.1-2).

In addition, the short duration of exposure to elevated total suspended solids (TSS) levels would have negligible affects on photosynthesis and there should be no indirect impacts to the eelgrass beds.

Macroalgae is less tolerant of suspended and deposited sediments since areas of hard substrate to which the algae attach are typically areas of minimal sediments. However, as with the eelgrass, the duration of anticipated elevated suspended sediment concentrations is unlikely to measurably reduce photosynthesis and there should be negligible indirect impacts to areas of macroalgae. Hard substrates that become covered with sediment up to 0.12 inch (3 mm), may not allow for settlement and attachment of macroalgae, if the hard substrates remain buried during the reproductive period. However, it is likely that wind and tidal induced currents may remove deposited sediments, since the Horseshoe Shoal area is shallow and experiences both tidal and wave induced currents.

While the majority of the potential SAV observed in the Horseshoe Shoal area was macroalgae consisting of red macro-algae (*Grinnellia americana, Dasya pedicellata* and *Gracillaria tikvahiae*), and green macro-algae (*Codium fragile, Ulva lactuca*), some eelgrass was observed. It is possible that some of the small clumps of eelgrass located at the northern end of the western SAV area, per the OSI 2003 and 2005 surveys in the Horseshoe Shoal area, could be disrupted by the cable jetting since an exact survey of eelgrass locations relative to the specific cable routes has not been performed. However, since the cable installation process involves disturbance of only a small percentage of the overall site of the proposed action in the western portion of Horseshoe Shoal, the majority of the small clumps of eelgrass should experience little to no direct impact from the installation and overall impacts on eelgrass would be minor.

Installation of WTG monopiles or ESP piles could result in the permanent loss of marine vegetation at the pile location. Jack up or spud barges could also result in very small, localized loss of vegetation within the footprint of the pads or spuds However, most of the monopiles occur in areas of no or very sparse macroalgae or seagrass, so direct impacts are unlikely. The dispersed and infrequent loss or alteration of small patches of macroalgae or seagrass would only result in minor affects on these species, and recovery of the area would occur over time.

During decommissioning, the offshore cables would be disconnected and pulled out of the J-tubes on both the WTGs and the ESP, and the cables would be cut below the seafloor. The cables would then be reeled in after being water jetted free of the bottom sand. The jetting to remove the cables would have the same affects as the jetting during cable installation, resulting in direct loss of vegetation within the trench area, and minor indirect sedimentation affects nearby, due to the predominance of coarse sediments which limits sediment resuspension, transport, and deposition.

In association with the construction process, particularly cable jetting, construction vessels would be held in position using a series of large anchors with thousands of feet of anchor cable deployed. While the applicant has committed to using mid-line buoys to help suspend a portion of the cable off the seafloor, there would be areas where the cable sweeps across the seafloor surface as the jetting barge moves. This could have the affect of a wire cheese cutter slicing the top layer of sediment, resulting in disturbance to rooted plants such as seagrass or severing the holdfasts of attached macroalgae which would turn it into drift algae. Since much of the macroalgae experiences seasonal die-back, the anchor cable removal of patches of algae would result in minor changes in the biomass of the algae present along the cable routes at levels well below the natural die-back. Since the presence of seagrass and macroalgae is predominantly only in a portion of the western part of Horseshoe Shoal, only a limited number of the inner-array cables would be constructed where this vegetation occurs.

**Conclusion**

The construction and decommissioning impacts on coastal flora are expected to range from negligible to minor, considering there is no significant coastal flora located at the landfall location or seagrass within close proximity to the undersea work area. The largest source of potential impact is associated with anchor cable sweep during jetting of inner-array cables in the western portion of Horseshoe Shoal.

#### 5.3.2.2.2 Operational Impacts

The impacts of the buried transmission cable in the coastal and intertidal environment during the operation phase of the proposed action should be negligible, but in the likelihood that the cable needs to be repaired, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter. The nature of the impacts would also be dependent on where the cable repair was needed, since the marine vegetation varies throughout the site of the proposed action. For example, between Horseshoe Shoal and Lewis Bay, there are no areas of seagrass or macroalgae. The probability of a repair being needed, and for it to be required within an area of vegetation, is low. As a result, impacts on marine vegetation during the operational phase if repairs are needed would be negligible.

**Conclusion**

The day-to-day operational impacts on coastal and intertidal flora are expected to be negligible as the cable is buried and there is no expectation that it would need to be uncovered for normal maintenance, so no seafloor disturbance should occur. Impacts from repairs would be similar to the installation impacts, although the duration of the impact would be shorter and would be considered negligible to minor depending on the repair location and the time of year. The WTGs and ESP maintenance activities would primarily be above water and not involve seafloor disturbance. If the scour protection needs maintenance, there would be disturbance of any macroalgae that has colonized the area, resulting in the minor loss of biomass that was artificially generated due to the installation of the monopiles and scour protection in the first place.

### *5.3.2.3 Terrestrial and Coastal Faunas Other Than Birds*

This section discusses impacts to those animals occurring along the land portion of the cable route as well as bats. There are species that are common to the area that have the potential to be affected by construction/decommissioning and operation of the proposed action. In addition, certain species, such as bats, may spend a majority of their time over land, but do have the potential to occur within the vicinity of the turbines on Horseshoe Shoal.

#### 5.3.2.3.1 Construction/Decommissioning Impacts

Installing the transmission cable within existing roadways serves to greatly reduce the potential impacts to local reptile and amphibian populations as many of the local populations of these species have adjusted the migratory patterns to avoid the roadways as well as the fact that roadways do not serve as habitat for these species.

Small mammals, reptiles, amphibians and invertebrates that utilize onshore areas adjacent to Long Pond may experience limited displacement or mortality during construction, and some foraging opportunities for waterfowl and other wildlife may be lost for a season or two along the disturbed area until vegetation becomes reestablished. However, this represents a small fraction of the maintained ROW habitat available to these species, and these impacts would be negligible.

The Eastern box turtle has been known to be found in this general area of Cape Cod along the roadway portion of the landfall route. The roadway itself would not be used for breeding, foraging, or nesting. The roadway may be crossed by the Eastern box turtle when migrating from breeding, foraging, or nesting areas, but the temporary affects of construction are limited compared to daily traffic. Overall, the construction impacts on the Eastern box turtle would be negligible. During decommissioning, work will be limited to the locations where the cable will be reeled in such that potential decommissioning impacts would be less than construction impacts.

The impacts to state listed T&E invertebrates would be minimized by installing and decommissioning the onshore transmission cable system during times when these threatened species are limited to the wetlands, that is, seasonal periods outside of summer months. This would be accomplished by installing the cable system when damselfly and dragonfly species are in the egg or aquatic nymph phases of their lifecycles and through the use of proper construction BMPs to prevent any sediment from entering wetlands. Using these BMPs, the construction impacts on the threatened or endangered damselfly and dragonfly species would be negligible. The damselfly and dragonfly egg or aquatic nymph phase of life occur at approximately the same time as the water-willow stem borers' egg or larval phase of life such that construction can be scheduled to avoid the aquatic phases of these species. The water-willow stem borer is a moth that is only found in southeastern Massachusetts. According to the NHESP fact sheet on the water-willow stem borer, the only plant species used by the water-willow stem borer is swamp loosestrife *(Decodon verticillatus*). Swamp loosestrife is listed as an obligate wetland plant for Region 1 according to the USDA plants database. With the proposed route only being in the buffer zone of wetlands, rather than directly crossing freshwater wetlands, no swamp loosestrife would be directly damaged by the construction activities and with proper construction BMPs, the potential for indirect impact on the water-willow stem borer would be negligible.

Short-term displacement and avoidance of active construction areas would have a localized and minor affect on wildlife present along the ROW route by causing them to temporarily abandon feeding, breeding, and resting activities. Most wildlife species are anticipated to move into similar nearby habitat areas until construction is completed and the disturbed areas become revegetated. In addition, small mammals, such as voles, may suffer some mortality due to trenching activities. However, the noise and vibration of construction machinery may cause some individuals to leave the construction workspace in front of the trenching activity, thereby avoiding mortality.

Spills during equipment refueling, hydraulic line leaks or ruptures, or sloppy application of lubricants and greases could result in contamination of soils. The applicant would construct and operate the proposed action with an approved SWPPP, which should serve to minimize the potential adverse affects of such unintentional releases on the environment, including wildlife.

During the construction installation phase and decommissioning in the ROW, the local terrestrial wildlife may be disturbed by construction activity and noise. The construction activity would most likely cause some wildlife to alter their travel patterns but this would be limited to small-localized areas. This impact would be relatively short in nature and be limited to small-localized areas. During the roadway installation, the noise could also disturb some of the wildlife. However, due to the installation being under the current roadway, much of the wildlife inhabiting the surrounding landscape should be accustomed to noise produced by traffic and should be familiar with avoiding the road. Thus noise impact to wildlife would be minor.

Significant bat foraging locations or migratory corridors are not anticipated to be impacted by construction or decommissioning of the WTG structures. Construction of the WTGs would not result in the loss of roosting habitat. Construction and decommissioning activities including the transport of large equipment, increased vessel traffic, monopile driving, or cable trenching are anticipated to have negligible to minor impacts to bat habitat as bats are not expected to frequent the area of the proposed action.

Onshore activities associated with installation of the transmission cable system would occur in existing ROWs (road or transmission line) within a developed region, and would therefore not result in loss of habitat. Use of onshore locations for the staging of offshore construction and decommissioning equipment would occur at existing developed locations that experience similar uses. Therefore, onshore activities associated with construction or decommissioning of the proposed action are not expected to result in loss of bat habitat.

There is a potential for collisions of bats with WTGs under construction, or construction equipment, if bats' migratory movements were to occur within the area of the proposed action. More information is needed to assess bat occurrence and flight behavior over areas of Nantucket Sound, as well as the mechanisms that result in collisions, including potential bat attraction to tall structures as potential roost habitat, or noise interferences with bat acoustical detection. However, bat occurrence greater than five miles offshore is anticipated to mainly be limited to migratory or dispersal periods due to the lack of suitable habitat offshore. Additionally, bat migratory or dispersal movements across the Sound are expected to be sporadic. There are no known bat migration corridors through the site of the proposed action and bats are not expected to frequent the area of the proposed action. Therefore, the risk of collision during construction or decommissioning activities is anticipated to result in negligible to minor impacts to bats.

**Conclusion**

The construction and decommissioning impacts on terrestrial and coastal faunas other than birds are expected to be negligible to minor. Short-term displacement and avoidance of active construction areas and noise disturbances are expected to have a minor impact on wildlife present along the ROW. The decommissioning activity should have a negligible impact to the wildlife along the proposed route, with the affected locations representing a small fraction of the habitat available to these species.

### 5.3.2.3.2 Operational Impacts

By landscapes along the proposed cable route not changing in land management or land use, the resources available to the fauna using terrestrial route should not be significantly different from the current condition. In the event that repairs are needed and the cable system needs to be excavated, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter. This would again cause some localized displacement of wildlife in the repair area work zone. This would also disturb any wildlife habitat that has established itself on top on the buried utility cable system. However, this would represent a small fraction of the proposed route.

Onshore wind projects have emerged as a potentially significant source of mortality for migrating bats based on the results of recent studies (Johnson and Strickland, 2004; Kerns and Kerlinger, 2004; Arnett et al., 2005; Curry and Kerlinger 2007; Kunz et al., 2007; Arnett et al., 2008). These studies have raised numerous concerns regarding the potential for collision mortality associated with wind turbines to impact bat populations (Williams, 2003). However, the concerns lie primarily with wind farms on forested ridgelines in the eastern United States, where documented bat fatality rates have been considerably higher (bats/turbine/year) than at western and mid-western wind farms (Johnson et al., 2003; Williams, 2003; Arnett et al., 2005). Mortality at western and mid-western facilities is much lower, with documented fatality rates ranging from only 0.07 to 2.32 fatalities/turbine/year while those from some eastern facilities ranging from 30 to 40 fatalities/turbine/year (Erickson et al., 2001; GAO 2005). Emerging evidence from one facility on the prairies of Alberta, however, indicate that bat mortality in those open habitats can be comparable to that observed along the forested ridgelines of the central Appalachian Mountains (unpublished data presented by Robert Barclay, University of Calgary, Alberta, at the North American Symposium on Bat Research, October 2005).

Several hypotheses regarding bats' vulnerability to collision with wind turbines have been proposed, but none have been adequately tested to date. Bats may be attracted to wind turbines due to curiosity about motion or noise, acoustic interference produced by turbines, or potential roost habitat on the turbines themselves. This possibility has been supported by thermal-imaging surveys at an operational facility in West Virginia, where bats appeared to approach and investigate operational wind turbines (Horn et al., 2008). Insects may also concentrate around turbines due to lighting or the heat of the nacelles, which could in turn attract bats to turbines. Landscape features such as topography, forest edges, roads, or watercourses may serve as corridors for migrating or foraging bats, funneling them towards wind turbines located near these features (Arnett et al., 2005). Cryan (2008) has also hypothesized that bats congregate near wind turbines and other tall structures during the mating period in the fall, increasing the likelihood of collision during these times. While the potential attraction of bats to wind turbines has only been studied at terrestrial wind farms, the pattern could also be expected at offshore facilities, where wind turbines could represent potential roost and foraging habitat for bats, attracting them to the facility. Some bats that fly close to turbines may not actually collide with turbines but may become trapped in the blade-tip vortices, and may be injured or killed by decompression as the blades rotate downward (Kunz et al., 2007). Specific weather conditions may attribute to bat collisions with wind turbines. Low cloud cover or thermal inversions following the approach of fronts may influence bats to fly at lower altitudes when migrating (Kunz et al., 2007).

Cryan and Brown (2007) determined that certain weather factors are associated with the arrival of migratory hoary bats at an island migration stop-over location in the Pacific. Low wind speeds, low moon illumination, overcast conditions, and low barometric pressure were associated with bat arrivals and departures. Island arrivals were most associated with passing storm fronts in autumn (Cryan and Brown, 2007). High intensity lights emitted from a lighthouse on the island was believed to influence the presence of migratory bats at this location. However, aviation lighting on wind turbines has not been shown to influence bat fatalities at existing wind farms (Cryan and Brown, 2007). The study supports the conventional belief that bats use vision to navigate during long-distance migration, and that bats may orient themselves toward visual landscape features during migration.

A few consistent patterns have emerged from mortality studies of bats at onshore operating wind energy facilities regarding the timing of mortality and the species most commonly found. The timing of fatalities documented at existing wind facilities and other structures suggests that fall migrating bats are at the highest risk, while risk during the summer feeding and pup-rearing period is low (Johnson and Strickland, 2004; Johnson et al., 2003; Whitaker and Hamilton, 1998; Cryan and Brown, 2007; Arnett et al., 2008). Additionally, only certain species of bats may be at risk. Of the 45 species of bats that occur in the United States, 11 have been found during mortality searches (Arnett et al., 2008). The species most commonly found during mortality searches are the migratory tree bats (eastern red bat, hoary bat, and silver-haired bat) and the Eastern pipistrelle. Although bat collision mortality has been documented during inclement weather (Johnson et al., 2003), collisions occur most frequently on nights with wind speeds of less than 9 to 13 mph (4 to 6 m/s) (Arnett et al., 2005; Kunz et al., 2007; Arnett et al., 2008).

Because the exact mechanisms that cause high collision rates among migratory bats at onshore projects are understudied, the process of accurately characterizing potential impacts of an offshore wind farm is difficult. Bats are known to migrate or disperse over-water and they are known to inhabit and stop-over at migratory locations on Martha's Vineyard in Nantucket Sound. Radar surveys conducted in the area of the proposed action in the absence of thermal imaging confirmation to differentiate between bird and bat targets cannot be used to assess bat use of the area of the proposed action. Therefore, there is limited information available to characterize bat frequency and flight behaviors within the area of the proposed action. However, due to the relatively low food availability and a lack of roosting structures offshore, the abundance of bats over the ocean is conventionally believed to be far less than the abundance of bats among onshore habitats.

Mortality data from onshore wind farms indicate that bat collision mortality is expected to occur mainly on nights with calm winds during migratory periods. Species at risk of collision with operating WTG structures mainly include long-distance migratory species. Non-migratory bats are expected to make infrequent crossings of the Sound during dispersal periods, and would therefore be at a very low risk of collision. Long-distance migratory bat species may be at a greater risk of collision due to the observed mortality at existing onshore facilities, however, bat use of Nantucket Sound is poorly understood and basing potential impacts of an offshore wind farm on existing data from onshore facilities may not be appropriate. There are likely differences between bat flight behaviors over water verses over forested landscapes or other open landscapes such as agricultural fields. The actual mechanisms that result in bat collisions as well as bat occurrence and flight behavior within the area of the proposed action require further investigation.

Bats may be among species of terrestrial animals impacted by artificial sources of EMF produced by the onshore transmission cable system. EMF may directly deter bats from an exposed area. Studies show that due to the thermal effects of EMF exposure, bat foraging activity was significantly reduced in habitats exposed to EMF (>2 v/m) when compared to similar habitats with no EMF levels (Nicholls and Racey, 2007). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to bats are anticipated to be negligible.

**Conclusion**

The day-to-day operational impacts on terrestrial and coastal faunas other than birds are expected to be negligible to minor. Impacts from repairs would be similar to the installation impacts, although the duration of the impact would be shorter and would be considered negligible to minor depending on the repair location and the time of year.

Because bat habitat does not occur within the area of the proposed action, the development of the proposed action is not expected to result in loss of habitat. Although there are no known migration corridors over Nantucket Sound, long-distance migratory species have been observed making seasonal movements over large bodies of water, and bats may be vulnerable to collision when migrating in the vicinity of the project, when they could potentially be attracted to turbines. However, impacts are expected to be limited in terms of seasonality (fall migration period) and species composition (migratory tree bats) based on current understanding of mortality patterns at operational wind facilities and would presumably be of lower magnitude than collision mortality at on-shore facilities. Impacts are expected to be limited to occasional collision mortality associated with bats migrating or dispersing through the area of the proposed action. The proposed action is anticipated to result in moderate impacts to migratory bats and negligible to minor impacts to non-migratory bats.

#### *5.3.2.4 Avifauna*

Potential impacts to avian species can result from the development and operation of an offshore wind farm. Construction and decommissioning activities can result in disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or with other large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality. Operation of a wind facility can result in long-term disturbances including habitat loss, disturbances associated with EMF from the offshore cables or onshore transmission cable system, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with monopile collapse or cable repair, impacts associated with oil spills, as well as the risk of collision with operating turbines.

Potential project impacts are largely species specific depending on each species use of the area of the proposed action as well as the particular flight or foraging behaviors of a species within the area of the proposed action. The following sections summarize the results of 2002 to 2006 boat, aerial, and radar bird surveys, and describe the potential proposed action impacts, and the magnitude of these impacts that could occur during the construction and decommissioning, and operational phases.

#### 5.3.2.4.1 Construction/Decommissioning Impacts

**Terrestrial Birds**

***Raptors (hawks, owls, eagles, falcons, etc.)***

There are a multitude of raptor species that occur during the breeding and wintering seasons in the region. A range of species also occur along the Atlantic Coast during spring and fall migration. The potential proposed action impacts to raptors during construction and decommissioning of the proposed action include loss or modification of habitat, impacts associated with EMF from the onshore transmission cable system, and the risk of collision mortality. Impacts associated with these sources of disturbance are anticipated to be negligible as most raptor species do not regularly occur 5 miles (8 km) out to sea. However, exceptions include a few species that are known to cross large expanses of ocean during migration and other raptors species that could get blown offshore during migration. Additionally, osprey may forage in Lewis Bay, the proposed cable landfall location.

***Raptor Observations in Nantucket Sound***

Raptors observed during surveys consisted of a total of eight ospreys seen during boat surveys in Nantucket Sound on August 15 and 22, 2002, and September 12, 2003 (Report No. 4.2.4-5 and Report No. 4.2.4-10). All individuals observed were seen less than one mile offshore south of Falmouth. The ospreys observed were foraging at heights less than 50 ft (15 m). No other raptor species were observed during the 125 aerial surveys or 89 boat surveys of Nantucket Sound conducted between 2002 and 2006.

***Raptor Observations at Existing Wind Facilities***

Relatively few observations of raptors at existing offshore facilities have been reported. Raptor observations in the vicinity of the Kalmar Sound facility in Sweden during Spring 1999 to 2003 and Fall 2000 to 2003 reported 150 individuals consisting of species of osprey, eagle, harrier, falcon, *buteo*, and *accipiter*. Raptors that flew through the area generally flew at high altitudes 492 to 656 ft (150 to 200 m), above the rotor zone of the Kalmar Sound facility. Migrant raptors that were observed near the project mainly passed between the facility and the shoreline (Pettersson, 2005). At the Horns Rev Offshore Wind Farm (Horns Rev) facility in Denmark, raptor observations near the facility consisted of eight total individuals including species of accipiter and falcon, during survey periods from August 2002 to November 2003, and March through May 2004. A few birds were observed as migrants, but Eurasian sparrowhawks (*Accipiter nisus*) were observed perching on turbine foundation structures (Christensen et al., 2003).

At land-based facilities located in close proximity to nesting or foraging habitat, high collision mortality of raptors has been reported. White-tailed eagles have experienced high mortality at an island-based facility on Smola off of the northwest Norwegian coast (Bird Life Intl., 2006). The island was designated as an Important Bird Area due to a high density of the nesting eagles. Altamont Pass in California is notorious for its high raptor collision mortality mainly due to turbines located in the vicinity of optimal foraging habitat and the type of turbines that occur there. Raptor mortality in the United States, outside of California, has been documented to be very low. For example, mortality rates found at onshore wind developments outside of Altamont Pass have documented 0 to 0.07 fatalities/turbine/year from 2000-2004 (GAO, 2005). As of 2002, there were seven reported raptor fatalities which occurred in North America outside of California (Kerlinger and Curry, 2002) and few have been reported from onshore facilities since then. The factors that may explain why raptor mortality outside of California has been notably lower include: significantly lower raptor use of existing area of the proposed actions; the lack of topographical features that funnel migrants toward existing facilities; the deployment of larger turbines with less frequent rotations per minute (rpm) that may be more easily avoided by raptors; and the now standard use of tubular towers that reduce perching opportunities below the spinning blades.

Table 5.3.2-1 shows a summary of available raptor mortality at recent studies in the U.S. outside of California. The numbers of raptor fatalities are relatively low compared to other species of birds (mainly passerines) found during mortality searches.

Whitfield and Madders (2006) used the Band Collision Risk Model to estimate the turbine collision avoidance rate of hen harriers (*Circus cyaneus*) at eight wind farms in the U.S. Estimates were: 100 percent at 6 sites, 99.8 percent at 1 site, and 93.2 percent at 1 site. Chamberlain et al. (2006) estimated an avoidance rate of 0.995 for golden eagles (*Aquila chrysaetos*) at two potential wind farm sites in the United Kingdom; this was drawn from work on golden eagles in the U.S. (Madders 2004 *as cited in* Chamberlain et al, 2006). There are, however, limitations to the Band Collision Risk Model, as it does not account for differences among bird activities and behaviors under a range of conditions and because avoidance rates exhibited by a range of species are understudied (Chamberlain et al., 2006).

Potential impacts during construction and decommissioning activities include loss of habitat or habitat modification, and the risk of collision with construction equipment or WTGs undergoing construction.

Onshore activities associated with installation of the transmission cable system would occur in existing ROWs (road and transmission line) within a developed region, and would, therefore, not result in loss of habitat or other disturbances to raptors. Near-shore construction and decommissioning activities may result in the temporary loss or modification of foraging habitat for osprey. Cable trenching would occur in Lewis Bay where osprey may forage. Increases in human presence and vessel activity during construction and decommissioning may temporarily displace foraging osprey. Cable trenching would result in sediment plumes that may temporarily displace prey fish. However, sediment suspended by trenching during cable installation is expected to be localized (20 mg/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. Therefore impacts to foraging osprey during cable laying are anticipated to be temporary and negligible.

Offshore construction and decommissioning may result in the potential for collision with WTG structures under construction or with construction equipment. However, because raptors are mainly diurnal, and have exhibited high turbine avoidance behaviors at wind farms that do not occur in high raptor use areas, and because they are not expected to regularly occur within the area of the proposed action, the risk of collision during construction and decommissioning is low. The risk of collision mortality during construction and decommissioning activities are expected to have negligible impacts to raptors.

***Passerines***

A substantial portion of the land bird population of North America consists of neotropical and regional migrant passerines. A large number of local or migrant passerine species occur in the area of Nantucket Sound at varying times of the year. While it's a conventional belief that coastal areas concentrate migrant songbirds during active migratory flights and during stopover events, little information exists on the actual numbers of night migrants in the air along the Atlantic Coast. While relatively few species routinely use open water, marine habitat, large numbers of songbirds could occur in and over the area of the proposed action during both nighttime and daytime migration. Migrants may be blown offshore depending on the prevailing wind direction during nighttime movements along the coast. Some neotropical migrant species, specifically those of the family Paurlidae (wood warblers), may make substantial water crossings during nocturnal migration (Richardson, 1978). Although a number of terrestrial ornithological radar studies have been conducted to determine the characteristics of nocturnal migration, there is little information available that thoroughly quantifies nocturnal migration over the ocean.

Potential impacts to migratory passerine birds during construction and decommissioning of the proposed action include risk of collision with WTGs undergoing construction, and onshore activities associated with installation of the underground transmission line, which would occur in roads and in an existing ROW. Specific information about passerines was not collected. It can be assumed that passerines migrate over Nantucket Sound as flocks of migrants are often documented stopping at on-shore locales surrounding Nantucket Sound, such as Cape Cod, Martha's Vineyard, and Nantucket Island.

Most bird mortalities at wind projects are believed to be caused by collisions with the turbine blades, particularly moving blades, but the monopiles may pose risks as well. Numerous studies have documented that passerines collide with stationary solid structures (Erickson et al., 2001; Shire et al., 2000). Hence, turbines that are under construction and stationary are a potential threat to passerines that happen to be moving through the project area. However, it is generally accepted that nocturnally migrating passerines fly at relatively high altitudes, that is, above 410 feet (125 m) (Mabee et al., 2004). Exceptions to this may occur when weather conditions, such as fog or light rain or wind, force birds to fly at much lower altitudes.

Onshore activities associated with installation of the transmission line would occur in roads and an existing ROW, and would therefore, not result in any permanent loss of habitat. Construction would cause the temporary displacement of birds that breed or forage in the immediate secondary vegetation or edge habitats present in uplands and wetlands on ROW. During the breeding season, this could include such species as Eastern towhee (*Pipilo erythrophthalmus*), song sparrow (*Melospiza melodia*) and field sparrow (*Spizella pusilla*) within the ROW, and species such as blue-winged (*Vermivora pinus*), prairie (*Dendroica discolor*), and chestnut-sided (*Dendroica pensylvanica*) warblers, and Baltimore oriole (*Icterus galbula*) along the edge of the ROW (King, 2003). Since secondary vegetation will be quickly restored, any impacts due to displacement will be temporary and minor.

**Coastal Birds**

A number of shorebirds, including piping plover (federally-threatened) and red knot (federally-listed as a species of conservation concern), as well as wading bird species such as herons and bitterns, are known to either breed, stage, or winter along the mainland and island shores of Nantucket Sound and surrounding areas. Wetlands and inter-tidal areas around the bay provide important habitat for a multitude of shorebirds and wading birds, including migratory species that commonly occur along the Atlantic coast.

Construction and decommissioning activities can result in impacts to coastal bird species as a result of disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or the risk of collision with large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality. Operation of a wind facility can also result in long-term disturbances including habitat loss, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with cable repair in Lewis Bay, impacts associated with oil spills, as well as the risk of collision with operating turbines.

Detailed analysis for species of conservation concern including piping plover and red knot have been provided in the BA in Appendix G and Section 5.3.2.9.

***Shorebird Observations in Nantucket Sound***

Few shorebirds were observed within the study area during aerial and boat surveys conducted by the applicant and MAS from 2002 to 2006. This may be due to the fact that aerial and boat surveys focused effort on shoal areas within Nantucket Sound instead of the shorelines of the mainland and islands of Nantucket Sound where the majority of local or stopping-over shorebird species aggregate for foraging. Few observations may also be due to the limitations of aerial and boat surveys. Low flying, small, light-colored birds may not be easily detected from altitudes of 246 ft (75 m) or greater during aerial surveys. Alternately, high flying birds may go undetected during boat surveys conducted at the surface of the water. Shorebird species migrating over the Nysted and Horns Rev wind farm in Denmark would have gone undetected by an observer had the radar not detected a flock flying over 984 ft (300 m) (Petersen et al., 2006). Surveys were limited to daytime periods of good visibility, therefore there is no data to describe shorebird occurrence in the study area at night or during periods of inclement weather.

Shorebird observations in the study area were limited to: one American oystercatcher (Report No. 4.2.4-8) one red knot in a mixed species flock with six other unidentified sandpipers observed flying low over the water near Cape Poge, Martha's Vineyard; and 20 dunlins observed on Muskeget Island (Report No. 4.2.4-3 and Report No. 4.2.4-9).

Potential impacts associated with construction and decommissioning activities may include habitat loss or modification, disturbances associated with human presence, the activity of construction equipment, and increased boat traffic, as well as the risk of collision with turbines under construction or large construction equipment.

*Habitat Loss or Modification*

The effects of habitat loss or modification can result in increases in energy expenditure as birds access alternate foraging habitats, which may ultimately result in decreases in nesting success or survival. HSS does not provide habitat for foraging shorebirds or wading birds, therefore, impacts would be limited to the proposed landfall of the transmission cable. The shoreline where the offshore transmission cable system would make landfall is developed and primarily consists of concrete and stone with minimal sandy areas. This area is not likely to provide important habitat for shorebirds or wading birds. Impacts associated with habitat loss or modification for shorebirds or wading birds at Great Island are expected to be negligible because the shoreline would be drilled under for installation of the cabling.

Specific construction techniques, including horizontal drilling and jet plow embedment, would minimize the impacts to the inter-tidal community within the vicinity of the landfall site. Sediment suspended by trenching during cable installation is expected to be localized (20 mg/liter within 1,500 ft

[457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). The laying of offshore transmission system cables in Lewis Bay and near the inlet of the bay are not expected to cause significant changes to the inter-tidal habitat structure or prey availability. The increase in suspended solids and the relocation of sandy sediments would be temporary and would result in no substantial changes in the coastal areas of interior Lewis Bay, or the beaches on either side of the inlet.

Because of the inherent dynamic nature of the inter-tidal zone, disturbances created during construction and decommissioning are not expected to cause lasting or particularly harmful effects. Small mortality events of infaunal organisms are likely to occur, but effects on local inter-tidal assemblages would be negligible. Disturbance of the sea floor within Lewis Bay may provide for opportunistic colonization by disturbance tolerant benthos after construction, and similarly after decommissioning activities; however, these changes are not expected to influence inter-tidal areas. Impacts associated with changes in inter-tidal habitat during installation of the offshore transmission cable system in Lewis Bay are anticipated to result in negligible impacts to coastal bird habitat.

*Human Disturbance (human presence, vessel activity, noise created by construction equipment)*

Red knot and piping plover are among species of shorebird that are sensitive to human disturbances, particularly during critical nesting or pre-migratory staging periods. Substantial disturbances may flush foraging shorebirds, resulting in increases in energy expenditure, decreased breeding success, and potentially decreased survival. Piping plover may abandon nests as a result of disturbance (USFWS, 1996). Red knot are among species known to be particularly sensitive to relatively high levels of vessel activity (Peters and Otis, 2007). Piping plover are known to nest on Great Island, the beach that occurs in closest proximity to the proposed offshore transmission system cable. Additional shorebird and wading bird species may occur at this beach. However, the island occurs in a developed area which experiences high human activity. The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. There would be an 820 ft (250 m) buffer or greater between cable construction activities and the beach area; therefore, increases in boat activity as well as the operation of loud construction equipment offshore would not result in significant impacts to shorebirds or wading birds. Human activity associated with performing the HDDs and pulling the cables through the installed conduits would involve minor and temporary disturbances, similar to other people walking and being present along the shoreline. A tracking system, consisting of a wire to power the drill head may be placed across the beach; however, this disturbance would be equal to a person walking across the beach. Due to the buffer between the beach and offshore construction activities, disturbances associated with construction and decommissioning would be minimal and temporary.

*Risk of Collision*

Risk of collision is based on the frequency of occurrence through the area of the proposed action, visibility conditions during encounters with structures, and the flight behaviors of birds during crossings of the area of the proposed action. Shorebirds and wading birds typically remain onshore except during migration although they occasionally cross water bodies such as bays to access foraging or high-tide roosting locations. As the site of the proposed action is located over 5 miles (8 km) offshore, coastal birds may only occur within the area of the proposed action during migration movements. Migrants may occur over areas of Nantucket Sound; however, there are no known shorebird or wading bird migration corridors that occur over HSS. During construction or decommissioning, shorebirds or wading birds, particularly species that migrate at night or during periods of low visibility, may be at risk of collision with WTGs under construction or with large construction equipment.

There is data that suggest refraction caused by lighting mounted on tall structures during periods of fog and rain can disorient birds traveling at night (Huppop et al., 2006). Lighting on tall structures is believed to be associated with high collision rates of nocturnal migrant passerines. The effects of lighting on nighttime migrating shorebirds and wading birds are not well studied. Shorebirds and wading birds represent a relatively small fraction of collisions documented with tall, lit structures (Huppop et al., 2006); however, the effects of refraction to lighting during periods of rain or fog may contribute to increased collision risk.

Petersen et al. (2006) observed a substantial decrease in the volume of migrating birds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006). Due to limitations of boat and aerial surveys, there is no coastal bird data available for nighttime migration or inclement weather conditions within the area of the proposed action. However, shorebird species have been documented at flights greater than 1.2 miles (2 km), well above the proposed rotor zone during nighttime migration movements (Richardson, 1978b). Shorebirds that migrate both day and night have been documented at heights as high as 2.8 to 3.7 miles (4.5 to 6 km) (Sibley, 2001). Shorebird species are known to migrate at altitudes from just above the surface of the water to 3.7 miles (6 km), depending on the altitude where favorable wind conditions exist (Sibley, 2001).

Many species are known to depart beaches for migration during rising tides, throughout the day, but mainly in the late afternoon or early evening (Sibley, 2001). Other observations indicate shorebirds may depart for migration mainly on sunny days, in the few hours before twilight (Harrington, 2001). Inclement weather may deter the departure of migrants as many shorebird species move inland during coastal storms to nearby agricultural fields (Sibley, 2001). Due to the generally high altitude of migrating shorebirds and the low risk of occurrence of shorebirds or wading birds in the site of the proposed action during periods of inclement weather, the risk of collision is low. Nighttime construction activities for the proposed action would occur and lighting would be used to illuminate structures under construction, however, construction activities would be limited on those nights with the greatest risk of collision during inclement weather. The risk of collision or shorebirds is low due to the generally high altitude of migrants and the low chance of occurrence in the area of the proposed action during periods of reduced visibility. Depending on the species affected, impacts associated with collision during construction are anticipated to be minor. Although the risk of collision is anticipated to be low for coastal bird species, any level of collision mortality for species of conservation concern, such as the federally-threatened piping plover, would represent a more substantial impact. The risk of collision of piping plover is discussed in detail in the BA in Appendix G and a more detailed description of risk of collision to coastal birds in general is in provided in Section 5.3.2.4.2. Impacts associated with collision during construction and decommissioning activities are anticipated to be minor for coastal non T&E bird species.

**Marine Birds**

The potential impacts to marine birds due to the proposed action vary among taxonomic groups of birds depending on use of the site of the proposed action, flight behavior within the site of the proposed action (particularly flight altitude), and the duration of time spent in the site of the proposed action.

Construction and decommissioning activities can result in disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or with large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality.

The following sections summarize marine bird uses of Nantucket Sound, and describe the potential proposed action impacts to marine birds according to taxonomic group during the construction and decommissioning phases, and finally, attempts to gauge the magnitude of impacts to marine bird populations.

***Marine Bird Observations in Nantucket Sound***

Observations of marine birds during aerial and boat surveys conducted by the applicant and MAS documented that the diversity and numbers of birds found in the area of the proposed action is a small subset of those found in other parts of Nantucket Sound (see Table 4.2.4-2 and Section 4.2.4.3 for more detailed study results). Of all the types of marine birds those most often seen on Nantucket Sound include terns and sea ducks.

The majority of tern observations in Nantucket Sound occurred outside of the Shoal study areas. Terns were generally concentrated around the mainland and island coasts of the Sound, particularly Monomoy Island during the late-August and early-September staging period. During this period HSS likely had the lowest level of activity out of any similar habitat surveyed in the Sound.

In general, throughout Nantucket Sound, the numbers of marine birds are highest in the months from October through April. These high numbers are related primarily to the occurrence of wintering sea ducks, mainly common eider, scoters, and long-tailed ducks. Aerial survey data collected by the applicant and MAS from 2002 to 2006 were used to calculate average densities of sea ducks for the season from October 8 through April 23. High densities of sea ducks (>4 birds per acre [>1000 birds per $km^2$]) were documented within and on the edge of the area of the proposed action boundary (Report No. 4.2.4-2). This would indicate that in recent winters, sea ducks are using HSS for foraging. Based on winter aerial survey data, the average numbers of eiders detected during surveys were between 60 and 280 (see Tables 4.2.4-15 and 4.2.4-16). Scoters were regularly detected in HSS during winter surveys, often in large flocks (>500 individuals) (see Tables 4.2.4-19 and 4.2.4-20). However, sea ducks were observed to be less abundant in HSS than other parts of Nantucket Sound. The total number of individuals observed in HSS (25,125) comprised 6.8 percent of the total sea ducks observed during aerial surveys, which is substantially lower than the 13 percent expected if the birds had been evenly distributed across the study area.

***Terns, skimmers, and gulls***

Nantucket Sound is known breeding and foraging habitat to a number of terns including common tern (Special Concern), least tern (Special Concern), and roseate tern (Endangered). A detailed description of impacts to roseate terns is provided in the BA in Appendix G. In Nantucket Sound, tern species nest on South Monomoy and Minimoy Islands (USFWS, 2005). A few other species occur in the bay at certain times of the year including black (*Chlidonias niger)*, arctic, royal (*Sterna maxima*), and Forster's (*Sterna forsteri*) terns. Black skimmers (*Rhynchops niger*), a relative of terns, are known to nest on South Monomoy (USFWS, 2005). Several species of gulls are common and numerous in Nantucket Sound during various periods of the year including great black-backed gull, herring gull, ring-billed gull, laughing gull, and Bonaparte's gull. Gulls breed within areas of the Sound; however, their nests in vicinity of endangered tern breeding locations are sometimes destroyed for predator control (USFWS, 2005).

Terns forage over shallow areas, reefs, and sand spits within the Sound where their prey, primarily sand lance, is available. Gulls are opportunists and take advantage of a variety of food sources; however, over the Sound, their foraging behaviors are similar to terns. During migration, large percentages of the North American populations of roseate, common, and least terns many occur in areas of the Sound.

*Habitat Loss or Modification*

There is no available tern or gull breeding habitat within or in close proximity to the proposed action boundary, and the transmission cable and proposed landfall would not cross breeding locations.

Therefore, the effects of habitat loss or modification would be limited to foraging areas in proximity to the WTGs and submarine cable.

Construction, operation, and decommissioning activities could directly deter terns or gulls or their prey from the area of the proposed action resulting in the temporary or permanent loss of habitat. A decrease in food availability can result in decreased breeding success or increased mortality (Safina et al., 1988). However, baseline surveys conducted in Nantucket Sound documented minimal tern use of the area of the proposed action in relation to other locations in the Sound. Most terns were observed traveling, fewer were seen actively foraging. Terns and gulls are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Visual data collected at the Nysted and Horns Rev facility in Denmark indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 miles (2 km) zone surrounding the facility (Petersen et al., 2006). One study documented habituation of gulls to turbines that were constructed on a jetty where the gulls were observed feeding, apparently undisturbed near the turbines (Kerlinger and Curry, 2002). Terns and gulls would be expected to habituate to the presence of the proposed turbines similar to how they have demonstrated habituation to a variety of man-made structures, including other turbines. These birds would likely continue to forage and travel in the vicinity of construction activities and operating WTGs, assuming that their food sources were not displaced.

Vibrations from pile-driving could startle and temporarily displace prey fish from the area of the proposed action. Increases in turbidity from cable trenching could temporarily impede fish foraging and navigation in disturbed areas (Jarvis, 2005). Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized within the area of the proposed action. A jack-up barge (approximately 172 square ft [15.9 $m^2$]) with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving. Sediment suspended by trenching during offshore cable installation is expected to be localized (20 mg/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (Report No. 4.1.1-2). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms would be stirred up and prey fish may be attracted to the area to forage. This in turn could attract terns and gulls to forage.

There is limited information available regarding the routes terns travel from breeding, staging, and roosting areas at sites in Long Island Sound, Long Island, Nantucket Sound, and Buzzards Bay. It is unknown if the project area serves as a traveling corridor for commuting terns. Available studies from existing offshore wind farms indicate that terns are displaced from direct turbine areas but continue their use of the nearby surrounding areas (Petersen et al., 2006), though other studies indicate that terns continue to travel through turbine areas making slight alterations to their flight paths (Evareart and Stienen, 2006). Therefore, impacts associated with habitat loss to commuting terns are anticipated to be negligible for terns. Based on available information, the area of the proposed action is not considered a significant tern foraging location. Because of the small footprint of the actual development area, negligible habitat loss is anticipated during proposed action construction and operation activities. Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, major impacts associated with loss of habitat or modification are not anticipated. To some extent, the increased substrate of under-water structures associated with the construction of the project may increase foraging habitat for terns and gulls (refer to Section 5.3.2.9.1 and 5.3.2.9.2 *Habitat Loss and Modification* for more detail). The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005).

*Human Disturbances*

Increases in human presence and vessel traffic could result in impacts to terns and gulls during the construction, and decommissioning phases of the proposed action. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction. During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the area of the proposed action. Additionally, small vessels from Falmouth, Massachusetts, and a maintenance support vessel from New Bedford would make regular trips to HSS during the construction period.

During high surf conditions, workers may be transported by helicopter to the platform on the ESP. There may also be occasional helicopter landings at the ESP in association with some regular maintenance activities. An increase in recreational fishing may occur around the WTGs if fish populations aggregate around foundations. The arrival of vessels and helicopters could temporarily displace terns or gulls from localized areas within the larger area of the proposed action. This type of disturbance already occurs to some extent within and adjacent to the area of the proposed action due to existing levels of vessel activity.

Terns and gulls appear to be less sensitive to human disturbances than other species of birds, and are also thought to be attracted to some areas of human activity (Borberg et al., 2005; Drewitt and Langston, 2006; Sadoti et al., 2005a). Terns are known to habituate to some levels of human presence and disturbance. Terns are regularly observed traveling and foraging in the vicinity of vessels and other man-made structures. At the Nysted and Horns Rev facilities in Denmark, gulls were abundant in the construction area likely as a result of increased vessel activity (Petersen et al., 2006). An increase in the presence of terns and gulls observed in areas around the Horns Rev offshore facility in Denmark was believed to be associated with increased boat activity for maintenance activities (Petersen et al., 2006). Therefore, terns and gulls are expected to continue their traveling and foraging activities despite the presence of increased boat traffic and the few anticipated helicopter landings in HSS. Terns and gulls would be expected to return to the area after the departure of the vessels.

Terns and gulls are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with construction and decommissioning activities. Therefore disturbances associated with increases in human presence and vessel activity are anticipated to have negligible impacts on terns.

*Risk of Collision*

The potential exists for terns and gulls to collide with WTGs under construction, and with large construction equipment. The results of available mortality studies indicate that the majority of avian collisions with man-made structures take place at night during periods of inclement weather (Kerlinger, 2000). Birds that fly within proximity to construction equipment or within the rotor zone of the turbines would be at greatest risk of collision. Risk of collision is expected to result in minor impacts to gull species based on the stable populations of species that are most abundant in the area (risk of collision is discussed in more detail in Section 5.3.2.4.2). Impacts to terns associated with collision during construction are anticipated to be moderate to major (risk of collision is discussed in more detail in

Section 5.3.2.4.2). Although the risk of collision during construction is anticipated to be low for tern species, any level of collision mortality for species of conservation concern, such as the endangered roseate tern, or for common or least terns (both species of special concern) would represent a major impact. A discussion of the risk of collision specific to roseate terns is provided in the BA in Appendix G. Risk of collision for tern species during the construction phase is anticipated to result in moderate to major impacts.

***Pelagic Species (shearwaters, petrels, gannets, auks)***

Oceanic or pelagic species such as shearwaters, gannets, storm-petrels, and auks typically spend most of their lives well offshore, particularly during the non-nesting season. However, storm events and strong, consistent on-shore winds can push these offshore species into coastal areas and occasional seasonal influxes of these species might occur during migration. Potential proposed action impacts are limited to risk of collision during operation of the proposed action (see Section 5.3.2.4.2). Due to the infrequent occurrence of pelagic species anticipated during the construction phase, risk of collision is anticipated to be low. Therefore, impacts associated with collision risk are expected to be minor.

***Waterfowl and Non-Pelagic Water Birds***

There are a number of sea duck, waterfowl, and diving species that occur within Nantucket Sound, particularly during the winter months. Species such as scoter, eider, and long-tailed duck over-winter in large flocks in the region. Also, a number of common and red-throated loon (*Gavia stellata*), as well as grebes, geese, brant, and dabbling ducks, are local to the bay during various times of the year. Double-crested cormorants are abundant in the site of the proposed action through the breeding season and late-fall. Great cormorants occur in the area mainly in the winter months.

*Habitat Loss and Modification*

Habitat modification during construction and decommissioning could displace sea duck and waterfowl. Displacement can lead to over-crowding and competition at alternative foraging sites and can ultimately result in increased mortality of more vulnerable species (Maclean et al., 2006). Optimal foraging locations are generally restricted to waters no deeper than 164 ft (50 m) deep, however, they are typically less than 31 ft (10 m) deep (USFWS, 2001b; Robertson and Savard, 2002). This is due to the energetic costs of diving to access resources. Sea ducks, including long-tailed duck, scoter, and eider, which forage on sedentary benthic invertebrates, are among species most sensitive to loss of habitat due to offshore wind development. A study at the Tuno Knob facility, in Denmark failed to find any evidence that the distribution of common eiders was affected by the presence of the turbines themselves, but was correlated to changes in bivalve distributions (Guillemette and Larsen, 2002). The impact of habitat modification on sea ducks would be dependent on the location of the turbines in relation to suitable feeding areas.

The area of the proposed action is characterized by water depths of 8 to 60 ft (2.4 to 18.3 m), and the average depth is less than 20 ft (6 m). The dominant substrate is medium and fine sand. Benthic macroinvertebrate sampling indicated the HSS benthic community included a variety of organisms such as crustaceans, clams, snails, and worms. Mussel habitat, such as boulders and ledges, are not a notable component of the area of the proposed action. Common eider diet consists mainly of mollusks and crustaceans (Palmer, 1976) and they prefer blue mussels (*Mytilus edulis)* which are typically attached to rocky substrates. Scoter diet consists of mollusks (Bordage and Savard, 1995; Brown and Fredrickson, 1997; Savard et al., 1998), such as Arctic wedge clam (*Mesodesma arctatus*) and Atlantic razor clam (*Siliqua costata*), found in sandy substrates along coastlines (Stott and Olson, 1973). The benthic community provides suitable foraging habitat for scoters and marginal foraging habitat for eiders. Long-tailed duck forage for crustaceans including amphipods and isopods, bivalves, gastropods, fish and fish eggs (Robertson and Savard, 2002). Other waterbirds such as cormorants may prey on small fish in the area of the proposed action.

Surveys conducted in the Nantucket Sound study area indicate that in recent years, sea ducks such as scoter and eider forage in the area of the proposed action during the winter. However, the abundance of sea duck in the area of the proposed action was low compared to other locations surveyed in the Sound, indicating abundant alternative foraging habitat outside of the area of the proposed action (Report Nos. 4.2.4-2, 4.2.4-12, and 4.2.4-13). Long-tailed ducks are thought to forage during the day south of Nantucket Island, on Nantucket Shoals (NS), and then commute in the evening to roost overnight in Nantucket Sound. Because much of the long-tailed duck population of Nantucket Sound is assumed to forage in NS, substantial loss of foraging habitat is not an anticipated impact for long-tailed duck.

During construction, increases in turbidity from cable trenching could temporarily impede foraging, as well as displace prey fish for foraging cormorant. Vibrations from pile driving could displace prey fish as well. Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill, 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized within the area of the proposed action. A jack-up barge (approximately 172 square ft [15.9 $m^2$]) with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving. Sediment suspended by trenching during cable installation is expected to be localized (20 mg/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms may be injured or killed. However, such benthic impacts would be minor and there are expected to be minimal impacts to the prey base due to construction of the proposed action.

High numbers of ducks (often greater than 1,000), particularly scotors, were observed in HSS, but these counts were not significantly higher than that observed for the rest of Nantucket Sound. The survey data do not indicate that HSS is preferred by waterfowl over other portions of Nantucket Sound. Because some species of waterfowl have been observed to be displaced by wind resource areas, the proposed project could result in habitat loss for waterfowl. However, it does not appear that HSS is surrounded by unsuitable habitat for displaced birds. Habitat loss or modification due to the project construction will affect waterfowl, but this is not considered to be a major effect.

Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, major impacts associated with loss of habitat or modification are not anticipated. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005). Project construction is expected to have moderate effects to waterfowl due to displacement. It remains to be seen if waterfowl and pelagic species return to HSS after construction is completed. There is evidence that some species will be displaced beyond construction (Petersen et al., 2006). The certainty of these effects to waterfowl remains low, but this will be better defined through the implementation of the proposed monitoring measures (Section 9.0).

*Human Disturbances*

Disturbances such as increased human presence and vessel activity during proposed action construction and decommissioning associated with the operation of loud construction equipment may result in impacts to sea ducks and waterfowl. If these disturbances are substantial, they may displace sea duck and waterfowl. The level of disturbance is based on the proposed action design and proximity to roosting, feeding and breeding habitat (Exo et al., 2003). Divers including loons and scoters are particularly sensitive and could be disturbed during construction and decommissioning activities due to their strong reaction to boats (Winkelman 1992 *as cited in* Maclean et al., 2006; Exo et al., 2003).

Noise and vibrations associated with construction activities such as drilling and piling and cable laying can impact the acoustic systems of benthic species within 328 ft (100 m) of the source and can cause some mobile species to avoid the area (Nedwell et al., 2004 *as cited by* Gill, 2005). Underwater noises are known to deter foraging waterfowl from the area (Gill, 2005). As pile driving and cable laying would be temporary and limited to small areas directly under construction, these disturbances are expected to result in minimal impacts to foraging birds (see previous section for a description for impacts associated with habitat modification).

Observations at existing offshore facilities indicate that increased vessel activity during the construction and decommissioning could result in disturbances to sea duck or waterfowl foraging in the vicinity of the area of the proposed action. The area surrounding the proposed development experiences regular vessel activity, therefore, increased human presence or vessel activity is not anticipated to present a substantial increase in disturbances. Results from other facilities indicate that divers and other sea ducks may be displaced by approaching vessels, however, they return after the vessel departs. Therefore, human disturbances are not expected to result in long-term or major impacts to foraging sea duck or waterfowl. Minor impacts are anticipated to result from human disturbances associated with construction, decommissioning of the proposed action.

*Risk of Collision*

The potential exists for migrating or dispersing birds to collide with WTGs under construction and with large construction equipment. The risk of collision depends on use of the area of the proposed action, visibility during crossings of the area of the proposed action, and flight behaviors exhibited during encounters with turbines. In general risk of collision during construction/decommissioning is expected to be negligible as impacts associated with collision are primarily related to operation of the wind turbines (see Section 5.3.2.4.2). Some waterbirds, such as cormorants, may be at risk for collision with stationary monopiles during construction. Cormorants are often seen flying within the range of the rotor-swept zone. There is some evidence that great cormorants may be declining (Nisbet and Veit, in review). Additional losses in the numbers of great cormorants due to collision with wind turbines may put the population at risk. Based on the uncertainty associated with turbine collision, effects of the proposed project to the North American population of great cormorants may be significant.

**Conclusions on Construction/Decommissioning Impacts**

Based on research cited and information discussed herein, with respect to affects resulting from habitat modification, human disturbance, and risk of collision, the overall construction and decommissioning impacts to non T&E avifauna would be minor.

#### 5.3.2.4.2 Operational Impacts

**Terrestrial Birds**

***Raptors (hawks, owls, eagles, falcons, etc.)***

The potential impacts to raptors associated with operation of the proposed action include loss or modification of habitat, a barrier effect due to the presence and operation of the WTGs, and risk of collision with the operating WTGs, and impacts associated with EMF from the onshore transmission cable system.

Osprey, in unusual situations have been known to forage as far offshore as 0.6 to 3.2 miles (0.6 to 5 km) (Poole et al., 2002), however they would not be expected to forage in HSS which is approximately 5 miles (8 km) offshore. No other raptor species would be expected to forage in the vicinity of the proposed action (Buehler, 2000). Therefore, no loss of habitat is expected to occur in HSS. Habitat loss associated with the presence of the offshore transmission cables system within Lewis Bay is anticipated to be negligible for raptors, since the buried cable does not represent a permanent alteration of habitat. During operation, the cable itself would result in minimal influences on the benthos, and therefore impacts to raptor foraging locations would be negligible.

There is a potential that the presence of WTG structures or ESP could result in habitat modification in the form of perching opportunities for migrant raptors. A Eurasian species of raptor at the Horns Rev facility was occasionally observed perching on turbine foundation safety railings (Christensen et al., 2003). However, specific design features have been incorporated to discourage avian perching on the ESP and WTG structures. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck. The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of tubular towers instead of lattice towers also discourages perching. Therefore, it is not anticipated that migrant raptors would use structures in the site of the proposed action for perching habitat.

The presence and operation of WTGs may result in a barrier to the flight path of migrating raptors. Due to the northeast to southwest orientation of the Atlantic Coast, many raptor and owl species follow the major ridgelines and the Atlantic coastline as ‘leading lines’ while migrating. Some species are known to occasionally migrate offshore and others may be blown offshore by changing weather conditions. Most raptor species are not expected to occur in the area of the proposed action during migration as most species generally avoid major water crossings (Wheeler, 2003). Exceptions include peregrine falcon, merlin, Northern harrier, and, occasionally, sharp-shinned hawk, and short-eared owl (Wheeler, 2003; Warkentin et al., 2005; MacWhirter and Bildstein, 1996; Wiggins et al., 2006). Wind direction and speed could result in migrants getting blown offshore while following the coast, however, raptors have been observed making adjustments to their flight behavior to avoid flying away from land in changing wind conditions (Crocoll, 1994; Bildstein and Meyer, 2000; Curtis, 2006). There are no topographic features (such as leading lines or shortest crossings) that would funnel migrants that may occur offshore into the area of the proposed action. If migrants were to occur offshore, they would not be expected to concentrate in the area of the proposed action. Therefore, it is not anticipated that development of the proposed action would result in a significant barrier effect to raptors that may occur offshore. Raptors may make alterations to their flight behavior to avoid encountering turbines during migration (refer to the following section describing turbine avoidance behavior); however, increases in energy expenditure are anticipated to result in negligible impacts to migrating raptor.

Raptors may be among species of terrestrial animals impacted by artificial sources of EMF. Some birds can detect the earth’s magnetic fields and may use magnetic fields for orientation during migration (Hanowski et al., 1996). Artificial sources of EMF could potentially influence the navigational systems of birds, but significant effects on the individual level or community level have not yet been determined (Fernie et al., 2000). Additionally, artificial sources of EMF have been shown to affect the reproductive success of kestrels (Hanowski et al., 1996). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system, the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to raptor species are anticipated to be negligible.

There is a risk of collision of migrant raptors with the operating turbines. The risk of collision depends on the frequency of occurrence in the area of the proposed action, weather conditions and visibility during encounters with WTGs, and the flight height of traveling raptors. Daytime boat and aerial surveys between 2002 and 2006 documented no raptor observations within the area of the proposed action. HSS is not anticipated to be an area of concentrated use by migrant raptors. The flight behaviors of raptors, if they were to occur in the area of the proposed action would depend on weather conditions.

The majority of raptor migration flights have been documented at elevations well above the proposed rotor zone 75 to 440 ft (23 to 134 m) (Poole et al., 2002; MacWhirter and Bildstein, 1996) although some have been documented flying just above the surface of the waves (Warkentin et al., 2005). Limited information on owl migration flight behaviors suggest owls occur at relatively low altitudes. Observations of barn owls over coastal migration sites reported flight altitudes greater than 32.8 ft (10 m) (Marti et al., 2005). Long-eared owls have been observed flying at altitudes of 98 to 164 ft (30 to 50 m) just after sunset (Marks et al., 1994). The majority of raptors migrate during the day during periods of strong thermal development when the risk of collision is low. However, some species of raptor, including peregrine falcon and Northern harrier, and owls are known to make movements at night (Wheeler, 2003). Merlin and Northern harrier will fly in periods of light rain and fog when conditions would increase the risk of collision (Wheeler, 2003; MacWhirter and Bildstein, 1996). However, the occurrence of raptors in HSS is anticipated to be infrequent and sporadic therefore the chance of turbine encounters is anticipated to be minimal. Some species of raptor have demonstrated high turbine collision avoidance behaviors at existing onshore wind farms. Whitfield and Madders (2006) used the Band Collision Risk Model to estimate the avoidance rate of hen harriers (*Circus cyaneus*) at eight wind farms in the U.S.: estimates were 100 percent turbine collision avoidance at 6 sites, 99.8 percent at 1 site, and 93.2 percent at 1 site. Another study reported a 99.5 percent turbine avoidance rate for golden eagle (*Aquila chrysaetos*) at a U.S. facility (Chamberlain et al., 2006). These avoidance behaviors reduce the risk of raptor collisions. Additionally, there are observations of raptors waiting out poor weather during migration (White et al., 2002). Although most owl migration occurs at night, movements are associated with clear weather during periods of light following winds (Marti et al., 2005; Cannings, 1993). Therefore, the chance of migrants occurring in the area of the proposed action during periods of elevated risk of collision is low. The risk for collision of raptors with operating WTGs is anticipated to be low; therefore, impacts associated with collision mortality are anticipated to be negligible.

The proposed action is anticipated to result in negligible impacts to raptor foraging habitat. The presence and operation of the WTGs is not expected to present a major barrier to the flight paths of migrating raptors because raptors are expected to occur infrequently and sporadically over the Sound. The overall risk of raptor collisions with WTG structures is low as raptor occurrence in the area of the proposed action is expected to be infrequent and sporadic. Therefore, operation of the proposed action is expected to result in negligible impacts to raptors.

***Passerines***

A substantial portion of the land bird population of North America consists of neotropical and regional migrant passerines. A number of local or migrant passerine species occur in the area of Nantucket Sound at varying times of the year. While it’s a conventional belief that coastal areas concentrate migrant passerines during active migratory flights and during stopover events, little information exists on the actual numbers of night migrants in the air along the Atlantic Coast. While relatively few species routinely use open water, marine habitat, large numbers of passerines could occur in and over the area of the proposed action during both nighttime and daytime migration. Migrants may be blown offshore depending on the prevailing wind direction during nighttime movements along the coast. Some neotropical migrant species, specifically those of the family *Parulidae* (wood warblers), may make substantial water crossings during nocturnal migration (Richardson, 1978a). Although a number of terrestrial ornithological radar studies have been conducted to determine the characteristics of nocturnal migration, there is little information available that thoroughly quantifies nocturnal migration over the ocean.

Potential impacts to migratory passerines during construction, operation, and decommissioning of the proposed action include risk of collision mortality, and potential impacts associated with EMF from the onshore transmission cable system.

*Known Collision Mortality at Existing Facilities*

Passerines are the most abundant group of birds occurring in North America and species of this group (e.g., warblers, vireos, thrushes, sparrows) account for up to 80 percent of known fatalities reported at onshore wind facilities (Johnson et al., 2003; Erickson et al., 2001). The estimated mortality rate of birds in Eastern North America due to terrestrial wind energy facilities is approximately 0-11.7 birds per kW per year. However, due to the small size of most passerine species and the inherent difficulty in finding and identifying carcasses near turbines, it is likely that mortality rates have been underrepresented by post-construction mortality surveys (NRC, 2007). Mortality of these species has included both daytime and nocturnal fatalities (Erickson et al., 2001). A wide variety of species have been found during mortality surveys but, to date, no large fatality events, as have been occasionally observed at tall communications towers, have been reported in the literature.

Erickson et al. (2001) provided a summary of known avian collisions with wind turbines. Fatality rates varied from 0 to 4.5 fatalities/turbine/year with most of the reported rates being less than 2 fatalities/turbine/year although more recent work has documented rates as high as 7.28 fatalities/turbine/year (GAO, 2005). They estimate an average of 2.19 bird fatalities/turbine/year in the United States, although this estimate does not reflect the variability in fatalities among wind energy facilities (i.e., some have reported dozens of fatalities while others have reported very few or none). However, they do recognize that sites in California have significantly more fatalities than elsewhere, and estimate the fatality rate to be lower outside of California, at approximately 1.83 fatalities/turbine/year (corrected for searcher efficiency and scavenging).

There are limited data available from existing offshore facilities. A study conducted at a coastal wind farm in the Netherlands documented songbird, water bird, and shorebird collision fatality rates ranging from 0.04 to 0.14 fatalities per turbine per day (Kerlinger and Curry, 2002). The study indicated that these coastal turbines created higher fatalities rates than other, onshore wind farms, likely as a result of the large concentrations of migrant and wintering waterfowl, shorebirds, and songbirds in the area (Winkelman, 1995, *as cited by* Kerlinger and Curry, 2002). It was believed that these fatalities were not only linked to migratory flight but also to birds undertaking low flights between feeding locations (Winkelman, 1995, *as cited by* Kerlinger and Curry, 2002).

*Risk of Collision*

An assessment of nocturnal migration over Cape Cod was made in the early 1960's, using radar. This survey at South Truro, Massachusetts, showed that migration was occurring at heights of approximately 600 ft to over 6,000 ft (183 m to 1,829 m) above ground level (Nisbet, 1963). Subsequent assessments of nocturnal migration in Nantucket sound, using modern radar systems, documented that the majority of nocturnal targets occurred at heights greater than 75 ft (23 m) AMSL (see Table 4.2.4-4; Report Nos. 4.2.4-5, 4.2.4-6 and 4.2.4-7).

Flight heights documented during 69 radar surveys conducted over eight seasons in terrestrial ecosystems throughout the Northeast, revealed that flight heights typically average 1,401 ft (427 m) above ground level, and nightly average flight heights ranged from 505 ft (154 m) to 2,112 ft (644 m) above ground level. Average seasonal passage rates ranged from 64 targets/km/hour to 732 targets/km/hour, with an overall average of 313 targets/km/hour (see Table 5.3.2-2).

A summary of the radar surveys is provided in Table 4.2.4-4. The average flight heights documented over Nantucket sound are lower than those documented for terrestrial ecosystems (Table 5.3.2-2). Also, the passage rates were lower over Nantucket Sound than at the majority of terrestrial radar sites (Table 5.3.2-2). Relatively low overall passage rates may have been due to the more limited ability for S-band radar to isolate small targets. Hence, passerine numbers were not well represented in the radar survey samples. The use of S-band radar may skew the data if too few targets are isolated, as is indicated in Table 4.2.4-4.

Despite the majority of migration occurring well above turbine height birds have been known to collide with tall solid structures (Shire et al., 2003). Mortality events greater than a few birds at single or adjacent turbines occur infrequently (Erickson et al., 2001). The ecological significance of the number of birds killed by turbines on regional populations has not been adequately addressed. Similarly, the significance of turbine related deaths in relationship with other anthropogenic mortality events has not been adequately defined. It is estimated that tens of millions of birds are killed annually by colliding with buildings, transmission lines, and vehicles, where as the annual estimate of birds killed by wind turbines numbers in the tens of thousands (Erickson et al., 2001). Further, Coleman et al., (1997) estimated that free ranging rural cats kill between 7.8 million and 217 million birds per year just in Wisconsin alone (Coleman, J.S.,S.A. Temple, and S.R. Craven. 1997. Cats and Wildlife: A Conservation Dilemma. 6 pp.).

Calculating risk of collision to species or groups of birds is difficult because of a paucity of information identifying exposure to collision. Certain passerine species may be more likely to fly within the rotor swept zone and are therefore at higher risk. The specific behavior patterns of birds species or groups coupled with their relative abundance in the proposed development area, must also be considered.

In general nocturnal migrant passerines do not fly within the turbine zone, and those flying over open water often return to land at dawn (Kerlinger and Curry, 2002). Despite the possibility that songbirds may be flying at relatively lower altitudes over Nantucket Sound it is likely that during periods of decent visibility these individuals would not be at risk for collision. The lighting of turbines is an important factor that can change the amount of risk to passerines and can be easily adapted. However, some evidence has shown that lighting structures can increase the risk of collision to birds during migration (Kerlinger and Curry, 2002), particularly during periods of fog or rain (Huppop et al., 2006). A more detailed discussion of structure lighting is provided in this section under Marine Birds – Risk of Collision.

Specific information about passerines was not collected. It reasonable to assume that passerines migrate over Nantucket Sound in a similar manner as that observed of passerines migrating over land, that is nocturnally, at relatively high altitudes, and landing at stop-over sites. Flocks of migrants are often documented stopping at on-shore locales surrounding Nantucket Sound, such as Cape Cod, Martha's Vineyard, and Nantucket Island.

Most bird mortality at wind projects is believed to be caused by collisions with the turbine blades, particularly moving blades, but the monopiles may pose risks as well. However, it is generally accepted that nocturnally migrating passerines fly at relatively high altitudes, that is, above 410 feet (125 m)

(Mabee et al., 2004). Exceptions to this may occur when weather conditions, such as fog or light rain, force birds to fly at much lower altitudes. This is a major consideration as 1 in 6 days are foggy in Nantucket Sound. It is suspected that the risk posed to passerines by the proposed action may be higher than the collision mortality observed at existing facilities due to the increased incidences of foggy days. Therefore, the impacts to passerines associated with collision mortality are anticipated to be moderate.

*Electromagnetic Fields*

Birds may be among species of terrestrial animals impacted by artificial sources of EMF. Some birds can detect the earth's magnetic fields and may use magnetic fields for orientation during migration (Hanowski et al., 1996). Artificial sources of EMF could potentially influence the navigational systems and reproductive success of birds (Fernie et al., 2000; Hanowski et al., 1996). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to passerine species are anticipated to be negligible.

**Coastal Birds**

***Operation***

The potential impacts to shorebirds or wading birds during proposed action operation may include impacts associated with disturbance from vessel activity during cable repair, impacts associated with oil spills or WTG or ESP damage fluid spills, the risk of collision of migrants with WTG structures, as well as barrier effects to traveling birds.

*Vessel Traffic*

There would be an increase in vessel activity associated with maintenance of the WTGs during the operation of the proposed action. During operation, maintenance vessels would mainly operate out of Hyannis or similar Cape Cod ports. These ports have adequate facilities for berthing and loading of the maintenance vessels. These ports occur in developed areas and currently experience similar uses. There are no known important coastal bird areas in the vicinity of these ports, therefore, the increase in vessel activity in these areas is anticipated to result in negligible impacts.

There may be an increase in vessel activity associated with offshore cable repair during the operation phase. However, the cable is designed under normal conditions to last the life of the proposed action. The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. Near shore maintenance activities in Lewis Bay would be temporary and there would be an 820 ft (250 m) or greater buffer between the offshore cable maintenance activities and potential shorebird habitat. Therefore, disturbances associated with maintenance activities are anticipated to result in negligible impacts.

*Oil Spills*

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. The presence of the facility may slightly increase the risk of spills from vessels colliding with one of the Cape Wind structures. The increase could be offset by the decrease in vessel trips in the region by tank barges carrying heavy fuel oil for oil-based energy-generating facilities. Oil spills may result in the release of contaminants from vessels or from the WTG or

ESP foundations themselves. Depending on the location and the size of a spill, shorebirds and wading birds may be impacted. If the feathers of birds become coated with oil, birds loose their ability to repel water and to insulate, and in some instances, loose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2005). Shorebird habitat was impacted by the oil spill, particularly at Barney's Joy, Dartmouth, and shorebird mortality was a resulting impact (NOAA, 2005), including 18 shore birds (12 dunlin, 2 willet, 4 yellow-leg), but no wading birds were documented (BBNEP, 2005).

Monopile collapse, vessel collisions, or storm damage to the ESP or WTG structures could result in oil or other fluid contamination. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons (158,987 liters) at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

The potential impacts of oil spills associated with the operation of the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the mortality of coastal birds if nesting, staging, or over-wintering areas were to be impacted. However, the event of an oil spill is unlikely, and due to the distance between the WTG area and the closest potential habitat on either the mainland or island shores of Nantucket Sound, the potential for impacts are reduced. Therefore, oil spills are anticipated to result in minor adverse impacts to coastal birds.

*Risk of Collision*

Risk of collision is based on the frequency of occurrence through the area of the proposed action, visibility conditions during encounters with wind turbines, and the flight behaviors of birds during crossings of the area of the proposed action. Shorebirds and wading birds typically remain onshore except during migration although they occasionally cross water bodies such as bays to access foraging or high-tide roosting locations. As the site of the area of the proposed action is located over 5 miles (8 km) offshore, coastal birds may only occur within the area of the proposed action during migration movements. Migrants may occur over areas of Nantucket Sound; however, there are no known shorebird or wading bird migration corridors that occur over HSS. During operation of the wind farm, shorebirds or wading birds would be at risk of collision with WTGs, particularly birds that migrate at night or during periods of low visibility.

Studies have demonstrated that steady burning FAA obstruction lighting (Gehring and Kerlinger 2007) and some other types of lighting, on tall structures can attract or disorient night migrating birds, resulting in collisions with those structures, especially during periods of fog, rain, or low ceiling (Huppop et al., 2006). Lighting on tall structures is believed to be associated with high collision rates of nocturnal songbird migrants (Huppop et al., 2006, Shire et al., 2000). The effects of lighting on nighttime migrating shorebirds and wading birds are not well studied. Shorebirds and wading birds represent a small fraction of collisions documented with tall, lit structures (Huppop et al., 2006; Shire et al., 2000); however, the effects of refraction to lighting during periods of rain or fog may contribute to increased collision risk of these birds. However, Petersen et al. (2006) observed a substantial decrease in the volume of migrating birds at an offshore wind farm in Europe during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006). A more detailed discussion of structure lighting and potential impacts to birds is provided in this section under Marine Birds – Risk of Collision.

Due to limitations of boat and aerial surveys, there is no coastal bird data available for nighttime migration or inclement weather conditions within the area of the proposed action. However, shorebird species have been documented at flights greater than 1.2 miles (2 km), well above the proposed rotor zone during nighttime migration movements (Richardson, 1978b). Shorebirds that migrate both day and night have been documented at heights as high as 2.8 to 3.7 miles (4.5 to 6 km) (Sibley, 2001). Shorebird species are known to migrate at altitudes from just above the surface of the water to 3.7 miles (6 km), depending on the altitude where favorable wind conditions exist (Sibley, 2001). Available data from existing offshore facilities in Europe indicate shorebird species generally migrate at altitudes well above the rotor zone, and birds that occur in the vicinity of the wind farm make efforts to avoid flying within the wind farm. Visual confirmation coupled with radar surveys during migration periods from 2003 to 2005 at the Nysted and Horns Rev offshore facility in Denmark observed shorebird migration through the project area. Shorebird migration generally occurred at altitudes high above the wind turbines >0.18 miles (>0.3 km). The flight altitude of one flock of shorebirds was estimated to be 0.25 miles (0.4 km) above sea level.

Many species are known to depart beaches for migration on rising tides, during all times of the day, but mainly in the late afternoon or early evening (Sibley, 2001). Other observations indicate shorebirds may depart for migration mainly on sunny days, in the few hours before twilight (Harrington 2001). Inclement weather may deter the departure of migrants as many shorebird species move inland during coastal storms to nearby agricultural fields (Sibley, 2001). It is, however, during periods of inclement weather when birds are traveling at lower altitudes or when birds are arriving or departing stopover habitats that these birds could be most at risk of encountering the proposed wind turbines. In fact, studies from the existing offshore wind farms in Europe indicate that shorebirds can be at risk of collision at stopovers during short flights to foraging or resting areas (Kerlinger and Curry, 2002, Everaert, 2004). However, the location of the proposed turbines would be at least 5 miles (8 km) from concentrated shorebird or wading bird use areas such as shorelines and shallow areas exposed at low tide; therefore, the risk of collision is reduced.

Breeding shorebirds are not expected to frequent the project area. However, migrating shorebirds that breed north of Nantucket Sound may fly through the area of the proposed action in spring or fall. Because little is understood about shorebird flight heights, it is reasonable to anticipate the project could potentially have significant risks to shorebirds and wading birds, particularly for species of conservation interest. Any level of collision mortality of the threatened piping plover would represent a more substantial impact because the loss of one breeding individual is detrimental to the regional population (the risk of collision of piping plover is discussed in more detail in the BA in Appendix G). The incidence of collision is uncertain for migrant shorebirds. Due to this level of uncertainty, the impacts associated with collision are anticipated to be moderate for coastal bird species other than the piping plover.

*Barrier Effect*

The presence of operating WTGs may present a barrier to the flight path of migrating shorebirds or wading birds. The creation of a barrier may result in increased energy expenditure to avoid the wind farm. Visual confirmation coupled with radar surveys during migration periods from 2003 to 2005 at the Nysted and Horns Rev offshore facility in Denmark observed shorebird migration through the project area. The behavior of shorebirds flying towards the wind farm was noted for four flocks of shorebirds: Golden Plover (N = 11), Curlew (N = 4), Whimbrel (N = 1), and Oystercatcher (N = 15). The flocks of golden plover and oystercatcher passed above the turbines, while the single Whimbrel entered the wind farm at the height of the rotors and flew southward through the wind farm. The one flock of Curlews hesitated before entering the wind farm, then increased their flight altitude and increased their wing beat frequency in order to pass above the wind farm (Petersen et al., 2006). These observations suggest that some birds may increase energy expenditure to fly above or around offshore wind turbines. The energy expended while birds make efforts to avoid offshore wind farms is believed to result in small increases in energy expended during migration movements. These increases are believed to be comparable to other increases in energy spent to avoid additional migration hazards including adverse weather (Petersen et al., 2006). There are no known migration corridors that would concentrate shorebird or wading bird migration through the site of the proposed action, therefore, barrier effects associated with the operating turbines are expected to result in minor impacts to migrants.

### Marine Birds

#### *Operation*

Operation of a wind facility can result in more long-term disturbances including habitat loss, disturbances associated with EMF from the offshore cable, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with monopile collapse or cable repair, impacts associated with oil spills, as well as the risk of collision with operating turbines.

The following sections summarize marine bird uses of Nantucket Sound, describe the potential proposed action impacts to marine birds according to taxonomic group during the operational phase, and finally, attempt to gauge the magnitude of impacts to marine bird populations. Detailed analysis for roseate tern, a federally-endangered species has been provided in the BA in Appendix G.

Scour control around monopiles and ESP piles would be accomplished either through the use of rock armor or scour control mats. These mats and the monopiles would increase the available surface area and provide substrate for the colonization of benthic invertebrates and habitat for prey fish. Fish may concentrate around turbine foundations similar to how invertebrates cluster around oil platforms (Vella, 2002 *as cited by* Jarvis, 2005). Habitat with more 'physical heterogeneity' can result in greater fish abundance (Jenkins et al., 1997 and Charbonnel et al., 2002 *as cited by* Gill, 2005). The underwater structures could create a localized 'artificial reef effect' (see Section 5.1.5.11), providing foraging habitat for terns and gulls in the immediate vicinity of the turbines. Terns and gulls may be at risk if they are attracted to foraging opportunities at the turbine bases. The spacing of turbines (0.39 to 0.63 miles [0.63 to 1.0 km] apart) does not necessarily permit safe foraging for tern and gull (see section Risk of Collision below).

The boundary of the area of the proposed action would include approximately 25 square miles (64.7 $km^2$) of WTGs and ESP (electrical service platform) foundations, and 5.89 acres (23,835$m^2$) of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area: including 0.67 acre (2,725 $m^2$) for the 130 turbines, 100 by 200 ft (30.5 by 61 m) for the ESP platform, and approximately 1.96 acres (7,946 $m^2$) for scour mat coverage, and 8.75 acres (35,417 $m^2$). The additional amount of surface area (approximately 1,200 square ft or 0.03 acres [111 $m^2$] per tower would result in a minor addition to the substrate that is currently available (Section 3.9 in ESS, 2007). Due to the small amount of additional surface area in relation to the total area of the proposed action in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant effect on the benthic community, the presence of prey fish, or foraging terns or gulls.

However, the additional substrate would be oriented vertically in the water column, and could result in localized and minor increases in certain fish prey species.

As the area of the proposed action is not a significant foraging location or traveling corridor, and because of the small footprint of the actual development area, minimal habitat loss is anticipated during proposed action operation activities.

*Human Disturbances*

While the proposed turbines are in operation, there would be regular vessel trips made from Falmouth and New Bedford harbors to the site of the proposed action. The expected maintenance schedule would be approximately two vessel trips per day for 252 days per year (five maintenance days per turbine per year) (see Section 2.4.3.1). However, the vessels would depart busy ports where similar uses occur, and therefore impacts are limited to areas along the offshore transmission cable system as well as the WTG area.

Terns and gulls are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with maintenance activities. Therefore disturbances associated with increases in human presence and vessel activity are anticipated to have minor impacts on terns.

*Electromagnetic Fields*

There is a concern that electromagnetic fields emitted from the offshore cables may impact prey fish. It has been suggested that EMF in ocean environments may effects movements of magnetosensitive species, however, it is unknown what these actual impacts may be (Gill, 2005).

The specifications of the proposed cable system require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Magnetic fields, however, can not be completely shielded because the magnetic field lines do not stop on objects; they form continuous loops around conductors carrying currents. The actual magnitude of typical 60 Hz magnetic fields in the vicinity of the offshore cables is, in most locations, well below that of the geomagnetic field (~ 500 mG). Therefore, no additional electric field impacts are expected to result from the submarine cables. There are no anticipated major impacts to foraging birds or their prey from the 60 Hz magnetic fields associated with the operation of the proposed action.

*Oil Spills*

During operations, the presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil could be released from tankers or damage to WTG structures or the ESP could result in the release of fluid contained within these structures. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons (158,987 liters) at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha’s Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

Because terns and gulls forage at the water’s surface, they are among those species of birds that are particularly vulnerable to oil spills (Jarvis, 2005). If the feathers become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2005). At least three adult roseate terns were found dead with traces of oil. Terns were discouraged from nesting on Ram Island in 2003 because it was soiled from the oil spill. Consequently, 250 pairs of roseate terns nested on Penikese Island that year and productivity suffered due to the late initiation of egg-laying (BBNEP, 2005). Gull species represented 15 of 315 dead birds collected after the spill.

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in mortality or could lead to decreased nesting success. Oil spills could directly impact tern colonies, as the Ram Island colony was affected in 2003. However, due to the distance of the proposed action from nesting colonies, oil spills associated with the proposed action are unlikely to impact nesting gull or tern colonies. Some individuals foraging in the direct oil spill area may be displaced from the area, or may become slicked with oil. However, the event of an oil spill is unlikely. Therefore, potential oil spills are anticipated to result in minor impacts to terns or gulls.

*Monopile Collapse*

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for terns and gulls would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a tern or gull dive for fish within this small plume, it could be harmed (see previous section for description of impacts associated with oil spills). There is a low likelihood of this occurrence and low probability of it occurring coincidentally with tern or gull use of the immediate area. Potential impacts to tern or gull in the event of a monopile collapse would therefore be negligible.

*Cable Repairs*

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Tern or gull foraging in areas of elevated suspended sediments would be reduced. In both instances the habitat and species would recover and no impacts to terns or gulls are anticipated from cable repair activities.

*Barrier Effect*

The presence of wind turbines and the spinning of the blades could present barriers to the flight paths of terns or gulls and could potentially affect or restrict access to breeding, staging, or foraging habitat. A wind farm could potentially lead to significant impacts if it were to occur in an area of high use by birds (Drewitt and Langston, 2006). Barriers can result in increases in energy expenditure if birds are forced to travel greater distances while accessing foraging habitats or while undertaking migration movements. However, there are no known situations where a wind farm has created a 'barrier effect' resulting in an avian population level impact (Drewitt and Langston, 2006).

Terns and gulls have been observed to continue to use WTG areas at existing offshore facilities during both migration and breeding periods. Post-construction radar studies during migration at the

Nysted and Horns Rev wind farms in Denmark indicate that, although the greatest levels of movement occurred outside of the wind farms, terns continued to migrate through the wind farm areas (Petersen et al., 2006). The facility is located 8.7 miles (14 km) offshore and is comprised of 80 turbines with a rotor zone of 98 to 360 ft (30 to 110 m). The turbines are spaced 1640 ft (500 m) apart, half the distance of the proposed action turbines. Visual data collected at the Nysted and Horns Rev facility indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 miles (2 km) zone surrounding the facility (Petersen et al., 2006). Terns were observed foraging at the outer edges of the facility around turbine structures. Small flocks flew into the farm, but then exited the area after passing through the second row of turbines (Petersen et al., 2006). Sandwich terns (*S. sandvicensis*) entered the wind farm between two turbines more frequently when one or both of the turbines were not active (Petersen et al., 2006). Common and artic terns (*S. paradisaea*), observed flying in the vicinity of turbines at a facility in Kalmar Sound, Sweden, flew between turbines or right next to the turbines instead of veering off in wide curves as waterfowl species were observed to do (Pettersson, 2005).

A post-construction study at the Zeebrugge wind farm in Belgium investigated the level of project disturbance on nesting terns. An artificial peninsula, created to provide nesting habitat for common, sandwich, and little (*S. albifrons*) terns, was built adjacent to 25 small to medium-sized turbines on a jetty. In 2004, terns nested as close as 98 ft (30 m) from the turbines, while the majority of nests were situated 328 ft (100 m) or further from the turbines (Everaert and Stienen, 2006). In 2005, terns nested as close as 164 ft (50 m) from the turbines. The greater distance between nests and turbines in 2005 was believed to be a result of the distribution of vegetative growth on the peninsula and not due to the operation of the turbines themselves (Everaert and Stienen, 2006). While terns traveled to and from the colony past the turbines, many made no apparent changes in their flight paths. The terns that exhibited a reaction to the turbines made slight changes in their flight paths to fly between turbines (Everaert, 2004). The turbines did not present barriers to the flight paths of terns and observations suggest the presence of turbines resulted in minimal increases in energy expenditure for the terns. It was concluded that the presence of the turbines represented little disturbance to the activity of breeding terns (however, the project has resulted in high numbers of collisions likely due to the facility's location in close proximity to the colony where frequent flights were made through the turbines as terns accessed breeding and foraging locations, discussed in the following section, Risk of Collision).

A tern-turbine interaction study closer to the area of the proposed action was conducted at the Massachusetts Maritime Academy (MMA) campus turbine. The MMA turbine has a maximum height of 243 ft (74 m) (85 to 243 ft [26 to 74 m] rotor zone) and is located at the western entrance of the Cape Cod Canal. The turbine is situated 328 ft (100 m) from the water's edge on a landmass adjacent to a popular common and roseate tern foraging location, the Mashnee Flats Shoal located 5.3 miles (9 km) from one of the largest roseate tern breeding colonies, Bird Island. Visual surveys and mortality searches were conducted from April 24 to November 30, 2006, during the breeding, staging, and fall migration periods (see the following Risk of Collision for information regarding mortality searches). Terns were most abundant in the area during the post-breeding period when they were foraging in large, mixed-species flocks. Terns were most abundant in the turbine airspace (within 164 ft [50 m] of turbine tower, rotor, and blades) during the chick-rearing period and least abundant during the nesting period. The average flight height of terns in the turbine airspace was 83 ft (25.4 m) and the mean flight height was 49 ft (15 m). The one positively identified roseate tern observed in the turbine airspace flew at 26 ft (8 m). In summary, of the terns observed in the 164 ft (50 m) airspace surrounding the turbine: 17 percent flew within, 74 percent flew below, and 9 percent flew above the rotor zone (85 to 243 ft [26 to 74 m]). The study demonstrated that terns continued to use the 164 ft (50 m) airspace around the turbine while traveling between foraging locations (Vlietstra, 2007). However, the operating rotors and spinning blades were observed to deter terns from flying directly within the rotor zone of the turbine when the rotor velocity was greater than 1 rotation per minute (rpm). Under these conditions, terns were found to be 4 to 5 times less abundant in the turbine airspace. Therefore, it was assumed that the terns visually and acoustically detected the spinning blades when the rotor was operating (Vlietstra, 2007). Despite the turbine's location in between foraging locations, terns continued to use the area and their access to habitat was not evidently restricted.

As terns and gulls are known to travel and forage around other man-made structures, including lighthouses, bridges, and wind turbines, it is likely terns would continue to travel through and around the area of the proposed action after construction of the proposed action. Although the majority of terns and gulls are expected to avoid the direct WTG rotor swept area (refer to the following section, Risk of Collision for detailed information of avoidance behavior), it is anticipated that terns would continue to travel and forage in the vicinity of the proposed action. Also, because the turbines are widely spaced (0.39 to 0.63 miles [0.63 to 1.0 km] apart), it is anticipated that most terns and gulls would occur between turbines while traveling at heights within the rotor swept zone. The space between the turbines at Zeebrugge was markedly less than this (27.45 to 36.6 ft [90 to 120 m]), and the terns at that facility continued to regularly travel through the turbines. Barrier effects are anticipated to result in minimal increases in energy expenditure for terns and gulls as they navigate the site of the proposed action for foraging and traveling purposes. Therefore, presence of WTGs and spinning blades is anticipated to result in negligible impacts to terns and gulls (see *Risk of Collision* for different impacts associated with collision mortality).

*Risk of Collision*

The potential exists for terns and gulls to collide with WTGs under operation, including the blades and tubular towers during the breeding, staging, and migration periods. The results of available mortality studies indicate that the majority of avian collisions with man-made structures take place at night during periods of inclement weather (Kerlinger, 2000). Birds that fly within the rotor zone of the proposed turbines (75.5 to 440 ft [23 to 134 m]) during periods of low visibility would be at greatest risk of collision.

Poorly sited facilities can result in high collision rates for terns and for gulls. A mortality study conducted at the Zeebrugge, Belgium facility reported notably high tern collision mortality. At this facility, terns have nested on a peninsula as close as 98 ft (30 m) from a string of 25 small to medium sized turbines located on an adjacent breakwater. The mean number of terns killed for all turbines was 6.7 terns per turbine per year, and the mean number of terns killed at the 14 turbines closest to the colony was 11.2 terns per turbine per year for 2004 and 2005 (Everaert and Stienen, 2006). The collision mortality observed at the Belgium facility was determined to have an adverse impact on the breeding terns. However, the majority of these collisions occurred at the 14 turbines located closest to the tern colony and most collisions may have been associated with the frequent flights through the rotor zone (Everaert and Stienen, 2006). The defensive behaviors that terns exhibited near the colony may have also contributed to collisions. If the peninsula colonized by the terns had not been created adjacent to the string of turbines on the breakwater, it is possible that the observed collision mortality would have been substantially lower. Because no colony is located adjacent to HSS, this data should be interpreted with caution when considering the risk of collision associated with the proposed project. Gulls are known to occasionally collide with bridges and vehicles, as well as communication towers. Some studies suggest that gulls could be particularly vulnerable to wind turbine mortality as they are often observed flying 100 ft (30 m) off the ground (Airola, 1987 *as cited in* Kingsley and Whittham, 2001). A study conducted at Blyth Harbour, Great Britain, concluded that great black-backed gulls were killed by turbines 'disproportionately to both their overall abundance and natural mortality' (Kingsley and Whittham, 2001). The collisions were associated, however, with poor weather and periods of low visibility.

Terns or gulls may cross the area of the proposed action during crepuscular periods or at night. There is limited data available regarding tern and gull flight behaviors in response to certain project design features, particularly FAA lighting. FAA regulation lighting is required for the proposed project. Each perimeter WTG nacelle would be lit at night with one red flashing FAA light. Corner WTGs would be equipped with medium intensity FAA L-864 lighting. The other perimeter WTGs would be equipped with low intensity lights visible up to 1.15 miles (1.9 km). The eight turbines adjacent to the ESP would have one L-810 flashing red light. FAA lighting would be synchronized to flash in unison at 20 FPM (Section 2.0 in ESS, 2007). Construction structures and equipment would be lit at night. Offshore construction activities are anticipated to take place continually, including at night and during inclement weather, at the discretion of the contractor.

Studies have demonstrated that steady burning FAA obstruction lighting, (Gehring and Kerlinger 2007) and some other types of lighting, on tall structures can cause collisions by attracting or disorienting night migrating birds, especially during periods of fog, rain, or low cloud ceiling (Huppop et al., 2006). However, other studies suggest that there are not statistical correlations between mortality at turbines that are lit verses un-lit at onshore wind farms (Jain et al., 2007). The substantially higher numbers of fatalities observed at lit communication towers (at heights greater than 1000 ft [305 m]) in the U.S. may be influenced by the greater heights of the towers, the guy wires, or the steady-burning lights mounted on many towers (Jain et al., 2007), verses the pulsing lights on wind turbines.

The birds involved in collisions with a lit platform located offshore were primarily night migrating songbirds and a few other species, including one dunlin (*Calidris alpina*) and four large gulls (Huppop et al., 2006). Terns are rarities among reported collisions at 47 mainly land-based and some coastal communication towers in the U.S. that are lit and typically over 200 feet (61 m), with one sooty and one common tern reported at the 47 towers as of the year 2000; gulls, terns, and petrels represented two percent of fatalities reported at these towers (Shire et al., 2000).

Although passerine species are known to be attracted to the refracted lighting at “offshore obstacles” during periods of fog or rain (Huppop et al., 2006), there is no data available that suggests terns are attracted to refracted lighting during these conditions.

It is unknown if natural sources of nighttime lighting (i.e., moonlight or starlight) may decrease the risk of tern collisions if their movements result in nighttime crossings of the proposed action area. It is also unknown if the lighting mounted on nacelles may help terns detect the presence of the WTGs (not necessarily the blades) and may facilitate avoidance of the WTG area.

At the Nysted and Horns Rev wind farm in Denmark, wind turbines positioned at the outer edge of the wind farm are equipped with two medium intensity flashing red lights on the top of the nacelles. The lights operate at a frequency of 20 to 60 FPM (Petersen et al., 2006). Radar observations suggest that birds approached the turbines at closer distances at night than during the day, and that more birds entered the wind farm at night than during the day. However, observations indicated avoidance behavior of the turbines by nighttime migrants. The typical distance at which an avoidance reaction occurred was 1,640 ft (500 m) from turbines at night and 1.9 miles (3 km) during the day (Petersen et al., 2006).

It may be that that migrating birds react later to the turbines at night due to decreased visibility, but are eventually able to detect the turbines due to lighting mounted on the nacelles or natural sources of night lighting. Another study conducted with vertically oriented radar suggests that migrating birds may also react to turbines by ‘vertical deflection’ at night instead of the linear avoidance primarily observed during the day (Blew et al., 2006 *as cited in* Petersen et al., 2006). Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of inclement weather (Petersen et al., 2006). Tern and gull reactions to FAA lighting on tall, offshore structures during foggy or inclement weather conditions at night have not been well studied.

However, refraction from lighting may be associated with collisions during periods of fog or rain. A mortality study conducted at a potential wind farm site in the North Sea found that collisions occurred at a radar platform that was illuminated at night, and that 50 percent of these collisions occurred on two nights with conditions of fog and drizzle during a heavy migration period (Huppop et al., 2006). Of the 442 birds (mainly passerines) believed to have collided with the lit research platform, four were gulls. It was believed that the birds may have been attracted to the lighting on the platform during inclement conditions. However, Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006).

Based on the available data, terns have been observed at heights well above the rotor zone when making long-distance migratory movements toward their wintering grounds. There have been observations of what were assumed to be both roseate and common terns departing South Beach in the fall around sunset, apparently heading toward their wintering grounds, and quickly gaining altitudes of hundreds of meters (Veit and Petersen, 1993). Other species of terns have been observed migrating at heights above 4,270 ft (3,000 m) when migrating over land (Alerstam, 1985). It is likely that nighttime long-distance migration movements, if they were to cross the area of the proposed action, would occur well above the rotor zone. The flight height, however, would be dependent on weather conditions and the location from which the birds departed (i.e., if terns were departing from locations in Nantucket Sound their flight height would be lower than migrating terns that departed from more northern breeding locations). If terns were to depart in unfavorable conditions such as strong headwinds, their flight heights would likely be lower as other tern species have been observed flying close to the water's surface during strong headwinds (Alerstam, 1985). However, it is unlikely that flocks of staging terns would depart for migration in unfavorable weather conditions during the day, and less likely at night. More data would be necessary to assess tern and gull flight behavior in the area of the proposed action during a variety of weather conditions.

The potential exists for terns and gulls to occur at heights within the rotor-zone of the proposed action while commuting through Nantucket Sound during the breeding season, especially if traveling downwind. If making shorter, more localized flights in an effort to forage in HSS, terns and gulls would be expected to occur at lower flight heights. Terns and gulls may fly higher in following winds and may occur within the rotor zone while commuting; however, terns may be at decreased risk of collision with the spinning blades if flying with following winds because of the shorter length of time spent in the rotor-zone due to a higher ground speed (Report No. 5.3.2-1); and because during the day, terns and gulls are generally expected to visually detect turbines.

Although flights into headwinds at rotor height would be more dangerous due to a greater amount of time spent in the rotor-zone while traveling through, terns and gulls are expected to fly closer to the water's surface when flying into headwinds to avoid excessive energy expenditure, and would therefore not be expected to fly in the rotor-zone during such conditions. It is unknown if terns or gulls cross HSS at night during breeding season commutes; however terns have been observed arriving at roosting locations after dark (Trull et al., 1999) and leaving roosting sites before first light (Hays et al., 1999), so there is a potential that flights after dark could occur through HSS. Collision risk is elevated during commuting trips in low-light conditions if birds are flying with following winds when they may occur within the rotor-zone.

As stated previously, terns and gulls may be attracted to turbine bases if the monopile bases adopt reef-like conditions and become FADs. If this becomes the case, then terns and gulls could increase foraging and traveling activities in the project area. It is important to note that terns have been observed exhibiting turbine-avoidance behavior at the majority of existing offshore and near-shore facilities. Visual data collected at the Nysted and Horns Rev facility indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 miles (2 km) zone surrounding the facility (Petersen et al., 2006). Terns were observed foraging at the outer edges of the facility around turbine structures. Small flocks flew into the farm, but then exited the area after passing through the second row of turbines (Petersen et al., 2006). Sandwich terns (*S. sandvicensis*) entered the wind farm between two turbines more frequently when one or both of the turbines were not active (Petersen et al., 2006). Common and artic terns (*S. paradisaea*), observed flying in the vicinity of turbines at a facility in Kalmar Sound, Sweden, flew between turbines or right next to the turbines instead of veering off in wide curves as waterfowl species were observed to do (Pettersson, 2005). Some terns at the Belgium facility made slight altercations to their flight paths while navigating through the turbines positioned between foraging and breeding sites (Everaert and Stienen, 2006).

Even if terns and gulls are not attracted to monopiles, they would still be expected to make direct flights while traveling through HSS to access the usual foraging or breeding locations. Based on the survey results, the majority of flight heights observed in the area of the proposed action occurred above or below the rotor zone (Report Nos. 4.2.4-3, 4.2.4-5, 4.2.4-7, 4.2.4-9, 4.2.4-10, and 4.2.4-11). During conditions of good visibility, terns would be expected to visually detect and react to turbine structures. Terns are not expected to frequent the area of the proposed action during those periods of inclement weather or at night, however, surveys have not been conducted under these conditions and therefore the potential for collision under these conditions can not be ruled out. However, if flying into strong headwinds, terns would be expected to fly closer to the water's surface. If flying at night, they may avoid encountering the proposed turbines based on the turbine avoidance behaviors observed by other waterbirds at night. Skimmers are known to forage during periods of low visibility, however, they do so just above the surface of the water (Sibley, 2001).

Hatch and Brault (2007) (Report No. 5.3.2-1) used a collision probability model to estimate the number of roseate tern, least tern, and common tern collisions with the proposed turbines per year. Their estimates suggest that 0.8 roseate terns, 12 common terns, and minimal least tern fatalities per year may occur as a result of the proposed action. (Refer to the Appendix G - Biological Assessment Section 5.3.1.2.3 for more detail on the roseate tern collision risk model and the results of a 2008 supplemental model run for roseate terns). Dr. Ian Nisbet, in his comments on the DEIS (2008), noted that common terns were about six times more abundant than roseate terns during the aerial and boat surveys in HSS and are present for about 7 weeks longer than roseates in the area. He also noted that the Zeebrugge tern study provides a species-specific collision avoidance parameter estimate for common terns of 0.911. Using these alternate values, Nisbet's mean estimate for common tern collision mortality due to the project was 200 individuals, with a possible range of 2 to 2,000 (Nisbet, 2008). Interpreting the results of the collision risk model alternate runs should be done with caution. The ratios of common terns to roseate terns based on data collected during the field surveys in HSS, used in both Hatch and Brault and Nisbet's models, are based on estimates. Additionally, the estimated collision avoidance parameters from the Zeebrugge tern study should be considered with caution. The Zeebrugge data represents the behaviors of terns flying through turbine arrays in close proximity (within 328 ft [100 m]) to a tern colony where frequent flights and defensive behaviors occurred. The tern flight behaviors that would generally occur in HSS include commuting and possibly foraging, greater than 5 miles (8 km) from breeding locations.

Above water foundations are not anticipated to create perching habitat or result in increased risk of collision for terns or gulls. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck (some species prefer perches with views). The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of perch deterrent devices has discouraged terns perching on the fence and deck of the platforms supporting the Cape Wind SMDS. The final design of perch deterrents would be based on recommendations from USFWS. The use of tubular towers instead of lattice towers also discourages perching under the rotors. Vibrations and low level noise created by operating WTGs may also deter terns and gulls from perching. Therefore, perching opportunities are not expected to increase the risk of collision of terns and gulls with the proposed turbines (refer to Section 5.3.2.9.2 for more discussion on tern collision risk due to increased perching habitat).

Some studies suggest that gull flight altitudes often occur below 100 ft (30 m) but do occur within the rotor zone of modern wind turbines (Kerlinger and Curry, 2002). Observations suggest that gulls could be particularly vulnerable to wind turbine mortality as they are often observed flying 100 ft (30 m) off the ground (Airola, 1987 *as cited in* Kingsley and Whittham, 2001). A study conducted at Blyth Harbour, Great Britain, concluded that great black-backed gulls were killed by turbines 'disproportionately to both their overall abundance and natural mortality' (Kingsley and Whittham, 2001). The collisions were associated, however, with poor weather and periods of low visibility. Due to the presence of gulls in the area, there is a risk of collision with the proposed turbines.

Although the flight altitude of gulls observed during the field surveys were predominantly below the rotor-zone, gulls may occur in the rotor-zone of the propose turbines if flying downwind. Population-level effects from those collisions, however, may be less likely for certain gull species due to their relatively stable regional populations. However, certain species of gull, such as herring gull (*Larus argentatus*), may be more susceptible to impact if their regional populations are declining. Herring gull may be declining in northern locations such as Maine, Newfoundland, and New Brunswick (Pierotti and Good, 1994). The impacts associated with collision risk coupled with other sources of mortality or population control for gulls including culling and nest destruction at tern and other seabird breeding locations, as well as entanglement in fishing line, may result in cumulative impacts to herring gull. Therefore, impacts associated with collision risk may result in major impacts to gulls.

Due to the potential of terns to occur in the rotor-zone during commuting flights between foraging, roosting, and breeding locations in Nantucket Sound, there is a risk of collision. This risk of collision is increased during periods of low visibility. The patterns of tern movements through the proposed action area are not well understood, particularly during post-breeding and staging periods in Nantucket Sound. There are limitations to the available data from field surveys in Nantucket Sound as terns are relatively small, light-colored marine birds and can be hard to detect from a plane if flying low over the surface of the water, and also difficult to detect from a plane or a boat if flying at high altitudes, out of the view of the surveyors. The available radar data can not provide bird group or species-specific data. Given the uncertainty surrounding tern use of HSS, it is important to be conservative in the assessment of risk. Therefore, impacts associated with collision for terns are anticipated to be major for roseate terns, common terns, and least terns due to their unstable populations. A discussion of collision related impacts for roseate terns is included in the BA in Appendix G.

***Pelagic Species (shearwaters, petrels, gannets, auks)***

*Risk of Collision*

The magnitude of collisions with wind turbines by these species is expected to be lower than other species, as they are expected to be infrequently present. However, if the presence of these species is typically associated with storm events and reduced visibility, the actual potential for collisions may be greater under these conditions. Additionally, these birds could be at risk of collision because they may react differently to turbines as they are not as habituated to obstacles in their flight path as near-shore species are (Tulp et al., 1999). However, observations from a study conducted in the North Sea near Denmark suggest that many species, including gannets, actively avoided the wind farm area and only occasionally entered turbine areas (Christensen and Houninsen, 2005).

Within this group of birds, some species may be more at risk than others. Gannets are often observed flying at heights within the range of the rotor-swept zone. The aerial and boat surveys conducted by the applicant documented hundreds of gannets during spring and fall surveys of Nantucket Sound. Gannet numbers were not notably higher in any part of the Sound. Soaring species (shearwaters) and species that plunge dive for food (gannets) may occur more commonly in the rotor swept zone of the proposed turbines while those that feed at the waters surface (storm-petrels) and heavy-bodied divers (the alcids) may spend far less time at heights above the water that would put them at risk of collisions with turbine blades. Aerial and boat surveys conducted in the study area were limited to daytime periods of good visibility. While documenting these species during periods of inclement weather (when they are most likely to occur near shore) presents difficulties, additional information on the frequency of occurrence and activity patterns should be investigated during a variety of weather conditions both day and night. However, due to the anticipated infrequent occurrence of pelagic species in the area of the proposed action, the risk of collision with WTG structures is anticipated to be low. Therefore, the risk of collision is expected to result in minor impacts to populations of pelagic species.

***Waterfowl and Non-Pelagic Water Birds***

There are a number of sea duck, waterfowl, and diving species that occur within Nantucket Sound, particularly during the winter months. Species such as scoter, eider, and long-tailed duck over-winter in large flocks in the region. A number of common and red-throated loon (*Gavia stellata*), as well as grebes, geese, brant, and dabbling ducks, are also local to the bay during various times of the year. Double-crested cormorant are abundant in the site of the proposed action through the breeding season and late-fall. Great cormorant occur in the area mainly in the winter months.

*Habitat Loss and Modification*

Habitat modification as a result of the operating facility could displace sea duck and waterfowl. Displacement can lead to over-crowding and competition at alternative foraging sites and can ultimately result in increased mortality of more vulnerable species (Maclean et al., 2006). The impact of habitat modification on sea ducks would be dependent on the location of the turbines in relation to suitable feeding areas.

Petersen et al. (2006) found that common scoters (*Melanitta nigra*) were among those species that exhibited complete avoidance of turbine areas, however were numerous in the surrounding waters. Sea duck may avoid the direct area of the wind farm; however, they are expected to continue to forage in the vicinity of the proposed action, assuming that their food sources were not displaced.

Sets of six scour-control mats (each mat would be 16.5 ft by 8.2 ft [5 m by 2.5 m] with 8 anchors to secure the mat to the seafloor) would be placed at the base of each monopile. The underwater structures could create a localized ‘artificial reef effect’, providing foraging habitat for sea ducks and other waterbirds. Wide spacing of turbines (0.39 to 0.63 miles [0.63 to 1.0 km] apart) would allow for diving between turbines.

The boundary of the area of the proposed action would include approximately 25 square miles (64.7 $km^2$) of WTGs and ESP (electrical service platform) foundations, and 5.89 acres (23,835 $m^2$) of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area: including approximately 0.004 $km^2$ (less than one acre) for the 130 turbines, 100 by 200 ft

(30.5 to 61 m) for the ESP platform, and 2.4 acres(9,712 $m^2$) for scour mat coverage (Jarvis, 2005). The additional amount of surface area (1,200 square ft or 0.03 acres [111 $m^2$]) per tower would result in a minor addition to the substrate that is currently available (Section 3.9 in ESS, 2007). Due to the small amount of additional surface area in relation to the total area of the proposed action in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant effect on the benthic community, the presence of prey fish, or sea duck or other water birds. However, the additional substrate would be oriented vertically in the water column, and could result in localized and minor increases in certain invertebrates and prey fish species.

Although there may be minimal impacts to the prey base due to construction of the proposed action, sea duck and waterfowl are among species of birds that may experience habitat loss due to the presence of operating turbines. Petersen et al. (2006) found that common scoters (*Melanitta nigra*) were among those species that exhibited complete avoidance of turbines, yet were numerous in the surrounding waters.

At Tuno Knob in Denmark, aerial and ground surveys were used to compare the abundance of birds before and after the construction of the wind farm determined that there were fewer birds post-construction although numbers remained stable in a control site (Guillemette et al., 1998). However, the change was believed to be due to differences in natural changes in food availability and not the presence of the wind facility. (Guillemette et al., 1998) concluded that the changes in the abundance and distribution of eiders during the winter of 1996 to 1997 could not be attributed to the wind turbines. Scoter numbers however, did not increase to their original, pre-construction numbers (Drewitt and Langston, 2006). At Horns Rev, divers and scoters occurred in numbers lower than expected in the wind-farm area post-construction. At the Horns Rev and Nysted wind farm in Denmark, loons and common scoters showed an increased avoidance of both wind facilities and this effect was documented to 2 to 4 km around the facility (Petersen et al., 2006). These results suggest that these birds may avoid wind farm areas.

Kaiser (2002) used field data in combination with a modeling approach to predict the change in over-winter mortality rates of common scoter as a result of displacement from potential feeding habitat through avoidance of wind facilities in Liverpool Bay. The study indicated that the displacement of common scoter from areas around four of five wind facilities (existing, authorized, or proposed) would have no major effects to the over-winter mortality of the population.

The actual development area (25 square miles [64.7 $km^2$]) cannot be considered a minor habitat loss. High numbers of ducks (often greater than 1,000), particularly scotors, were observed in HSS, but these counts were comparable or less than that observed for the rest of Nantucket Sound. The survey data do not indicate that HSS is preferred by waterfowl over other portions of Nantucket Sound. Because some species of waterfowl have been observed to be displaced by wind resource areas, the proposed project could result in habitat loss for waterfowl. However, it does not appear that HSS is surrounded by unsuitable habitat for displaced birds. Habitat loss or modification due to the project will affect waterfowl, but this is not considered to be a major effect.

Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, major impacts associated with loss of habitat or modification are not anticipated. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005). The proposed project is expected have moderate effects to waterfowl due to collision risk, displacement, and barrier effects. The certainty of these effects to waterfowl remains low, but this will be better defined through the implementation of the proposed monitoring measures (Section 9.0).

*Human Disturbances*

Disturbances, such as increased human presence and vessel activity during proposed action operation, may result in impacts to sea ducks and waterfowl. Divers including loons and scoters are particularly sensitive and could be disturbed during maintenance activities due to their strong reaction to boats (Maclean et al., 2006).

Observations at existing offshore facilities indicate that increased vessel activity during the operational phases could result in disturbances to sea duck or waterfowl foraging in the vicinity of the area of the proposed action. Helicopters and boats approaching a wind farm in Denmark for maintenance services flushed flocks of scoter. It was observed that birds tended to eventually return to the same area after the helicopter or service boats had left the area (Petersen et al., 2006). At a Sweden facility, it was observed that service boats are more of a disturbance to birds than the operating turbines (Pettersson, 2005). Long-tailed duck and scoter foraging in the immediate vicinity of turbines were flushed as facility service boats approached (Pettersson, 2005). Spring 2003 studies showed that long-tailed duck and possibly scoter that stage in the wind farm area leave the area when the service boat comes but were observed to return in the evening after the boat was out of the area (Pettersson, 2005). It was suggested that was it the boat activity in the area that displaced the birds, not the wind farm structures themselves; the birds were present in the morning and evening when the boats were not present (Pettersson, 2005). Despite the presence of turbines and service boats, many species of waterfowl continued to use the area as foraging and staging habitat at the Sweden facility. Eider feeding in vicinity of the turbines at the Sweden facility in an area that receives less boat activity, appeared to be unaffected by the presence of the boats suggesting boat disturbance is limited to the immediate vicinity of the boats, for most species.

The area surrounding the proposed development experiences regular vessel activity, therefore, increased human presence or vessel activity is not anticipated to present a substantial increase in disturbances. Human disturbances are not expected to result in long-term or major impacts to foraging sea duck or waterfowl. Minor impacts are anticipated to result from human disturbances associated with operation of the proposed action.

*Electromagnetic Fields*

There is a concern that electromagnetic fields emitted from the offshore cables may impact prey fish. It has been suggested that EMF may disorient or attract prey fish, however, it is unknown what these actual impacts may be (Gill, 2005).

The specifications of the proposed cable system require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Magnetic fields, however, can not be completely shielded because the magnetic field lines do not stop on objects; they form continuous loops around conductors carrying currents. The actual magnitude of typical 60 Hz magnetic fields in the vicinity of the offshore cables is, in most locations, well below that of the geomagnetic field (~ 500 mG). Therefore, no additional electric field impacts are expected to result from the submarine cables. There are no anticipated major impacts to foraging birds or their prey from the 60 Hz magnetic fields associated with the operation of the proposed action.

*Oil Spills*

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil could be released from tankers or damage to WTG structures or the ESP could result in the release of fluid contained within these structures. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons (158,987 liters) at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). In the unlikely event of an oil spill, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

Because sea duck and waterfowl dive at the water's surface, they are among those species of birds that are particularly vulnerable to oil spills. If the feathers become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening.

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Diving species including loon and scoter suffered relatively high mortality from the spill. Over 100 loons were collected dead. More than double this number were slicked and collected alive. This likely represents a high regional population impact to these birds. Over 70 diving duck, sea duck, merganser, and grebe (combined) were collected dead. Cormorant species (N=17) also represented a substantial portion of the dead birds found (315 total) associated with the oil spill (BBNEP, 2005).

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in mortality. Some individuals foraging in the direct oil spill area may be displaced from the area, or may become slicked with oil. However, the event of an oil spill is unlikely. Therefore, potential oil spills are anticipated to result in minor impacts to sea duck and other waterfowl.

*Monopile Collapse*

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for sea duck and other waterfowl would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a bird dive for food within this small plume, it could be harmed (see previous section for description of impacts associated with oil spills). There is a low likelihood of this occurrence and low probability of it occurring coincidentally with bird use of the immediate area. Potential impacts to sea ducks or waterfowl in the event of a monopile collapse would therefore be negligible.

*Cable Repairs*

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Sea duck or waterfowl may be temporarily displaced from areas of suspended sediments. In both instances the habitat and species would recover and no impacts to sea duck or waterfowl are anticipated from cable repair activities.

*Barrier Effect*

Structures that extend above the natural landscape such as towers, buildings, and bridges can act as barriers in the flight paths of birds. A barrier effect to migrating sea duck or waterfowl may occur if their movements were to cross HSS. Barriers to the flight paths of birds can result in increases in energy expenditure during migration movements. Significant impacts may result if access to preferred foraging habitat is restricted or if movements along migration corridors are impeded. There are no existing facilities known to create a barrier effect that has resulted in a population level impact. A wind facility, however, could potentially lead to significant impacts if it were to occur in a frequented flight path between nesting and foraging locations (Drewitt and Langston, 2006).

Observations at existing wind farms indicate that migrating waterbirds make efforts to avoid entering or encountering wind farms. At the Horns Rev wind farm in Denmark, radar studies showed that 71 to 86 percent of birds approaching the windfarm avoided entering the wind farm. There was a 78 percent observed avoidance of the wind farm by approaching birds (Petersen et al., 2006). For eider, it was found that of 10 flocks that would have entered the wind farm prior to construction, eight flocks would avoid the wind farm during post-construction (this number however, was believed to be over-estimated due to detection bias) (Petersen et al., 2006).

At a Sweden wind facility, it was observed that the post-construction migratory flight paths of ducks, geese, and cormorants shifted up to 1.2 miles (2 km) eastward from the baseline corridor as the birds made efforts to avoid flying less than 0.6 miles (1 km) from turbines (Pettersson, 2005). The birds' increased energy expenditure was calculated; it was estimated that their migration flight path was extended by 0.7 to 1.8 miles (1.2 to 2.9 km) resulting in a 0.2 to 0.5 percent extension of the total estimated migration distance of the waterfowl (Pettersson, 2005).

At the Utgrunden wind facility in the Baltic Sea, long-tailed ducks were observed to fly between turbines as they traveled between foraging locations (Pettersson, 2005). The birds made minor changes to their flight behavior to avoid encountering turbines.

At the existing Mass Maritime Academy (MMA) turbine in Buzzards Bay, cormorants, geese, and other birds were observed heading toward the turbine, and as they approached, they abruptly changed their flight direction to avoid the turbine (Vlietstra, 2007). Generally, the likelihood of terns and other birds including double-crested cormorants, rock doves, and gulls entering the turbine airspace was dependent on the velocity of the rotor and blades. However, no measurable impacts were observed as birds traveled between foraging locations and their access to these areas was not believed to be restricted. Therefore, the effects of the barrier appeared to be minor.

Barrier effects may result in changes in the flight behavior of traveling birds. Observations at existing facilities indicate there are no known situations where a barrier effect has resulted in a population level impact to birds. Sea duck and waterfowl are expected to make alterations to their flight behavior to avoid encounters with turbines. However, these altercations are anticipated to result in minimal increases of energy expenditure. No major impacts associated with barrier effects are anticipated for sea duck or waterfowl.

*Risk of Collision*

The potential exists for migrating, commuting, or dispersing water birds to collide with WTGs under construction, large construction equipment, or operating WTGs. The risk of collision depends on use of the area of the proposed action, visibility during crossings of the area of the proposed action, and flight behaviors exhibited during encounters with turbines.

Sea duck and waterfowl exhibit certain characteristics that may decrease their ability to avoid wind turbines: they travel in flocks, and due to their large size, they are less agile fliers than smaller seabirds. Sea duck and waterfowl can be active during a variety of times of the day, including at night. Studies suggest that the vast majority of collisions with turbines take place at night and in twilight, especially on those nights with strong winds and poor visibility (Winkelman, 1992 *as cited by* Tulp, 1999).

Diving ducks may fly just above the surface of the water in lines or V's during their daily movements between foraging locations, and may migrate at heights just above the surface of the waves to altitudes well above the rotor zone (Bordage and Savard, 1995; Cramp and Simmons, 1977 *as cited by* Savard et al., 1998). During surveys in the study area, diving species typically flew below 98 ft (30 m) above the waves, although they were occasionally observed flying between 98 and 197 ft (30 and 60 m) (Report No. 4.2.4-10).

Observations of waterfowl from onshore wind facility sites, particularly the Top of Iowa project, indicate that collisions with wind turbines can be extremely low, even in areas with very high waterfowl use (Koford et al., 2005). Tulp (1999) found that waterbirds diverted their daytime and nighttime movements away from turbines at even greater distances. Results from offshore wind facilities in Denmark and Sweden showed that flocks of migrating eiders (and other waterfowl) change their flight path around the wind facility and/or avoided turbines by flying between the rows or by changing height (Desholm and Kahlert, 2005; Desholm, 2006; Pettersson, 2005).

Survey results from offshore European facilities provide additional evidence that waterfowl can detect and avoid offshore turbines at night. Observations from a study conducted in the North Sea off of Denmark suggest that divers, gannets, and scoters actively avoided the wind farm area and only occasionally entered the wind farm (Christensen and Houninsen, 2005). Eiders at that facility often deflected their flights away from the turbines beginning at distances of 1,300 to 1,640 ft (400 to 500 m) from the turbines (Christensen and Houninsen, 2005 *as cited by* Maclean et al., 2006).

The lighting mounted on nacelles as well as natural sources of nighttime lighting are expected to decrease the risk of bird collisions if their migratory movements result in nighttime crossings of the area of the proposed action. At the Nysted and Horns Rev wind farm in Denmark, all the wind turbines are equipped with yellow navigational lighting. In addition, all wind turbines positioned at the outer edge of the wind farm are equipped with two medium intensity flashing red lights on the top of the nacelles. The lights operate at a frequency of 20 to 60 FPM (Petersen et al., 2006). Radar observations suggest that birds approached the turbines at closer distances at night than during the day, and that more birds entered the wind farm at night than during the day; however, observations indicated avoidance behavior of the turbines by nighttime migrants. The typical distance at which an avoidance reaction occurred was 1,640 ft (500 m) from turbines at night and 1.8 miles (3 km) during the day (Petersen et al., 2006). It may be that that migrating birds react later to the turbines at night due to decreased visibility, but are eventually able to detect the turbines due to lighting mounted on the nacelles or natural sources of night lighting. Another study conducted with a vertically oriented radar suggests that migrating birds may also react to turbines by 'vertical deflection' at night instead of the linear avoidance primarily observed during the day (Blew et al., 2006 *as cited by* Petersen et al., 2006).

During periods of inclement weather, however, lighting may result in increased avian collisions. A mortality study conducted at a potential wind farm site in the North Sea found that collisions occurred at a radar platform that was illuminated at night, and that 50 percent of these collisions occurred on two nights with conditions of fog and drizzle during a heavy migration period (Huppop et al., 2006). The species composition of the 442 birds believed to have collided with the lit research platform include mainly thrushes, common starlings (*Sturnus vulgaris*), and sky larks (*Alauda arvensis*), as well as 1 dunlin, four gulls, and one pigeon (*Columba livia*). It was believed that the birds may have been attracted to the lighting on the platform during inclement conditions. However, the data indicated no mortality of sea duck or waterfowl. Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006).

For the Nysted offshore wind facility, Petersen et al., (2006) developed a stochastic predictive collision model to estimate numbers of common eiders likely to collide with turbine blades each autumn. Using data derived from radar studies and infrared video monitoring, they predicted with 95 percent certainty that 0.018 to 0.020 percent of 235,000 passing birds (41 to 48 individuals) would collide with all 72 turbines in a single autumn (one eider/turbine/year). Collision mortality predicted by Hatch and Brault (2007) (Report No. 5.3.2-1) for sea duck at the proposed facility was estimated to be lower than the fatalities predicted for the facility in Denmark due to the relatively fewer migrants along the Atlantic Coast. The number is estimated to be well below the annual hunt of 15 to 20,000 eider and long-tailed duck along Atlantic Coast states (USFWS 2006 *as cited in* Report No. 5.3.2-1).

Potential impacts may be associated with increased collision mortality due to perching opportunities under turbines. Cormorants, in particular, are a bird group that may be attracted to the WTG area for perching opportunities. However, above water foundations are not anticipated to create perching habitat or result in increased risk of collision. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck (species such as cormorant prefer perches with views). The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of tubular towers instead of lattice towers also discourages perching under the rotors. Vibrations and low level noise created by operating WTGs may also deter birds from perching.

Although certain species may fly within the rotor zone of the proposed turbines, sea duck and waterfowl have demonstrated turbine avoidance behavior. These birds likely have reduced movements during periods of darkness and inclement weather, therefore, this bird group is at a lower risk of collision with turbines than other species groups. In general, populations of many of these species are relatively large, and could likely sustain low levels of collision-related fatalities. Therefore, waterfowl and other non-pelagic species are estimated to experience impacts associated with collision mortality. However, affects to many of these species is anticipated to result in minor impacts on the population levels.

Conversely, some waterbirds, such as cormorants, may be at risk for collision with stationary monopiles during construction. Cormorants are often seen flying within the range of the rotor-swept zone. There is some evidence that great cormorants may be declining (Nisbet and Veit, in review). Additional losses in the numbers of great cormorants due to collision with wind turbines may put the population at risk. Based on the uncertainty associated with turbine collision, effects of the proposed project to the North American population of great cormorants may be significant.

**Conclusions on Operation Impacts**

Based on research cited and information discussed herein, with respect to affects resulting from habitat modification, human disturbance, and risk of collision, the overall operational impacts of the proposed action to non T&E avifauna would be moderate.

### *5.3.2.5 Subtidal Offshore Resources*

#### 5.3.2.5.1 Construction/Decommissioning Impacts

**Impacts on Hard Bottom Benthic Communities**

Potential impacts to hard bottom benthic communities that have been reported in limited areas of the proposed action locale would be associated with indirect and localized affects from sediment suspension and deposition resulting from cable jetting, the vessel anchoring process associated with jetting, and the introduction of new and additional hard substrate due the presence of the monopiles and rock scour armor, where that may be used. Sessile epifauna and macroalgae noted to occur in these areas could be subject to effects of sediment suspension and deposition and filter feeding organisms may experience clogging of feeding and respiration organs. These effects are expected to range from negligible to minor and be temporary. Such sediment would be expected to be removed by natural processes occurring in the adjacent mobile and dynamic sandy substrate environment. Although not anticipated, a thick layer of deposited sediments could permanently cover hard substrate areas, such as glacial till/cobble surfaces.

**Impacts on Soft-Bottom Communities**

Potential impacts to soft bottom communities relate to areas of the seafloor that are temporarily disturbed by geotechnical investigation methods such as coring and boring, and construction/decommissioning activities such as cable jetting, monopile and ESP pile installation, HDD of the shoreline crossing, and scour protection installation. The hydraulic jet plow embedment procedure simultaneously lays and buries the cables and ensures placement of submarine cable systems at target burial depths with minimal bottom disturbance and sediment dispersion. Use of hydraulic jet plowing technology for cable installation is considered the least environmentally damaging alternative when compared to traditional technologies (IFC, 2007). Indirect impacts would occur from water withdrawals associated with construction vessels and jetting, which entrain the planktonic larvae of benthic species, assumed to result in 100 percent mortality of the entrained organisms.

**Soft-Bottom Benthic Invertebrate Communities**

***Direct Seafloor Disturbance***

Potential areas where seafloor impacts may occur were determined based on the proposed action design and construction methodologies. The length of cable needed for linking all the wind turbine towers to the ESP is approximately 66.7 miles (107.3 km). A zone of disturbance between 4 and 6 ft (1.2 and 1.8 m) wide is anticipated for burial of the inner-array cables to a target depth of 6 ft (1.8 m). Thus, the seafloor area anticipated to be disturbed during the inner-array cable installation is between approximately 1,408,704 and 2,113,056 square ft (32.34 and 48.51 acres or 130,872 and 196,309 $m^2$). Also, two 3 ft (0.9 m) wide skid pontoons would ride on the substrate surface on either side of the jet plow to help control the depth of cable embedment. Pontoon impacts that result from installation of the inner-array cables would be 2,113,056 square ft (48.51 acres or 196,309 $m^2$). Combined temporary disturbance would be up to 4,226,112 square ft (97.02 acres or 392,618 $m^2$) of sea bottom within the perimeter of the WTGs, or approximately 0.61 percent of the 25 square miles (64.7 $km^2$) area defined as the total area of the proposed action (see Table 5.3.2-3).

Approximately 12.5 miles (20.1 km) (4.9 miles [7.89 km] in federal waters and 7.6 miles [12.23 km] in state waters) of offshore transmission system cable is required for joining the ESP to the mainland. A disturbance zone of 4 to 6 ft (1.2 to 1.8 m) wide is expected for burial of each of the two offshore transmission cable circuits to a target depth of 6 ft (1.8 m). Thus, the seafloor area that would be disturbed during installation of the offshore transmission cable system along the proposed route would be approximately 792,000 square ft (18.18 acres or 73,579 $m^2$). The two skid pontoons would impact another approximately 792,000 square ft (18.18 acres or 73,579 $m^2$). The resulting combined temporary disturbance is expected to be up to 1,584,000 square ft (36.36 acres or 147,158 $m^2$) of sea bottom or approximately 0.228 percent of the area of the proposed action (see Table 5.3.2-3).

Since there are shallow water depths in Nantucket Sound, shallow draft vessels/barges are necessary for installation. These types of vessels/barges commonly use anchors for positioning. The processes of positioning, anchoring and movement of cable installation barges are expected to result in impacts occurring along cable installation paths. The impact area would vary with water depth, weather and sea conditions, and the type of bottom substrate. Average impact areas for each anchor deployment can be made using properties of anchor behavior that have been described by the U.S. Navy (NAVFAC, 1985; NCEL, 1987; Taylor, 2002). Using the width of an anchor (10.6 ft [3.23 m] including stabilizer bar), the number of anchors necessary for securing and moving a vessel (6), and the required setting drag length for deep water (20 ft [6.1 m]), the estimate is that up to 7,230 square ft/mile (0.17 acre/mile or 420 $m^2$/km) would be disturbed from the deployment and retrieval of anchors. Anchors would disturb the substrate to a depth of 4 to 6 ft (1.2 to 1.8 m) for each anchor deployment and leave a temporary irregularity to the seafloor with localized mortality of infauna. In addition, the seafloor area that would be swept by anchor cable as the jetting barge moves along the cable routes was calculated to be 311,880 square ft (7.16 acres or 28,975 $m^2$) per linear mile (1,609 m) of cable. Use of mid-line anchor buoys would minimize potential impacts but cannot eliminate them entirely. Anchor cable sweep impacts would be expected to disturb sediment to a depth of up to 6 inches (15.2 cm) (Algonquin Gas Transmission Company, 2000). Organisms that may be subject to impacts from anchor line sweep include mollusks such as soft shell clams, surf clams, and whelks and other sessile species such as tube dwelling polychaetes or mat forming amphipods which make up a large portion of the taxa occurring in the area of the proposed action. Organisms that are mobile, such as certain polychaete species, amphipods, Tanaidacea, Mysidacea, and crabs may be able to avoid impacts from the anchor line sweep because of sediment vibrations stimulating avoidance behaviors as the cable moves slowly laterally across the seafloor.

Total anchoring and anchor sweep impacts that are part of the installation of 66.7 miles (107.3 km) of inner-array cables would be approximately 21,030,177 square ft (482.79 acres or 1,953,768 $m^2$), or approximately 3.02 percent of the area of the proposed action (see Table 5.3.2-3). Vessel anchoring and anchor sweep impacts that are part of the installation of the 115 kV transmission system that would span the approximately 12.5 mile (20.1 km) route between the ESP and the mainland are anticipated to impact approximately 7,979,925 square ft (183 acres or 741,359 $m^2$), or approximately 1.15 percent of the area of the proposed action.

In addition to temporary construction impact from installation of offshore transmission cable systems, it is expected that there would be temporary impacts to the seafloor in the proposed wind turbine tower locale from placement of jack-up barges that would be used for installing each tower. These jack-up barges would not require any anchoring. However, jack-up barges that have a range of four to six jacking legs are expected to have pads that contact the sea floor over an area of 172 square ft (0.0039 acres or 19 $m^2$) each. The maximum expected temporary impact area related to the jack-up barge for installation of the WTG and ESP pilings (136) would be 140,352 square ft (3.22 acres or 13,039 $m^2$).

After pilings are in place, a second vessel would need to jack-up at each piling for installation of turbines, blades and other equipment. A second vessel would also need to jack-up near the ESP pilings for construction of the ESP platform. In order to connect inner-array cables to the WTGs and the ESP platform, a third vessel would need to jack-up at each tower and the ESP. A vessel would also need to be located at each piling for installation of the scour control mats or rock armor that are to surround each piling.

According to the calculations and assumptions described, it is anticipated that total combined temporary impact from the jack-up barge use related to installing turbine towers and association equipment, the ESP platform, connection of inner array-cables (using J-tubes) to WTGs, and installation of scour control mats and rock armor would be approximately 411,133 square ft (9.4 acres or 38,195 $m^2$), or 0.06 percent of the total area of the proposed action (see Table 5.3.2-3).

In the locale where temporary disturbance of the seafloor occurs due to cable and monopile placement substantial mortality of benthic organisms is expected; however, the impacts are expected to be minor since the area disturbed is somewhat limited, abundant area of similar habitat type occurs in the surrounding vicinity, and the sand bottom community typical to the area is adapted to frequent natural sediment movement that creates temporary impacts. Information reported in the scientific literature indicates that certain benthic invertebrate species opportunistically invade substrate areas that are unoccupied after disturbances have occurred (Hynes, 1970; Rhoads et al., 1978; Rosenberg and Resh, 1993; Howes et al., 1997).

***Suspended Sediment and Deposition Impacts***

For determination of volume of suspended sediments from the jet plow embedment process SSFATE modeling was conducted (Report No. 4.1.1-2). The results of the SSFATE model indicated that sediments suspended by the jet plow would settle alongside the cable route, primarily because of the relatively coarse nature of the sandy sediments. Depending on horizontal distance from the trench, trench geographic orientation, and tidal current direction deposition of sediment is predicted to range from 0.04 to 0.2 inches (1.0 to 5.0 mm) thick. Depositions that range in thickness from 0.4 to 1.8 inches (10 to 45 mm) are expected to occur in isolated locations when tidal currents are in slack water (Report No. 4.1.1-2).

Sediment suspension times vary according to particle size, distance from the cable route and tidal current strength. Sediments may remain suspended approximately 2 to 18 hours. Gravel and sand settle more quickly than silts and clays. Sediment transport modeling studies concluded that sediment deposition from the jet plow embedment operations would be minimal compared to active sediment transport that has been observed in Nantucket Sound during natural tidal and weather conditions (Report No. 4.1.1-2).

Results from sediment transport modeling indicate that benthic organisms would suffer some mortality due to the temporary disturbance from jet plowing activities. Species-specific responses to suspended sediments and sediment deposition have been studied and vary depending on a particular species' feeding mode and mobility (see Table 5.3.2-4). Benthic organisms that are mobile and species that can burrow can evade areas with sediment deposition. This includes species such as crabs and lobsters. Sedentary organisms, such as the northern quahog and the eastern oyster, not able to evade sediment deposition may be subject to mortality or impact to reproduction and growth. Due to the highly dynamic environment in Nantucket Sound and that most naturally occurring species are adapted to settle and move in the sandy environment and recover from burial, the expected sediment deposition is expected to have minimal adverse impacts to benthic resources. Since sediments expected to be suspended by jet plow operations are minimal in comparison to active sediment transport known from Nantucket Sound, filter and deposit feeding benthic organisms are not expected to be substantially impacted from suspended sediments from the jet plow installation. Compared to the Horseshoe Shoal locale, impacts may be greater from the jet plowing activities in nearshore areas of Lewis Bay since weak currents and finer sediments may remain in an elevation of suspended sediments as long as 48 hours.

Benthic community recovery rates have been studied by Dernie et al. (2003) who has shown that sediment particle size and rate of disturbance infilling have an effect on recovery rates. Also, benthic communities adapted for surviving in high-energy types of environments are assumed to recover more quickly after disturbances (Dernie et al., 2003). Dalfsen and Essink (2001) have noted with sand extraction and/or nourishment that assessment of direct effects is difficult as benthic organisms may survive the dredging activities and colonization occurs almost instantaneously with recruitment and immigration. Further benthic community response after sand extraction and/or nourishment tends to follow well defined patterns with rapid development of "opportunistic" species and then subsequent recovery of community composition and structure. Dalfsen and Essink (2001) indicated that in dynamic coastal areas such as those off the Netherlands that recovery of the benthic community is relatively fast.

Since the WTG area is a naturally dynamic environment, benthic organisms that occur are adapted to fluctuations in concentrations of suspended sediments in the water column. These organisms are not expected to be impacted substantially by sediment resuspension and deposition occurring on a short-term basis and could be expected to recover as quickly as they have reproductive mechanisms allowing for rapid colonization. Focusing on dredging, Coastline Surveys Limited (1998) and Newell et al. (1998) suggested that in general, recovery times of 6 to 8 months are characteristic for many estuarine muds, two to three years for sand and gravel, and 5 to 10 years with coarser substrates. Thus, benthic invertebrate populations occurring at the site of the proposed action could be reasonably expected to commence recovery within several months. However, the infaunal community may continue reestablishment for up to four years (Byrnes et al., 2004a, van Dalfsen and Essink, 2001 Newell et al., 2004).

Moderate long-term (permanent) impacts related to installation of the pilings that support the wind turbine towers and the ESP would be anticipated to affect the soft-bottom benthic communities in the area of the proposed action. Round pilings to be constructed include 130 for the wind turbine towers and six for support of the ESP. Dimensions of each wind turbine piling depend on the depth of water in which it is located. Dimensions would be 16.75 ft (5.1 m) diameter at the seafloor for a piling that is situated in water depths ranging from 0 to 40 ft (0 to 12.2 m), and 18.0 ft (5.5 m) diameter for pilings situated in water depths ranging from 40 to 50 ft (12.2 to 15.2 m). The diameter of ESP pilings would be 42 inches (106.7 cm) at the seafloor. Thus, there is a direct impact area that is equal to 220 square ft (0.005 acre or 20 $m^2$) for each 16.75 ft (5.1 m) diameter wind turbine tower piling (111 pilings) and 255 square ft (0.005 acre or 21 $m^2$) for each 18 ft (5.5 m) diameter wind turbine tower piling (19 pilings). The impact of the ESP would be expected to be approximately 9.6 square ft (0.0002 acre or 0.9 $m^2$) per piling. This would result in a total area of permanent impact of approximately 29,351 square ft (0.67 acre or 2,727 $m^2$) for the 130 wind turbine towers and the 6 ESP pilings. This is approximately 0.004 percent of the area of the proposed action and an even smaller percentage of similar habitat within Nantucket Sound (see Table 5.3.2-3).

***Permanent Alteration of Habitat***

The applicant evaluated and has requested the use of two engineered scour mitigation methods, scour mats and rock armor. The specific type of engineered scour mitigation method proposed for each location has been proposed. Where depths are shallow and current speeds are relatively faster, rock armor will be used. In relatively deeper water, where current speeds are relatively slower, scour mats are proposed. The scour protection proposed, by location, is presented in Figure 2.3.2-4.

Final consideration for scour protection would be based on an assessment of potential environmental impact and scour performance. Scour mats have been used previously for scour protection and are anticipated to last the life of the project (Report No. 5.3.1-1). Long term field monitoring of two types of scour mats are ongoing at the meteorological station. The multi-year pilot study is testing the effectiveness and durability of scour mats of different designs. Results would be incorporated in the final decision regarding which scour mitigation method is most effective and has the least environmental impact, and in the case of scour mats, which type is best for a particular application.

More precise qualitative and quantitative evaluations are proposed for the final design process. Scour tolerances will be calculated based upon final design, including factors such as pile diameter, length, and components' weights. If post-installation inspections indicate the scour tolerance may be exceeded at a location with scour mats, and adjustments to the scour mat configuration is not successful at mitigating the scour at a specific monopile, the scour mats will be removed and rock armor will be installed.

The current scour protection plan calls for scour mats to be placed at the base of 106 of the WTG pilings to minimize scour related to prevailing currents. Synthetic fronds that mimic seafloor vegetation were determined to be an option that would provide needed scour protection but minimize possible changes to the soft-bottom and fish communities that are associated with the Horseshoe Shoal locale. When they are attached to the bottom as a network, these synthetic fronds trap sediments and eventually become buried. As a result of this sediment trapping mechanism, this form of scour protection provides a low bottom relief similar to that which exists on Horseshoe Shoal rather than traditional boulder revetment. A scour control mat has an area of 135 square ft (0.003 acre or 13 $m^2$), and it is estimated that six mats would be required to protect a wind turbine piling. The area around a piling protected with scour control mats would be 810 square ft (0.02 acre or 75 $m^2$), which results in a total scour protection area of 85,229 $ft^2$ or 1.96 acres (7,946 $m^2$) for the 106 wind turbine towers. Scour would total 4,871 square ft (0.11 acre or 452 $m^2$) for the 6 ESP pilings. Thus, scour protection using mats would alter conservatively 0.0006 percent of the area of the proposed action (see Table 5.3.2-3).

Permanent colonization of the scour control mats by attached benthos is expected to be minimal since the scour control mats are designed to capture and retain sediment from the surrounding sea floor. The sediment that these mats trap is expected to be colonized by the benthos typically found in the shifting mobile sands of Nantucket Sound. Although it is expected that the trapped sediment would be scoured from the mat during periods of intense current movement or storm driven wave action, it is unlikely that the mat would be utilized by any attached benthic organisms. Evidence from the Field Report on Seabed Scour Control Mats (Report No. 4.1.1-8) showed photos of crabs on the mats. Crabs are not attached to the mat and are likely to be opportunistically utilizing the mat as a stable substrate during a period when the mat was exposed. Crabs were also present on the meteorological tower pilings, as previously described in Section 4.2.5.3, and common in benthic samples collected and analyzed from sandy substrates of Horseshoe Shoal and Nantucket Sound (Report No. 4.2.5-1 and Report No. 4.2.5-2). Since the scour control mats are designed to trap sediment and regularly be buried, no permanent colonization by epilithic fauna would be expected.

Rock armor scour control would provide scour protection at the base of 24 of the WTG pilings to reduce scour related to prevailing currents. The scour protection proposed, by location, is presented in Figure 2.3.2-4. This type of scour control involves use of smaller sized stones overlaid by rock armor stones. These materials would be placed so that final elevations would approximate bottom contours similar to those prior to installation of the monopiles. The filter layer material serves to fill most of the scour hole that may be expected to form after the monopile installation. It would also reduce the possibility of wave action to remove natural underlying sediments and reduce possible settlement of the rock armor into the natural underlying sediments. Armor stones would be large enough to deter removal by current conditions and wave effects and small enough for prevention of removal of stone fill material that is placed beneath them. The armor stones would cover approximately 15,884 $ft^2$ or 0.36 acres (1475 $m^2$) per piling. The total area covered by rock armor for the 24 monopiles of approximately 381,216 square ft (8.75 acres or 35,417 $m^2$). Thus rock armor scour protection proposed for these locations may alter approximately 0.05 percent of the area of the proposed action. Figure 2.3.2-4 shows the location of the 24 monopiles where rock armor is proposed. Rock armor could be used to replace scour mats in areas where the scour mats are less effective. The worst case scenario would involve rock armor placed around all 130 monopiles and the ESP. This would result in a conservative total scour protection area of 2,064,964 square ft (47.41 acres or 191,841 $m^2$) for all 130 wind turbine towers and 17,664 square ft (0.41

acre or 641 $m^2$) for the 6 ESP pilings. Thus, rock armor scour protection would conservatively alter 0.296 percent of the area of the proposed action (see Table 5.3.2-3).

If rock armor were used for scour control, it would be only as fill in a scoured area around the turbine piling and would not appreciably change the local seafloor topography. This design would promote deposition of a sand/silt matrix in the interstices of the boulder framework with the eventual burial of all the rock armor. Tidal currents may expose portions of the rock armor at the surface for short periods of time. However, the bi-directional nature of these currents should lead to establishment of a dynamic equilibrium, allowing the average condition of the scour-protected zone to be buried by sand. Thus, the faunal composition around the base of wind turbines at the site of the proposed action could be similar to that found pre-construction.

In the case that a portion of the rock armor becomes permanently exposed above the sandy seafloor, the fauna that colonize it would likely be similar to that found on the turbine pilings. As previously described in Section 4.2.5.3, macroinvertebrate sampling on support pilings of a meteorological tower in June 2005 yielded 26 taxa including seven species that were not observed during other baseline surveys at Horseshoe Shoal. These seven species, as previously described in Section 4.2.5.3, are likely to be within the site of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders.

***Oil Spills***

During construction there is the potential for spills and accidental releases of material such as diesel fuel, lubricants, and hydraulic fluid. Commitment to careful construction practices to minimize potential for spills and accidental releases and having an OSRP Plan that includes rapid spill response and clean-up capabilities are measures that should minimize the potential for harm to benthos and benthic habitats relative to spills and accidental releases during construction activities.

***Decommissioning Specific Impacts***

Impacts related to removal and decommissioning (refer to decommissioning procedure details in Section 2.0) of proposed action-related structures including wind turbine towers, foundations, scour control mats, ESP and offshore cables, would be expected to result in temporary seafloor impacts comparable to those that have been described above for construction activities during installation.

Monopiles would be decommissioned by removing sediments from inside the pile, cutting and removing the pile 15 ft (4.6 m) below the seabed, and then returning sediments to the sea floor to re-establish pre-proposed action seabed conditions. For each WTG constructed in water depths less than 40 ft (12.2 m), approximately 3,744 cubic ft (106 $m^3$) of material would be moved and returned. For each WTG constructed in water depths greater than 40 ft (12.2 m), approximately 4,324 cubic ft (122 $m^3$) of material would be moved and returned. During removal it is anticipated that any sediment plume would be minimal due to sediments being contained in the monopile and pump hoses. After cutting of the monopile, best practices available would be employed to minimize any sediment plume. Once removed, sediments inside monopiles would be suctioned out to a depth of approximately 15 ft (4.6 m) below existing sea bottom. Sediments would be pumped and stored on a barge and then returned to the excavated pile site using a vacuum pump and diver assisted hoses to minimize sediment disturbance and turbidity. Impacts related to removal and return of sediments from inside the monopile are anticipated to be temporary and localized.

Removal of the wind turbine tower foundations and ESP piles would result in a local shift from structure-oriented habitat to the original shoals type of habitat that was present prior to installation of the proposed action. There would be a return to pre-construction conditions. Decommissioning activities would also include removal of the network of inner-array cables and offshore transmission cable system linking the ESP to the mainland. These actions would result in temporary resuspension of bottom sediments along each cable path and anchor and anchor line impacts associated with any required vessel anchoring similar to those described above for the construction phase.

***Impacts to Shellfish and Lobsters***

The activities that would affect shellfish include installation of monopile foundations, inner-array cables, and the offshore transmission cable system and HDD activities in Lewis Bay, which is similar to those described above for general benthos.

In the sections of the proposed action area where temporary disturbance occurs, some shellfish mortality is expected. However, the impacts are expected to be minor since the areas disturbed are limited portions of the larger proposed action area and similar habitat types occur in the surrounding vicinity. However, certain shellfish species can be long lived, such as quahogs, and recovery of similar aged species would take longer.

As described in Section 4.2.5.4.2, the lobster fishery in Nantucket Sound does not appear to be a major fishery. In a Survey of Commercial and Recreational Fishing Activities (Report No. 4.2.5-6) it was commented that the Horseshoe Shoal locale was too sandy for support of a viable lobster fishery. Direct impacts to lobsters are anticipated to be minor and any possible mortality limited to individuals that are less mobile and may be in the immediate post lease geological and geophysical assessment and proposed action construction activity area. Use of the hydraulic jet-plow installation method would reduce impacts to the immediate construction corridor compared to a bucket dredging or cutter wheel trenching approach. Sediment suspension during installation of both the cable and monopiles is not anticipated to result in significant indirect impacts since the sediments settle relatively quickly. Review of the literature has indicated that lobsters have been described as having high tolerance to sediment deposition and suspended sediment (Ely, 1988 and Wilber et al., 2005) (see Table 5.3.2-4). In addition, lobsters have a rapid retreat response when threatened and the mobility and sensory capabilities of adult lobsters would allow them to largely avoid areas where active disturbances occur (Jury et al., 1995).

Interpretation of results from sediment transport modeling indicates that shellfish would suffer some mortality due to the temporary disturbance from jet plowing activities. Mollusks within the trench area are likely to suffer high injury or mortality because of either deep burial within the fluidized sediments or physical injury from jet water pressure or jet skids. Species-specific responses to suspended sediments and sediment deposition have been studied and vary depending on a particular species' feeding mode (e.g., deposit feeding, suspension feeding) and mobility (see Table 5.3.2-4). Species such as crabs and lobsters may be able to avoid areas of heavy sedimentation due to their mobility. Sedentary organisms, including species of commercial interest such as the northern quahog and soft shell clam, not able to evade sediment deposition may be subject to mortality or impact to reproduction, body condition and growth. Due to the highly dynamic environment in Nantucket Sound and that most naturally occurring species are adapted to settle and move in the sandy environment and recover from burial, the expected sediment deposition is not anticipated to have more than minor adverse impacts to shellfish resources. Since sediments expected to be suspended by jet plow operations (limited to the construction timeframe) are anticipated to be minimal in comparison to active sediment transport known from Nantucket Sound, filter and deposit feeding shellfish are not expected to be substantially impacted from suspended sediments from the jet plow installation.

The proposed cable route has been located to avoid privately licensed shellfish areas or grants in Lewis Bay. The proposed cable route would cross approximately 600 ft (182.9 m) of the recreational shellfish bed in Lewis Bay. The HDD would be used for crossing the area that is 200 ft (61 m) closest to shore with the remaining 400 ft (122 m) to be crossed using a jet plow. Moderate impacts to the benthic community are likely to occur from the placement of the pre-excavation pit that would be necessary for the transition from the seaward terminus of the HDD conduit to the offshore transmission cable system. Temporary impacts from the pre-excavation pit would involve 2,925 square ft (0.07 acre or 272 $m^2$) of seafloor which is approximately 0.0004 percent of the area of the proposed action. Thus, approximately 12,525 square ft (0.29 acre or 1,164 $m^2$) would be directly disturbed in the recreational shellfish bed 2,925 square ft (0.07 acre or 272 $m^2$) from the pre-excavation pit and 9,600 square ft (0.22 acre or 892 $m^2$) from jet plow embedment of the offshore transmission cable system. The applicant has committed to providing the town of Yarmouth with funds for mitigation of direct impacts to shellfish resources in accordance with the Town's shellfish mitigation policy.

### Impacts on Meiofauna and Plankton

#### *Meiofauna*

The meiobenthic community is likely to be adversely affected in a very similar manner to the sessile or less mobile soft bottom benthos discussed above. Because benthic meiofauna are extremely small and live in the interstices between sediment particles they are susceptible to bottom disturbing activities and sediment deposition. Recovery of the meiobenthic community from sediment disturbance is expected to be as fast as or faster than that of the macrobenthos. Past studies of meiofauna and sediment disturbance have generally documented quick recolonization following disturbance, with predisturbance densities usually reached in a few hours to a few days (Alongi et al., 1983; Fegley, 1988; Ingole et al., 2005). In some instances, the rapid recovery may be attributable to an increase in food availability (Ingole et al., 2005). However, even in experiments where the sediment was completely defaunated, recolonization occurred in a few weeks (Alongi et al., 1983). Meiobenthic assemblages also recover quickly, with predisturbance species compositions achieved within 90 days (Alongi et al., 1983). Thus, temporary disturbance of sandy substrate during post lease G&G investigations, and construction and decommissioning activities should have minor long-term impacts on the meiobenthos. Also, the nature of the construction and decommissioning activities are such that work progresses in sequence over a period of several months. Thus, impacts to the meiofauna that could potentially impact the marine food web would only be expected to occur on a localized level as the work takes place. An example of the ability of the meiofauna community to survive frequent sediment disturbance is evidenced by the continued use of large benthic organisms and fish of areas that experience regular and repeated bottom fishing. Further evidence of this community's ability to survive disturbed sediments is reflected in the abundance of these organisms within those portions of Nantucket Sound experience high movement of bottom sediments, visible as sand waves, due to natural conditions.

#### *Plankton*

Phytoplankton and zooplankton are not expected to be affected by post lease geotechnical and geophysical investigations nor construction or decommissioning activities. These activities are anticipated to temporarily increase suspended sediment concentrations in the area of activity. This may limit depth of maximum light penetration and thereby reduce ability of phytoplankton to photosynthesize. However, due to Nantucket Sound's intense tidal flushing, suspended sediment concentrations would be flushed away from the offshore cable route and are expected to settle approximately three hours after the jet plow passes. At most, this could result in small-scale, temporary reduction of primary production by phytoplankton, which could in turn suppress grazing zooplankton populations for a short time. During jet plow installation activities, direct mortality is expected for those phytoplankton and zooplankton that are entrained into the jetting system and injected into the sediments at high pressures. However, the jetting water withdrawal volumes represent a small fraction of the water in Nantucket sound at any one time and loss of these individuals would not be detectable in their populations nor have any adverse affect on the marine food web. Further details are presented in Section 5.3.2.7.1.

Similar negligible impacts to plankton would occur due to the water withdrawals and subsequent entrainment of plankton into the engine cooling and other water use system on board the construction and decommissioning vessels. Because this mostly occurs while ships are underway, the impacts are diffuse and temporary, spread along the transit route of the vessels. Hundreds of similar water withdrawals occur throughout Nantucket Sound and adjacent waters due to the operation of recreational boats, and commercial shipping, such as the ferries between the islands and Cape Cod and commercial fishing vessels. There is no reported harm to plankton communities due to these existing water withdrawals, and the short period, a year or two each, during which construction and decommissioning would occur, is unlikely to measurably alter or reduce the plankton community.

Sediments found in the area of the proposed action have been reported to be mainly sand and chemical constituent concentrations have been noted to be below the established thresholds that are in applicable reference sediment guidelines. Sediment core samples that were obtained at the proposed WTG site locale and along the proposed offshore cable routes had chemical constituent concentrations that were all below Effect Range-Low (ER-L) and Effect Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995). Disturbance and suspension of the sediments associated with the monopile foundation, inner-array and offshore transmission cable system installation activities are not anticipated to cause phytoplankton and zooplankton to be exposed to such contaminants during proposed action activities.

In the event of an unplanned activity, such as an oil spill during construction, the plankton community within the plume area would experience toxic affects of the released hydrocarbons. The applicant would construct and decommission the proposed action with an OSRP in place that should serve to minimize the harmful affects of an accidental oil spill.

**Conclusion**

Overall the post lease G&G investigation, and construction and decommissioning impacts on soft-bottom benthic invertebrate communities, shellfish, meiofauna, and plankton are expected to range from negligible to minor as these impacts would be for the most part temporary in nature. Furthermore, much of the Nantucket Sound benthos in shoal areas, have adaptive mechanisms for surviving in and on sediments that experience regular and ongoing disturbance due to the energetics of tidal currents and wave action in shallow water ecosystems.

### 5.3.2.5.2 Operational Impacts

Potential impacts to benthic communities that are associated with operation of the proposed action relate to areas of the seafloor that remain altered by the proposed action's features, or that could be affected by accidental and unplanned activities.

**Soft-Bottom Benthic Invertebrate Communities**

The vertical structures introduced by the installation of the wind turbine towers would be a source of new hard substrate with vertical orientation. These structures would be present during the full time of the operation of the proposed action. The Horseshoe Shoal area of Nantucket Sound has limited amounts of this type of habitat. Monopile foundations that were selected for this proposed action are smooth and lacking in complexity in comparison to scaffolding that is often used for oil platforms (MMS, 2000). Substrates that are irregular and rough offer organisms structural complexity for protection from predation and/or exposure to high current velocities and scour. Organisms that may settle on wind turbine towers could include algae, sponges, tunicates, anemones, hydroids, bryozoans, barnacles, and mussels. These organisms are known to occur on other hard substrate areas in Nantucket Sound including substrates such as those of navigation buoys or pier pilings. Organisms including polychaetes, oligochaetes, nematodes, nudibranchs, gastropods, and crabs are expected to occur as fouling organism growth develops. Results from the 2005 Macroinvertebrate Survey of the Meteorological Tower (described previously in Section 4.2.5.3.2) indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized the support pilings. Noted were seven species not observed during other baseline surveys at Horseshoe Shoal. These new taxa were noted to likely be in the site of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders. It was expected the pilings would support more taxa since they may attract organisms from both sandy substrate habitats and those that would be attracted to fixed structures.

Although use of the monopile structures is expected by some hard-bottom and fouling organisms, individual monopiles are not anticipated to act as true artificial reef structures that would significantly change benthic or fish communities in Nantucket Sound. Studies at Danish Wind Farms have noted that recruitment of larvae and juveniles is expected to be governed by tidal and residual currents and the structure location with respect to factors such as depth and distance from recruitment source (DONG Energy et al., 2006). The monopiles would have wide spacing (0.34 to 0.54 mile (629 to 1,000 m) apart). Additional amounts of surface area that are being introduced, approximately 1,200 square ft (0.03 acre or 111 $m^2$) per tower with 30 ft (9.1 m) as an assumed average water depth, for a total of about four acres, would be minor. The addition of rock scour armor would increase this acreage compared to that of the monopiles alone, but represent a small fraction of change in the overall site of the proposed action.

Observations that are similar to those made at the meteorological tower in Nantucket Sound have been made at the monopile foundation installations at existing European wind farms such as Denmark's Horns Rev and Nysted offshore wind farms (Birklund and Petersen, 2004; Bio/consult as., 2005). At these wind farms, hard-bottom attachment sites are created habitat for the benthic organisms that require a fixed (non-sand) substrate. Two annual post-construction/operation surveys of monopile communities at the Horns Rev wind farm identified taxa of seaweeds and faunal invertebrates, some of which were mobile species. Some epifaunal species had not previously been reported at the mostly sandy habitat. It was noted that the monopiles and scour control devices (raised hard-bottom platforms) had changed the substrate from all sand to one with foundations of steel, gravel, and stones. The monitoring reports noted further that native infaunal communities had been replaced with epifaunal communities usually found in the hard-substrate type of environment. In the year between the two surveys significant species and population variations were noted along with variation in spatial and temporal distribution. Such changes may have occurred because of regular scouring and recolonization due to severe storms and winter conditions. Studies have noted that though heavily populated fouling communities can establish themselves in as short a time as a year with placement of new hard-bottom habitat, stability of such a community is not reached till five to six years after a structure's establishment (Bio/consult as., 2005).

A post-construction survey at Nysted windpark found blue mussels, barnacles, bryozoans, and macroalgae at various depths on the monopile. Macroalgae were found on the monopile foundation and anti-scour concrete and stone base platform. Other invertebrate species noted along the base of the monopile foundation and raised scour protection platform included polychaetes, amphipods, gastropods, and bivalves (Birklund and Petersen, 2004). The raised hard-bottom platforms used at the Horns Rev and Nysted wind farms had greater substrate complexity than that proposed for this proposed action with scour control mats, although the alternative proposed rock armor backfill would increase substrate complexity around monopiles. In comparison to the Danish wind farms that provided greater surface area for colonization, hard-bottom colonization is anticipated to be less at the site of the proposed action in Nantucket Sound.

In addition, post-construction monitoring results from these European wind farms documented that a significant alteration to the food-chain basis (benthic organisms) did not occur. Therefore, it is not anticipated that the proposed action would impact the food chain or greatly impact predator-prey relationships supported by the benthic resources.

The presence of the ESP, with an overwater surface area of 20,000 square ft (0.46 acre or 1,858 $m^2$), may affect the soft-bottom benthic invertebrate communities in its immediate locale due to shading. It is expected these possible effects would be negligible since the ESP structure is to be located approximately 39 ft (12 m) above the MLLW datum plane in 28 ft (8.5 m) of water. The shadow from the structure is expected to move rapidly across the seafloor during the daylight hours.

***Impacts from Unplanned or Accidental Events***

In addition to the referenced operational impacts on benthic resources, there are potential impacts that could result from the unlikely requirement for repair of the electric cable. Such impacts would include temporary turbidity and some localized deposition of sediments during the repair process. Turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments for reburial of the repaired cable. Cable repair procedures are discussed in more detail in Section 2.4.6. Temporary impacts would also occur in the area where anchors were deployed or anchor cable sweeps the bottom. Impacts on benthic resources as a result of cable repair would be temporary, occupy a very small area of the seafloor and would therefore be negligible overall.

Other accidental situations, such as vessel collision or monopile collapse are most likely only going to have an affect on the benthos in the immediate area around the damaged monopile. Impacts would be consistent with and similar to those discussed above for construction and decommissioning, although in reverse occurrence, since the damaged monopile would be removed and a new one installed. Because of the temporary nature and localized impacts from sediment disturbance and vessel activities associated with this type of event, impacts to benthic resources would be negligible.

**Shellfish**

Potential impacts to shellfish due to operation of the proposed action are similar to those described above for soft-bottom benthic invertebrate communities.

In addition, with cable installation involving burial with a minimum of 6 ft (1.8 m) of cover below the seafloor possible interference with lobster or other shellfish migration or use of nursery or habitat areas is not expected. Use of submarine cable installation methods may result in temporary depressions in the seafloor, but since these are similar to natural topographic relief there is not expected to be interference with lobster, crab, gastropod or other mobile benthos movement or migration (Fogerty, 2000).

No adverse impacts from heat associated with submarine cables are expected for benthic and shellfish resources. Burying of cables below the seafloor and proper cable system design, serve to minimize potential thermal impacts during the operation of the proposed action.

During operational related activities there is the potential for spills and accidental releases of material such as diesel fuel, lubricants, and hydraulic fluid. Commitment to careful operational related practices to minimize potential for spills and accidental releases and having an OSRP Plan that include rapid spill response and clean-up capabilities are measures that should minimize the potential for harm to benthos and benthic habitats relative to spills and accidental releases during operation of the proposed action.

**Impacts on Meiofauna and Plankton**

***Meiofauna***

The meiobenthic community may be affected from sediment disturbance from maintenance activities during operation. Recovery of the meiobenthic community from sediment disturbance is expected to be as fast as or faster than that of the macrobenthos, as previously described in the construction/decommissioning impacts. Thus, temporary disturbance of sandy substrate during periodic maintenance activities should have minor impacts on the meiobenthos.

***Plankton***

Phytoplankton and zooplankton are not expected to be significantly affected by operational activities. Temporary disturbance of sandy substrate during periodic maintenance activities should have minor impacts on phytoplankton and zooplankton.

Wind turbine operation would shade small areas of water which may result in minor reduction of photosynthesis by phytoplankton. This potential for shading is expected to be inconsequential since water in Nantucket Sound typically moves rapidly through the site of the proposed action due to tidal currents. Thus, there should be minor potential for phytoplankton disturbance.

**Conclusion**

Wind Turbine operations are expected to have negligible impacts on soft and hard bottom benthic invertebrate communities, shellfish, meiofauna, and plankton. Since the proposed action's operation does not involve planned activities resulting in seafloor disturbance, only those unplanned or accidental events that occur would result in the potential to impact these species. It is inherent in an activity that is unplanned that if have a low probability of occurrence, and for this proposed action, any such activity is likely to involve on a short duration and a small area.

### *5.3.2.6 Non-ESA Marine Mammals*

#### 5.3.2.6.1 Construction/Decommissioning Impacts

Non-ESA listed marine mammal species may be impacted by activities associated with proposed action construction, operation/maintenance and decommissioning. This section discusses the impacts on the specific species mentioned in Section 4.2.6. These species are all protected under the MMPA. The applicant would be required to abide by any measures required by NOAA Fisheries under the terms of its review and approval process under the MMPA. Again, MMS will require that the MMPA authorization be in place before commencing any activities under MMS purview that may take marine mammals. Threatened or endangered marine mammals protected under the federal ESA are presented in Section 5.3.2.9 and the BA in Appendix G.

Review of scientific literatures, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of marine mammals have been conducted within Nantucket Sound. For the purpose of documenting the presence of marine mammals in Nantucket Sound, incidental observations during aerial surveys were combined with a comprehensive literature search, stock assessments, sighting, strandings and population studies information. There are limitations to the use of incidental observations and sightings data to document the presence of marine mammals in Nantucket Sound and should not be considered as an absolute documentation of the occurrence of any particular species, because the results are dependent in part on the level of effort that is expanded in looking for marine mammals and there is potential for misidentifying species. However, this information, combined with the best available scientific and commercial information, serve as a general indicator of where marine mammals are likely versus unlikely to occur in order to make an adequate informed evaluation regarding potential impacts to marine mammals.

NOAA/NMFS have established acoustical harassment guidelines that set thresholds to prevent acoustic injury (Level A) and acoustic disturbance (Level B) to marine mammals under NOAA's purview. The Level A threshold is 190 dB for pinnipeds (except Pacific walrus) and 180 dB for cetaceans, and the Level B threshold is 160 dB for cetaceans and pinnipeds (except Pacific walrus). The hearing threshold is the minimum sound level in a 1/3-octave band that can be perceived by an animal in the absence of significant background sounds. The hearing bandwidth for an animal is the range of frequencies over which an animal can perceive sound. Note that since the NMFS 180 dB re 1μPa guideline is designed to protect all marine species from high sound levels at any point in the frequency spectrum, and is very conservative criterion. This is further supported by Southall et al. (2007) which found, after a review by an expert panel of all known studies and information on the effects of sound, the existing criteria of 160 dB, 180 dB and 190 dB may be very conservatively set based on available information. However, these remain the standards used by NOAA Fisheries for their assessment and will remain so until NOAA Fisheries fully vets and officially adjusts these guidelines.

It is important to note that what little literature exists regarding the propagation of sound during pile driving activities from foreign offshore wind facilities generally provides measured sound values in different units and techniques than what NOAA Fisheries uses within its current acoustic guidelines. For example, researchers assessing acoustic impacts from offshore pile driving in the UK generally prefer to measure sound in a $dB_{ht}$ calculated value for each combination of proposed action activities and marine species because the $dB_{ht}$ method takes into account the frequency distributions of both the sound source and the receiving animal's hearing threshold. These studies did show marine mammal avoidance reactions occurring for 50 percent of individuals at 90 dB re 1 μPa, occurring at 80 percent at 98 dB re 1 μPa, and occurring for the single most sensitive individual at 70 dB re 1 μPa (Nedwell and Howell, 2004). The 90 dB re 1 μPa threshold for significant behavioral response is then consistent with NOAA Fisheries guidelines defining a zone of influence (i.e., annoyance, disturbance) for marine animals as a sound pressure level 80 to 100 dB above an animal's hearing threshold (University of California, 2005). Based on this approach to calculating and modeling the propagation of sound at the proposed project site, the applicants provided Report No. 5.3.2-2. The water sound levels perceived by marine mammals from the proposed action's construction and perceived sound of pile driving are presented in Tables 6 and 8 of the report, respectively. The predicted underwater sound levels perceived by marine mammals from the proposed action's operation are presented in Table 7 of the report.

Based on a review of the available information, the assessment below provides the study results from foreign-based offshore wind facilities and then MMS's analysis of what it predicts will be the sound propagation characteristics, in terms of the NOAA Fisheries acoustic guidelines, from the construction and decommissioning of the proposed action.

**Review of Existing Information from Existing Offshore Wind Facilities**

Studies show that the maximum submarine sound generated during the construction of the Wind Park will occur during installation of the monopile foundations. Measurements taken during pile driving of five smaller offshore windparks in the United Kingdom document that underwater sound levels varied between 243 and 257 dB re 1μPa @ 3.3 ft (1 m), having an average value of 250 dB re 1μPa @ 3.3 ft (1 m) (Nedwell et al., upubl. data). Underwater sound from pile driving operations can remain above the background sound to ranges of 25 km or more but can also diminish within 10 km, dependent on the local environmental conditions (Nedwell et al., upubl. data).

Measurements of actual underwater sound levels taken during the construction of the five offshore windparks in the United Kingdom indicate that there are two areas at which protected whales may be adversely impacted, the area of noise injury and the area of behavioral effect. (Nedwell et al., unpub. data). Physical effects (injury) to whales may occur at a distance when $dB_{ht}$=130 re 1μPa, while behavioral effects (avoidance) may occur at a distance when $dB_{ht}$=90 dB re 1 μPa (Nedwell et al., unpub. data). The area in which physical injury could occur may extend to a few hundred meters from the pile driving operations, while the area in which behavioral changes may occur may extend to a kilometer or greater (Nedwell et al., unpub. data). Therefore, based on the mitigation and monitoring measures required during pile driving activities for the proposed action, although marine mammals may hear the underwater construction sounds they are not expected to cause physical harm to cetaceans. Table 5.3.2-5 presents a summary of information on pile driving activities and equipment and also includes an assessment of the sound propagation for the piles under the proposed action at 500 m, 1 km and 2 km.

Additional sound source data for construction effects underwater were provided by GE Wind Energy from recent tests at the Utgrunden Project in Denmark which has similar environmental conditions to Nantucket Sound, and the size of the monopiles and the installation techniques proposed for this proposed action are the same as for the Utgrunden Wind Park (Report No. 4.1.2-1). The Utgrunden data show a maximum sound level of 178 dB at 1,640 ft (500 m) with peak energy from pile driving at 315 Hz, and with underwater sound levels falling below background levels (inaudible) for frequencies below 5 Hz.

**Summary of Pile Driving Activities and Estimated Sound Propagation for Proposed Action**

Table 5.3.2-5 presents a summary of information on pile driving activities and equipment and also includes an assessment of the sound propagation for the piles under the proposed action at 500 m, 1 km and 2 km. In an effort to minimize or eliminate the potential impacts from construction activities, MMS developed a mitigation and monitoring plan (see Section 8.1 of Appendix G) which outlines the measures MMS will require to reduce the potential for impacts. This plan also addresses mitigation, monitoring and reporting for all phases of the proposed project from construction through decommissioning. The measures outlined in this plan are to be set in place for ESA-listed and non-listed marine mammals. These measures may also change dependent on the outcome of the ESA consultation and the applicant’s MMPA authorization.

Based on the existing literature, the results of the sound propagation modeling in Table 5.3.2-5, and the current NOAA Fisheries acoustic guidelines setting potential for injury at 180 dB and 190 dB, MMS will require that the applicant establish a preliminary 750 m (2,461 ft) radius exclusion zone for marine mammals and sea turtles around each pile driving site in order to reduce the potential for serious injury or mortality of these species. The applicant then has the option of conducting field measurements to verify the received sound levels at various distances to the source. Based on the outcome of the field-verified sound levels, the applicant can either: (1) retain the 750 m zone or (2) establish a new zone based on field-verified measurements demonstrating the distance from the pile driving source where underwater SPLs are anticipated to equal or exceed the received the 180 dB re 1 microPa rms (impulse). Any new exclusion zone radius must be based on the most conservative measurement (i.e., the largest safety zone configuration), include an additional ‘buffer’ area extending out of the 180 dB zone and be approved by MMS and NMFS before implementing. Once approved, this zone will be used for all subsequent pile driving and will be periodically re-evaluated. Visual monitoring of the exclusion zone by one qualified NOAA Fisheries observer will then be conducted during driving of all piles. Soft starts will also be required at the start of driving any new pile. Further detail can be found in Section 8.1 of Appendix G.

**Additional Sound Sources Related to Construction and Decommissioning**

The jet plow embedment process for laying the two submarine cable circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge will produce sound typical of vessel traffic already occurring in Nantucket Sound. No substantial underwater sound will be generated during horizontal directional drilling (HDD) operations used to transition the submarine cable to the upland cable system in Lewis Bay. Due to the sound-insulating qualities of earthen materials (the sediment), and the fact that the drilling would take place through unconsolidated material, the HDD transition is not anticipated to transmit vibration from the sediment to the water (i.e., it would not add appreciable sound into the water column).

The sound source level for a tug and barge traveling at low speed, the typical construction and maintenance vessels for this proposed action, is 162 dB at 3.3 ft (1 m) (Malme et al., 1989). Operation of the vessels dynamic positions (DP) systems to assist in the construction of the ESP and WTGs will have sound levels around 120 dB re 1 µPa.

Underwater sound produced by the decommissioning of the proposed action is expected to be similar to those produced during the proposed action's construction except there will be no pile driving activities. Decommissioning will involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but the monopiles and transition pieces would be cut off at the mudline. Explosives will not be authorized to cut the piles. As such, the underwater sound impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and will be minor. However, consultations with other Federal agencies through the ESA Section 7 process and via the applicant and NOAA Fisheries through the MMPA authorization process will be conducted in order to confirm the potential for impact.

**Review of Potential Impacts to Different Marine Mammal Groups**

**Pinniped Species**

Pinnipeds have a hearing bandwidth of 100 Hz to 100 kHz, but their most sensitive hearing is at middle frequencies of 1 kHz to 30 kHz where their hearing threshold is 60 to 80 dB re 1 µPa (Richardson, 1995). In the low frequencies below 1 kHz where construction sound is concentrated, pinnipeds have a high hearing threshold of 80 to 100 dB re 1 µPa.

The predicted underwater sound level perceived by harbor, harp and hooded seals from project construction is 97 $dB_{ht}$ re 1 µPa at 1640 ft (500 m) (Table 6 of Report No. 5.3.2-2) or by NOAA Fisheries acoustic guidelines as high at 500 m as 178 dB re 1 µPa. Gray seals have a slightly lower hearing threshold and bandwidth. Based on the analysis, seals in the proposed action area are likely experience received sound levels exceeding 160 dB as far away as 2 km from the pile driving site. Again, NOAA Fisheries sets the acoustic harassment guidelines at 160 dB re 1 µPa for pinnipeds (except Pacific walrus) and injury at 190 dB re 1 µPa. By MMS requiring a preliminary exclusion zone of 750 m, this helps ensure that pinnipeds in the proposed action area do not come within distances of the pile driving activity where injury could result but acoustic harassment would be likely. Pinnipeds in the proposed action area are then likely to temporarily avoid the zone of behavioral response around the monopile being driven.

Important coastal habitat for the gray and harbor seals exist in Nantucket Sound, but at distances from the proposed action area that exceed approximately 12 miles (19.5 km) for gray seal breeding and pupping grounds at Monomoy Island and 8 miles (13 km) from Muskeget Island. Tuckernuck and Muskeget Islands (approximately 9.8 miles (15.7 km) and 8 miles (13 km), respectively from the WTG array site) are important haul out sites for harbor seals. Further, as only one monopile will be driven at any given time, it can be expected that pinnipeds will avoid the areas around that monopile for foraging, but this will not adversely impact the overall foraging ability of seals in the area. Therefore, it is anticipated that impacts to seals by the construction of the monopiles will be minor to moderate, given the mitigation and monitoring measures set in place by MMS, with the potential for avoidance of the area around the single monopile being driven.

***Vessels***

The sound source level for a tug and barge at low speed, the typical construction vessel for the proposed action, is 162 dB re 1 µPa at 3.3 ft (1 m) (Malme et al., 1989). Using the reported sound source for tugs and barges, the maximum perceived underwater sound level was evaluated at 150 ft (45.7 m) for seals using the hearing-threshold data (Table 3 of Report No. 5.3.2-2).

To represent a worst-case scenario, the maximum hearing-threshold sound levels ($dB_{ht}$ re 1 µPa) for a proposed action vessel were calculated at 150 ft (45.7 m), which gave a hearing threshold of 44 $dB_{ht}$ for seals. The seal would be able to hear the vessel but the sound levels are safely below the 130 $dB_{ht}$ re 1 µPa threshold for preventing injury or harassment to marine animals at the 90 $dB_{ht}$ re 1 µPa threshold for significant behavioral response (i.e., annoyance, disturbance). Therefore, proposed action vessels will not cause physical harm or behavioral effects in seals.

***Decommissioning***

Underwater sound produced by the decommissioning of the proposed action is expected to be similar to those produced during proposed action construction with the exception of no pile driving activity. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any blasting or activities which approach the sound level of pile driving. During decommissioning, the monopiles and transition pieces would be cut off at approximately 15 ft (4.6 m) below the seabottom. As such, the sound impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be minor.

Given the known areas that the seals within Nantucket Sound inhabit, minor to moderate impacts would be anticipated for seals due to proposed action construction generated underwater sounds, and any sounds should not affect the migration, nursing/breeding, feeding/sheltering or communication of seals. If seals are in the proposed action construction area, they are likely to temporarily avoid a given area around the construction, specifically around during pile driving operations.

***Increased Vessel Traffic***

The proposed action would temporarily increase the number of vessels within the vicinity of the area of the proposed action, especially in the route between Quonset, Rhode Island and the area of the proposed action. During pile driving construction activities, it is estimated that approximately 4-6 vessels would be present in the general vicinity of the proposed action. Other project vessels will be delivering construction materials or crew to the site and will be transiting from the various points on the mainland to the proposed action site and back. Barges, tugs and vessels delivering construction materials will travel at 10 knots (18.5 km/hr) or below and may range in size from 90 to 400 feet (27.4 to 122 m). The only vessels that are anticipated to be traveling at greater speeds are crew boats that will deliver and return crew to the proposed action area twice per day. Crew boats are anticipated to be approximately 50 feet (15.2 m) in length, and may travel at speeds up to 21 knots (30.9 km/hr). These crew boats are similar to typical vessels traveling through Nantucket Sound on a regular basis.

The additional traffic from construction and decommissioning vessels may increase the chance of a strike or harassment of seals. However, important coastal habitats for seals are not located in the immediate vicinity of the proposed action which would minimize the potential to negatively impact the seals.

*Vessel Strikes*

Collisions between proposed action vessels and seals may cause severe damage or even mortality to the animal. Vessel strikes were determined to be the cause of death in some stranded harbor seals and other species in New England waters (Waring et al., 2006). Between September 1, 2005 and August 31, 2006 there were 114 documented strandings of seals on Cape Cod and southeastern, MA, of which 2 were documented to be from vessel strikes (Cape Cod Stranding Network, Inc., 2006).

Because some seals may readily habituate to vessels, they may be more susceptible to vessel collisions. However, seals are agile and at the sight or sound of an approaching vessel seals are known to dive into the water and swim away. In addition, vessels moving at slower speeds (less than 14 knots or 35.9 km/hr) such as the tugs and barges used for proposed action construction and decommissioning, would be clearly audible and can be detected easily by seals. Thus, close encounters between vessels and seals are likely to be rare and result in minimal physical disturbance to the animals.

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

The assumed risk of vessel strikes to seals is considered minor as vessel traffic associated with the proposed action will not occur in areas where there have been high concentrations of seal sightings and construction vessels will move at slower speeds to reduce the likelihood of vessel collisions. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with seals. As a result, impacts on seal populations in Nantucket Sound would be minor.

*Vessel Harassment*

There have been many studies of the effects of vessels on marine mammals, particularly the underwater sounds they make (Richardson et al., 1985; 1991; 1995), and it likely that seals react primarily to the sound generated by vessels, and not their physical presence. It has been reported that vessel traffic may displace some seals from feeding areas and may disturb breeding, pupping, and haul out activities if the vessel makes repeated approaches or if vessel traffic is heavy. However, seals have been known to habituate to most anthropogenic sounds and activities, such as those at harbors and coastal airports (Vella et al., 2001). Furthermore, studies performed during the construction of the Horns Rev Wind Farm in Denmark showed the increase in vessel traffic during construction did not disturb the seals on land at the Rodsand Seal Sanctuary located nearby and did not cause the seals to flee into the water more often than before construction was initiated (Danish Offshore Wind – Key Environmental Impacts, 2006).

Important coastal habitat for the gray and harbor seals exist in Nantucket Sound, but at distances from the proposed action area that will prevent harassment from construction vessels and interactions with humans near the proposed action area. Gray seal breeding and pupping grounds in Nantucket Sound occur at Monomoy and Muskeget Islands (approximately 12 miles (19.5 km) and 8 miles (13 km), respectively from the WTG array site). Tuckernuck and Muskeget Islands (approximately 9.8 l miles (15.7 km) and 8 miles (13 km), respectively from the WTG array site) are important haul out sites for harbor seals.

Some displacement of seals from feeding grounds due to an increase in vessel traffic may occur if the vessel makes repeated approaches or if vessel traffic is heavy. However, prey for all seal species is prevalent in Nantucket Sound and foraging can occur in locations less disturbed by proposed action vessels. In addition proposed action vessels would be similar to typical vessel traffic occurring in Nantucket Sound on a regular basis, to which seals are already acclimated.

If seals are present in the area of the proposed action or along the vessel routes, potential behavioral changes in response to vessel traffic would be short-term, and would likely be similar to the behaviors observed during activities that regularly occur in Nantucket Sound such as the personal boat use, whale watching cruises, ferry traffic and fishing. Seal habituation to proposed action activities may occur following initial avoidance or investigative behavior. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

The effects of vessel harassment on the migration, breeding and feeding behaviors of seals during both construction and decommissioning are expected to be minor. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document and as contained in Section 8.1 of Appendix G. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with seals. Therefore, it is not expected that the proposed action will contribute to the harassment of seals. As a result, impacts on seal populations in Nantucket Sound would be minor.

***Temporarily Reduced Habitat***

Activities related to proposed action construction and decommissioning may cause a temporary reduced availability of habitat for seals in the vicinity of the area of the proposed action. The main anticipated impact would be part or complete avoidance of areas of pile driving and areas of high traffic, specifically the route the proposed action-vessels would use to and from the proposed action.

Studies conducted throughout the construction of offshore projects in Denmark, showed that only during pile driving activities was there a slight change in seal behavior or distribution, reducing haul-outs on nearby landfalls and temporary avoidance of the general area at great distances (Danish Offshore Wind – Key Environmental Impacts, 2006). In order to study the seals' use of the wind farm area and surrounding sea, a total of 32 seals were tagged with satellite transmitters around the Nysted and Horns Rev wind farms before construction began. In addition, aerial observations from an airplane and land visual observations were made to gather baseline data from a bird observation tower at the Rods and Seal Sanctuary located 2.48 miles (4 km) from the Nysted Wind Farm. While construction was anticipated to cause a significant disturbance to seals in the area, the time spent in the wind farm area during construction, only during pile driving activities were measurable effects observed when a decrease in seals were observed on land at the sanctuary. Satellite tagging showed that the time spent in the area of the Horns Rev wind farm showed no sign of deterring effect of the construction the use of the wind farm area by the seals, except that no seals were observed on days which pile driving operations occurred. However, normal behavior and distribution returned quickly after pile driving activities ceased and continued through the operation of the Wind Farm.

Similar effects of temporary avoidance are anticipated during the construction of the proposed action. However, as under normal conditions the seals are exposed to high volumes of vessel traffic due to commercial and recreational ships within Nantucket Sound, the increase in traffic is not anticipated to displace the seals for long periods of time and not result in any major impacts to seals. The pile driving operations will take place over 4-6 hours at each of 130 discrete locations, with all foundations being installed within two construction seasons. However, as mentioned previously important coastal habitat for the gray and harbor seals exist in Nantucket Sound, but at distances from the proposed action area that will prevent harassment from construction vessels and interactions with humans near the proposed action area. Gray seal breeding and pupping grounds in Nantucket Sound occur at Monomoy and Muskeget

Islands (approximately 12 miles (19.5 km) and 8 miles (13 km), respectively from the WTG array site). Tuckernuck and Muskeget Islands (approximately 9.8 miles (15.7 km) and 8 miles (13 km), respectively from the WTG array site) are important haul out sites for harbor seals. Therefore, it is not anticipated that construction will cause any major effects to the seal populations in the area.

As most seals forage and inhabit areas inshore, the HDD operations within Lewis Bay may cause temporary displacement from near-shore foraging areas. Studies do show that seals can rapidly habituate to construction activities, including pile construction, only showing alarm when support vessels moved within hundreds of meters of the seals (Westerberg, 1999). Some disturbance from vessel traffic and underwater construction sounds may occur, temporarily displacing seals from feeding or haul-out sites, but this impact would be minor and would terminate when proposed action construction concluded.

The proposed action may cause temporary displacement of prey during construction and decommissioning activities; however, seals that may feed on fish would be able to find suitable prey in areas adjacent to the area of the proposed action. Construction activities may result in an increased availability of seal prey species, especially during winter construction periods when fish may experience higher levels of injury or mortality, providing a short-term increased opportunity to feed on injured fish and macroinvertebrates (Report No. 4.2.5-5).

The temporary loss of habitat within Nantucket Sound during the construction and decommissioning of the proposed action is expected to have negligible impacts to seals.

***Habitat Shift (Non-structure Oriented to Structure)***

The presence of 130 monopile foundations, 6 ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system, with minor effects to seals. Additional amounts of surface area that is being introduced, approximately 1,200 square ft (0.03 acre or 111 $m^2$) per tower with 30 ft (9.1 m) as an assumed average water depth, for a total of about four acres, would be a minor addition to the hard substrate that is already present. The addition of rock scour armor would increase this acreage compared to that of the monopiles alone, but represent a small fraction of change in the overall site of the proposed action. Due to the small amount of additional surface area in relation to the total proposed action area and Nantucket Sound and the spacing between WTGs (0.34 to 0.54 nautical miles (0.63 to 1.0 km) apart), the new additional structure is not expected to affect the overall environmental, benthic community composition or seal populations. As seals do not often utilize the waters within the vicinity of the area of the proposed action for foraging, but rather remain closer inshore, the change of habitat structure with the addition of the WTGs would have minor impacts on seal populations.

***Habitat Shift (Structure to Non-structure Oriented)***

Removal of the WTG monopile foundations and ESP piles at the time of decommissioning would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoal-oriented habitat present prior to construction to the proposed action. As the addition of the monopiles would have minor impacts to seals in the area by increasing the amount of hard substrate that was present prior to the construction of the proposed action, the removal of the WTGs and ESPs would not have a major impact. Any seal that may have been attracted to the WTGs for feeding would have ample supplies of prey species in other locations within Nantucket Sound. Therefore, any impacts from the habitat shift from the structure oriented to non-structure oriented would be minor.

***Water Quality***

*Turbidity and Total Suspended Solids*

The primary water quality concern to seals during construction activities is elevated concentrations in total suspended solids (TSS), which cause lower visibility within the water impacting the foraging abilities of seals. Construction activities associated with installing the monopile foundations, scour control, and submarine cables will result in a temporary and localized increase in TSS concentrations. The pile driving hammer and jet plow technology that will be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sands in Nantucket Sound, localized turbidity associated with Project construction and decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles and the submarine cable route. In Lewis Bay, suspended sediments are predicted to remain in suspension considerably longer than in Nantucket Sound due to weak tidal currents. As such, impacts are anticipated to be minimal. Seals within the area of Nantucket Sound and Lewis Bay are accustomed to substantial amounts of suspended sediment on an irregular basis, from storms and strong tidal currents, and should not be substantially impacted by a temporary increase in turbidity from proposed action activities. Further, seals are mobile and can move away from any disturbance, including any increases in suspended sediments. The total expected impacts of increased turbidity and TSS are minor for seals within Nantucket Sound.

***Contaminated Sediments***

Seals bioaccumulate contaminants from their ocean environment almost exclusively through their food sources. The potential mechanism by which sediments suspended during proposed action construction can harm seals is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey (indirectly).

Analysis of sediment core samples obtained from the area of the proposed action indicate that sediment contaminant levels were below established thresholds in reference ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Therefore, the temporary and localized disturbance and suspension of these sediments during proposed action construction activities are not anticipated to result in increased contaminants in lower trophic levels.

During the nearshore installation, the release of contaminants from the HDD operation within Lewis Bay would be minimized through a drilling fluid fracture or overburden breakout monitoring program, minimizing the potential of drilling fluid breakout into the water.

Seals are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the proposed action vicinity, and any impacts are expected to be minor.

***Geotechnical and Geophysical Investigations***

Many of the types of disturbances that would occur during the geotechnical and geophysical investigations are short term and very localized. Section 8.1 of Appendix G outlines what MMS will require for mitigation, monitoring and reporting during the conduct of G&G investigations. A very small area of the sea floor would be disturbed by coring activities, either at the core hole or associated with the coring vessel anchor placements. It is likely that the duration of activity at any one coring location would be no more than a few days. The high resolution geophysical survey work, including collection of shallow (Chirp) and intermediate depth (Boomer) subbottom profiler data and sidescan sonar and magnetometer data, uses mobile gear towed behind a vessel, and would not result in bottom disturbance, nor does it result in activity at a fixed location. The geotechnical investigations would result in a negligible temporary loss of some benthic organisms, and a localized increase in disturbance due to vessel activity, including underwater sounds and anchor cable placement and retrieval. Given the small area of disturbance, short duration of activities, and the required mitigation and monitoring outlined in Section 8.1 of Appendix G, potential adverse impacts from geotechnical and geophysical investigations to seals would be minor (Additional details on geotechnical and geophysical field investigations are presented in Section 2.7).

**Impacts to Cetaceans**

This section discusses the impacts on the specific cetacean species mentioned in Section 4.2.6.2.2 that could occur in the site of the proposed action and may be impacted by activities associated with proposed action construction and decommissioning. An introduction to underwater sound is provided in Section 5.3.2.6, including a description of the analyses used to calculate the hearing thresholds of toothed whales.

Extensive study has been done on the hearing thresholds of toothed whales (odontocetes), using a variety of methods. In general, toothed whales have a hearing bandwidth of 100 Hz to over 100 kHz, with the most sensitive hearing in the high-frequency range of 10kHz to 65 kHz where their hearing threshold is 45 to 85 dB re 1µPa (Richardson et al., 1995). Communications among these mammals occurs primarily in the lower end of this high-frequency band, and echolocation for navigation uses the upper end. In the low frequencies below 1 kHz where construction sound is concentrated, toothed whales have a very high hearing threshold of 80 to 130 dB re 1µPa. Hearing thresholds and bandwidths for harbor porpoises, striped dolphin and bottlenose dolphin are summarized in Table 1 of Report No. 5.3.2-2, in which 13 research studies have been combined to produce maximum likelihood estimates (Nedwell et al., 2004). For the other species without data, including the Atlantic white-sided dolphin, short- beaked, common dolphin, Risso's dolphin, spotted dolphin, pilot whale, *Kogia sp*. and minke whale, the results for the bottlenose dolphin are recommended as best estimate.

The principal sound from construction would be pile driving of monopiles, one monopile at a time The predicted underwater sound level perceived by cetaceans from project construction ranges from 93 $dB_{ht}$ re 1 µPa at 1640 ft (500 m) for pilot and minke whales to 99 $dB_{ht}$ re 1 µPa at 1640 ft (500 m) for harbor porpoises (Table 6 of Report No. 5.3.2-2). During pile driving, it is anticipated that at 4,626 ft (1,410 m) harbor porpoises may experience a behavioral response, specifically avoidance. At 2,592 ft (790 m) striped dolphins may show a behavioral response, and at 2,329 ft (710 m) the remaining toothed whales may begin to the avoid that area. Avoidance by a minority of individuals would be expected at lower levels and hence at slightly greater distances than on average. Assessing potential impacts based on the NOAA Fisheries acoustic guidelines, cetaceans approaching the pile driving source as 500 m would experience received sound levels as high 178 dB re 1 µPa. At 2 km, the received sound level would be 166 dB re 1 µPa. Based on the analysis, cetaceans in the proposed action area could experience acoustic harassment at distances greater than 2 km from the source and may even potentially experience injury producing levels when closer than 500 m from the source. However, MMS will require monitoring of a preliminary exclusion zone of 750 m which helps ensure that cetaceans in the proposed action area do not come within distances of the pile driving activity where injury could result but acoustic harassment would be likely. It is possible then that cetaceans in the proposed action area would likely temporarily avoid the zone of behavioral response around the monopile being driven. Any impacts are not expected to affect the migration, nursing/breeding, feeding/sheltering or communication of cetaceans.

***Vessels***

The sound source level for a tug and barge at low speed, they typical construction vessel for the proposed action, is 162 dB re 1 µPa at 3.3 ft (1 m) (Malme et al., 1989). Using the reported sound source for tugs and barges, the maximum perceived underwater sound level was evaluated at 100 ft (45.7 m) for toothed whales using the hearing-threshold data (Table 1 of Report No. 5.3.2-2).

To represent a worst-case scenario, the maximum hearing-threshold sound levels ($dB_{ht}$ re 1 μPa) for a proposed action vessel were calculated at 100 ft (45.7 m), which gave a hearing threshold of 45 $dB_{ht}$ for toothed whales. The cetacean would be able to hear the vessel but the sound levels are safely below the 130 $dB_{ht}$ re 1 μPa threshold for preventing injury or harassment to marine animals at the 90 $dB_{ht}$ re 1 μPa threshold for significant behavioral response (i.e., annoyance, disturbance). Therefore, proposed action vessels will not cause physical harm or behavioral effects in toothed whales.

***Decommissioning***

Underwater sounds produced by the decommissioning of the proposed action are expected to be similar to those produced during proposed action construction with the exception of no pile driving activity. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities, which approach the sound level of pile driving. During decommissioning, the monopiles and transition pieces would be cut off at approximately 15 ft (4.6 m) below the seabottom. As such, the sound impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be minor.

Any cetaceans are likely to temporarily avoid a given area around the construction, and only minor impacts would be anticipated due to proposed action construction generated sounds. Any sounds should not affect the migration, nursing/breeding, feeding/sheltering or communication of cetaceans.

***Increased Vessel Traffic***

As mentioned above, the additional traffic from construction and decommissioning vessels may increase the chance of a strike or harassment of cetaceans. It is anticipated that 4-6 construction barges, tugs and vessels, ranging in size from 90 to 400 feet (27.4 to 122 m) in length, will travel between the staging site in Quonset, RI to the proposed action area at speeds of 10 knots (18.5 km/hr). In addition, crew boats approximately 50 feet (15.2 m) in length may travel at speeds up to 21 knots (38.9 km/hr) twice per day.

*Vessel Strikes*

Vessel strikes to cetaceans can result in injury or death of the animal. The potential risk to whale and dolphin species from collisions with proposed action-vessels is evaluated below. Documentation of vessel strikes on smaller cetaceans, such as those mentioned in Section 4.2.6.2.2 are less common than strikes on for the humpback, North Atlantic right and fin whales. For the purposes of this analysis, the general assumptions and impacts discussed for these three whales would apply to other MMPA protected cetaceans. Detailed discussion of these three whale species is presented in the BA in Appendix G, which provides information on T&E species and potential effects to T&E species.

Vessel strikes are a significant source of mortality for inshore species of baleen whales (Waring et al., 2006; NMFS 1991). While ship strikes occur throughout the world, several studies document that the greatest number of incidents occur within the North American east coast (Laist et al., 2001; Jensen and Silber, 2003; Waring et al., 2006). Along the North American east coast there is a high concentration of large cetaceans and a significant volume of vessel traffic, enabling a greater chance of a collision but also the greater likelihood of reporting of any strikes possibly biasing any assumptions (Jensen and Silber, 2003). As has been documented for bowhead whales (George et al., 1994), the size and extent of scarring on whales indicate that collisions are primarily with large, faster moving vessels such as container ships, tanker, or military vessels. However, recent evidence indicates that boats less than 65 feet (19.8 m) in length pose a risk to right whales with a total of 14 instances of small boat interactions observed during the winder 2005 season (Right Whale News, 2005). However, these collisions were boats traveling at higher speeds. Collisions with vessels that are moving at slower speeds (less than 14 knots [7.2 m/s]), such as the construction vessels to be used for the proposed action, while possible are less likely, and there have been few ship strikes from vessels traveling less than 10 knots (5.1 m/s) (Laist et al., 2001).

A tugboat cruising at 2 to 6 knots (3.7 to 11.1 km/hr) with a barge in tow generates underwater sounds with peak intensities in the optimum range of hearing in those species of whales and dolphins discussed in Section 4.2.6.2.2 (Miles et al., 1987; McCauley 1994). The cetaceans that may cross the area should be able to detect any tugboat, barge and other slow-moving vessels within the area of the proposed action. Whale and dolphin responses, however, are unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vehicles. Right whales hear approaching vessels, however they continue to die from vessel collisions (Richardson et al., 1995; Nowacek et al., 2004). A study by Nowacek et al., (2004), reported that right whales did not respond to the sounds of approaching vessels or the actual vessels. Some anecdotal observations suggest that right whales only respond when vessels approach to within a very close range. Right whales off the eastern coast of North America are frequently exposed to vessels, and they may have habituated to the sounds of approaching vessels at great distances (Richardson et al., 1995; Terhune and Verboom, 1999; Laist et al., 2001). According to a recently published large whale ship strike database based on public information collected by NOAA Fisheries from 1975 to 2002 (Jensen and Silber, 2003), finback whales are the most often reported species hit by ships (75 records of strike) followed by humpback (44 records), North Atlantic right (38 records), gray (24 records), minke (19 records), southern right (15 records), and sperm whale (17 records).

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

Although vessel collisions are a primary cause of large whale mortality in the western North Atlantic, the proposed action is not anticipated to subject whales and dolphins to increased risk of vessel strike. As stated earlier, vessels moving at slower speeds (less than 14 knots (25.9 km/hr), such as the construction vessels, are less likely to cause collisions (Laist et al., 2001). In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document and Section 8.1 of Appendix G. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with cetaceans. As a result, impacts on cetacean populations in Nantucket Sound would be minor.

*Vessel Harassment*

There have been many studies of the effects of vessels on cetaceans, particularly the underwater sounds they make (Richardson et al., 1985, 1991). It is likely that whales and dolphins react primarily to the sound generated by vessels, and not their physical presence (NMFS, 2001; NMFS, 2002). Moreover, the central portion of Nantucket Sound and the vessel routes proposed to be used by the proposed action vessels are not within what is considered a high use area for whale species. If any cetaceans are present in the area of the proposed action, potential behavior changes in response to proposed action-related vessel traffic would be short-term and would likely be similar to the behaviors observed during regularly occurring activities in Nantucket Sound such as the personal boat use, whale watching cruises, ferry traffic and fishing. Close encounters between proposed action vessels and cetaceans are likely to be rare and result in minimal physical disturbance to the animals.

The effects of vessel harassment on the migration, breeding and feeding behaviors of cetaceans are expected to be minor. Based on the undeveloped source of prey in Nantucket Sound, it is highly unlikely that cetaceans would be migrating through, nursing or feeding in Nantucket Sound, but further offshore. The physical presence of vessels associated with proposed action construction would not contribute to the harassment of migrating, nursing or feeding cetaceans. Some seasonal residents of Nantucket Sound, such as harbor porpoises, may experience some displacement from traditional feeding grounds, however this should be temporary and most species found within the vicinity of the proposed action are habituated to high volumes of vessel traffic.

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

The vessels used for the construction and decommissioning of the proposed action would be smaller, slower moving vessels than those that regularly cruise Nantucket Sound. In addition, the vessel routes proposed to be used for the proposed action do not occur in areas where there have been high concentrations of whale sightings. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document and Section 8.1 of Appendix G. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with cetaceans. Therefore, it is not expected that the proposed action will contribute to the harassment of cetaceans. As a result, impacts on cetacean populations in Nantucket Sound would be minor.

***Temporarily Reduced Habitat***

Activities related to proposed action-construction may cause a temporary reduced availability of habitat for cetaceans in the vicinity of the area of the proposed action. The main anticipated impact would be avoidance of areas of high traffic mainly the route the proposed action vessels would use to and from the proposed action. However, as under normal conditions the cetaceans are exposed to high volumes of vessel traffic due to commercial and recreational ships within Nantucket Sound, the increase in traffic is not anticipated to displace cetaceans for long periods of time. Some avoidance may also occur during construction activities due to acoustical harassment, as mentioned previously. However, this disturbance would be temporary and would not result in any major effects on the cetaceans. Studies of harbor porpoises during the construction of the off-shore Danish wind farms showed that harbor porpoises temporarily avoided the area in the vicinity of the turbines only during construction, and mainly during pile-driving activities (Danish Offshore Wind – Key Environmental Impacts, 2006). Surveys were conducted from ship and aircraft to determine the extent of harbor porpoises in the vicinity of the Nysted and Horns Rev wind farm prior to construction, during construction and during operations. Decreases in porpoise abundance were found at both sites during construction, only a slight decrease at Horns Rev, and a much stronger decrease at Nysted, with clear effects from the pile driving and ramming activities. At Horns Rev, there was no observed effect of wind farm operation, while at Nysted; the decrease in porpoises observed during construction has persisted during the first two years of operation, with indications of a slow recovery. The conclusions in these studies are that most effects of the wind farms on cetaceans are temporary and related to underwater construction sound, but the reasons behind the slow recovery at Nysted are unclear.

Proposed action construction and decommissioning are not anticipated to result in changes in cetacean prey abundance or distribution. Some temporary displacement may occur during periods of underwater sounds or high suspended sediments, but this would be limited to areas directly surrounding the given activities, causing both prey species and cetaceans moving to an undisturbed area. Pelagic prey tends to be highly variable and animals foraging on these sources move with the food source, as seen with many cetaceans and their prey species. Any temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and is likely available in other areas of Nantucket Sound and surrounding waters for foraging by cetaceans. Therefore, proposed action construction is anticipated to have minor impacts on cetaceans in regards to reduced habitat and prey availability.

***Habitat Shift (Structure to Non-structure Oriented)***

The presence of 130 monopile foundations, six ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system. Additional amounts of surface area that is being introduced, approximately 1,200 square ft (0.03 acre or 111 $m^2$) per tower with 30 ft (9.1 m) as an assumed average water depth, for a total of about four acres, would be a minor addition to the hard substrate that is already present. The addition of rock scour armor would increase this acreage compared to that of the monopiles alone, but represent a small fraction of change in the overall site of the proposed action. Due to the small amount of additional surface area in relation to the total proposed action area and Nantucket Sound and the spacing between WTGs (0.34 to 0.54 nautical miles (0.63 to 1.0 km) apart), the new additional structure is not expected to affect the overall environmental, benthic community composition or cetaceans populations. Furthermore, the whale species are not anticipated to be attracted to the WTGs for feeding purposes as Atlantic herring is the only dolphin and porpoise-preferred prey anticipated to potentially forage within the wind farm, and ample supplies of this prey is located in areas other than the proposed action area. In addition, it is anticipated none of the whale species would be attracted to the WTGs as potential shelter. Therefore, the habitat shift from non-structure oriented to structure oriented will have negligible to minor impacts on cetaceans in Nantucket Sound.

***Habitat Shift (Structure to Non-structure Oriented)***

Removal of the WTG monopile foundations and ESP piles at the time of decommissioning would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoal-oriented habitat present prior to construction to the proposed action. As the addition of the monopiles would have minor impacts to cetaceans in the area by increasing the amount of hard substrate that was present prior to the construction of the proposed action, the removal of the WTGs and ESPs would not have a major impact. Any cetacean that may have been attracted to the WTGs for feeding would have ample supplies of prey species in other locations within Nantucket Sound. Therefore, any impacts from the habitat shift from the structure oriented to non-structure oriented would be minor.

***Water Quality***

*Turbidity and Total Suspended Solids*

The primary water quality concern to cetaceans during construction activities is elevated concentrations in total suspended solids (TSS), which cause lower visibility within the water impacting the foraging abilities of cetaceans. Construction activities associated with installing the monopile foundations, scour control, and submarine cables will result in a temporary and localized increase in TSS concentrations. The pile driving hammer and jet plow technology that will be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sands in Nantucket Sound, localized turbidity associated with Project construction and decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles and the submarine cable route. In Lewis Bay, suspended sediments are predicted to remain in suspension considerably longer than in Nantucket Sound due to weak tidal currents. As such, impacts are anticipated to be minimal as cetaceans within the area Nantucket Sound are accustomed to substantial amounts of suspended sediment on an irregular basis, from storms and strong tidal currents, and a temporary increase in turbidity from proposed action activities would have minor impacts.

During the post lease G&G field investigation, vibracores and drilling of bore holes would take place to acquire subsurface geological information on the sea bottom. This would result in turbidity, which would be localized and temporary, and impacts on cetaceans would be negligible.

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. The suspension of solids are expected to be temporary and localized, as the removal technology that would be used to install the monopile foundations and the offshore cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Further, the physical composition of the sands and the physical characteristics of the Sound environment provide reason to assume that any localized turbidity would settle back to the sea floor within a short period of time (one to two tidal cycles) and distance.

*Contaminated Sediments*

Cetaceans bioaccumulate contaminants from their ocean environment, almost exclusively through their food sources. The potential mechanism by which sediments suspended during proposed action construction can harm cetaceans is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey (indirectly).

Analysis of sediment core samples obtained from the site of the proposed action indicate that sediment contaminant levels were below established thresholds in reference ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Therefore the temporary and localized disturbance and suspension of these sediments during proposed action construction activities are not anticipated to result in increased contaminants in lower trophic levels. Therefore, cetaceans are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the proposed action vicinity, and any impacts are expected to be minor.

The suspension of the sediments due to proposed action decommissioning activities is not anticipated to increase the amount of contaminants found within lower trophic levels, as there is little potential for cetaceans to bioaccumulate chemical contaminants in their tissue from consuming prey within the area of the proposed action.

**Conclusion**

The overall impacts on marine mammals from construction and decommissioning activities associated with the proposed action are expected to range from negligible to moderate (for pile driving). Impacts at no more than moderate are further supported by the MMS mitigation, monitoring and reporting requirements outlined in Section 8.1 of Appendix G as well as the required MMPA authorization and ESA incidental take allowance. The moderate impacts would be limited to the construction phase of the proposed action. Marine mammals may experience limited and temporary acoustic harassment if they occur near or within the 750 m exclusion zone (or revised field verified zone), as the anticipated sound levels will be slightly greater than the NMFS Level B standard. However, the required exclusion zone monitoring is expected to keep received sound levels by marine mammals less than the NMFS Level A standards, and thus not result in any injury to marine mammals. It is anticipated that marine mammals would avoid the WTG locations while pile driving is occurring. A recent study by Thomsen et al. (2006) revealed that seals and porpoise left the area of the proposed action during pile driving. Seals subsequently returned although porpoise had not as of the study's publication. Negligible impacts would be confined to the duration of the proposed action and the area of the proposed action activities.

### 5.3.2.6.2 Operational Impacts

**Pinniped Species**

***Vessel Strikes/Harassment***

The proposed action's operation and maintenance activities are expected to require two vessel trips per working day for 252 days of the year, traveling from New Bedford and Falmouth, Massachusetts to the proposed action area. Crew boats are anticipated to be approximately 50 feet (15.2 m) in length and may travel at speeds up to 21 knots (38.9 km/hr).

As mentioned previously, vessel strikes have caused some mortality in seals in New England waters (Waring et al., 2006). Because of the ability of seals to habituate to vessels and because seals inhabit coastal shores, they may be more susceptible to ship collisions. However, seals are extremely agile and aware of their surroundings in the water, and able to detect approaching vessels in time to swim away. The vessels used for the operation and maintenance of the proposed action would be smaller and slower moving than those that regularly cruise Nantucket Sound. It is possible that some increased recreational fishing effort may occur after the proposed action is operational due to the "fouling potential" of the WTGs. Seals may be attracted to the WTGs for foraging purposes, as it is anticipated some prey species specifically Atlantic herring and alewife may also be attracted to the area. However, those vessels used for operation and maintenance of the proposed action will be similar to typical vessel traffic occurring in Nantucket Sound already on a regular basis.

In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document and in Section 8.1 of Appendix G. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with seals. Therefore, it is not expected that the proposed action will contribute to the harassment of feeding seals. As a result, impacts on seal populations in Nantucket Sound would be minor.

***Wind Turbine Operational Underwater Sound***

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Preliminary results from underwater sound studies conducted in the United Kingdom suggest that in general, the level of sounds created during the operation of offshore windfarms is very low and does not cause avoidance of the area by marine species (Nedwell, unpub. data). Even in the area directly surrounding the wind turbines, underwater sounds was not generally found above the level of background sound, resulting in normal activity of marine animals (Nedwell, unpub. data).

Acoustic modeling of underwater operational sound at the UK Wind Park was performed for the design wind condition (see Section 3.13 of ESS, 2007). Baseline underwater sound levels under the design wind condition are 107.2 dB. The predicted sound level from operation of a WTG is 109.1 dB at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total sound level falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m). Since the WTGs will be spaced farther apart than 360 ft (110 m) (approximately 629 to 1,000 m or 0.34 to 0.54 nautical miles apart), no cumulative impacts from the operation of the 130 WTGs in the Wind Park are anticipated.

An analysis of predicted underwater sound levels perceived by seals from proposed action operation show that no injury or harassment to seals are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the proposed action is operating at the design wind speed as all $dB_{ht}$ values at this minimum distance are well below 90 dB re 1μPa (Table 7 of Report No. 5.3.2-2). In fact, proposed action operation would be inaudible for all seals at the close distance of 65.6 ft (20 m) with the perceived operational sound level at <0 $dB_{ht}$ re 1µPa. Therefore, it is anticipated that underwater operation sounds from the proposed action would result in negligible impacts on seals in Nantucket Sound.

***Electric and Magnetic Fields (EMF)***

The cable system for the proposed action includes the inner-array cables and two submarine cable circuits, will be a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed inner-array and submarine cable systems would contain grounded metallic shielding that effectively blocks and electric fields generated by the operating cable system. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the submarine cable system and inner-array cables. The magnetic fields associated with the operation of the inner-array cables and submarine cable system are not anticipated to result in adverse impact to seals or their prey (Report No. 5.3.2-3). Further, the burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables.

The research presented in Report No. 5.3.2-3 indicates that although high sensitivity has been demonstrated by certain species for weak electric fields (especially sharks), this sensitivity is limited to steady (DC) and slowly-varying (near-DC) fields. The proposed action produces 60-Hz time-varying fields and no steady or slowly-varying fields. Likewise, evidence exists for marine organisms utilizing the geometric field for orientation, but again, these responses are limited to steady (DC) and slowly-varying (near-DC) fields. The 60-Hz alternating power-line EMF fields such as those generated by the proposed action have not been reported to disrupt seal behavior, orientation, or migration. Therefore, it is anticipated impacts to seals or their prey species during the normal operation of the cable systems are expected to be negligible.

***Pollution/Potential Spills***

Following the *Exxon Valdez* oil spill in 1989, the harbor seal populations in and around Prince William Sound were extensively studied and monitored to determine the impacts of the spill. Because the seals rely on coastal areas to haul-out and some to reproduce, they have the potential to be exposed on land as well as at sea (Frost 1997). Seals have thick layers of blubber that prevent them from becoming hypothermic if they were to become coated oil as a result of a spill, as such while in the water, seals are most vulnerable when they surface for air, at which time they may inhale hydrocarbon vapors which can damage lungs. An estimated 302 harbor seals were killed not by oiled pelage but likely from inhalation of toxic fumes leading to internal bleeding of organs; liaisons to the brain; inflamed eyes; skin irritations; and stress and disorientation (Frost, 1997; Loughlin 1994). Seals can also become impacted by an oil spill through bioaccumulation of the pollutants from their prey species.

On haulout sites in oiled areas, seals crawled through oil and rested on oiled rocks and algae (Frost 1997). Pups were born on haulout sites in the following May and June, when some of the sites still had oil on them; and many pups became oiled shortly after birth. It is estimated that in Bay of Isles and Herring Bay in Prince William Sound, 89-100 percent of pups were seen to be covered in oil (Frost 1997). Seal pups are most vulnerable if oil reaches the shoreline, because they have not developed the protective blubber. Some of the contamination was from contact with oiled mothers, but the oil may have come from covered rocks and algae, especially popweed (*Fucus*) which covers the haulout sites and remained oiled well after the rest of the areas were cleaned (Frost 1997). Abnormal behavior by oiled harbor seals was also observed on many occasions during surveys in April to June 1989 (Lowry et al, 1994). Oiled seals were reported to be sick, lethargic, or unusually tame. Excessive tearing, squinting and disorientation were also observed, possibly leading directly to the deaths of pups due to abandonment and of older seals due to drowning (Frost 1997).

Long-term effects of the *Exxon Valdez* oil spill have also been studied. By early September 1989, less than 20 percent of the seals observed in the oiled area were oiled (Frost 1997). Most seals older than pups had molted, shedding their oil-stained hair. By April and June 1990 no visual signs of oiling were observed on any seals, and no seals showed signs of acting lethargic and sick (Frost 1997). One year after the spill, none of the tissue samples from seals showed significantly elevated concentrations of oil-related hydrocarbons (Frost 1994). However, elevated levels of hydrocarbons in bile indicated recent exposure to oil, suggesting seals were still encountering oil in the environment, possibly from ingesting contaminated prey, or they were metabolizing fat reserves that had elevated levels of hydrocarbons (Frost 1997; Peterson et al., 2003).

The ESP and WTGs will contain small amounts of various lubricating oils, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment. In addition, the ESP will be the primary oil storage facility for the proposed action and will contain a maximum 42,000 gallons (158, 987 liters) at any given time. The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The WTGs will contain lesser amounts of fluids, approximately 214 gallons (810 liters) at any given time (27,820 gallons, or 105,310 liters, for all 130 turbines). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibly of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system, and during operation small leaks could occur as the result of broken gear oil hoses/pipes and/or broken coolant hoses/pipes. The submarine cables do not contain any fluids or oils; therefore, there is no risk of oil release.

In order to minimize and mitigate any minor spill incidents or leaks during routine maintenance and operation of the ESP and WTGs, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed onboard each WTG, which is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated for correct disposal once the containers are off-loaded at the dock. With the proper measures in place, any potential oil spill should be quickly contained. The gray seal, which breeds in Nantucket Sound during the winter, is most susceptible to impacts from an oil spill. Gray seal breeding and pupping grounds in Nantucket Sound occur at Monomoy and Muskeget Islands (approximately 12 miles (19.5 km) and 8 miles (13 km), respectively from the WTG array site). Tuckernuck and Muskeget Islands (approximately 9.8 miles [15.7 km] and 8 miles [13 km], respectively from the WTG array site) are important haul out sites for harbor seals. A worst-case scenario would be a spill that reaches Monomoy and Muskeget Islands during mid-January, which is the peak breeding season for the gray seal. However, as described above, it is unlikely that a major oil/chemical spill will occur during operation. In addition, the amount of oil being used and the distance to shore would most likely lead to less severe impacts than described for the *Exxon Valdez*. While the likelihood of a major spill as a result of the proposed actions operation is low, in the event of an oil spill, the impacts are expected to be minor to moderate depending on the location and amount of oil released.

***"Fouling Communities"***

The WTG monopile foundations would represent a source of new hard substrate with vertical orientation in an area that has limited amount of such habitat. Therefore, the WTG monopiles foundations and ESP piles may attract finfish and benthic organisms, potentially indirectly affecting seals by causing changes to prey distribution and/or abundance. Atlantic herring (*Clupea harengus*) and alewife (*Alosa pseudoharengus*) are the only two species of seal-preferred prey anticipated to potentially forage within the area of the proposed action. Since these fish species are migratory, they are not likely to aggregate within the proposed action area; therefore it is unlikely that seals would be attracted to the WTGs and ESPs for foraging purposes and any impacts associated with the additional hard substrate are expected to be minor.

### Impacts to Cetaceans

#### *Vessel Harassment/Strikes*

As previously discussed, cetaceans that may traverse the area should be able to detect any tugboat, barge and other slow-moving vessels within the area of the proposed action as the underwater sounds produced by the vessels are within the peak intensities in their optimum range of hearing (Miles et al., 1987; McCauley 1994). Whale and dolphin responses, however, are unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vehicles. Any impact would be limited to temporary avoidance of an area; however, this is unexpected due to the high volumes of vessel traffic that normally travel the waters of Nantucket Sound. Therefore, the impacts of increased vessel traffic should have minor impacts on cetaceans.

It is possible, yet difficult to predict, whether there would be increased fishing activity after the proposed action is operational. Such fishing efforts would mainly be by private and recreational charter boats using hook and line fishing gear, which should not adversely impact any whale or dolphin species.

In addition, the vessel routes proposed to be used for the proposed action do not occur in areas where there have been high concentrations of whale sightings. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document and in Section 8.1 of Appendix G. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with cetaceans. Therefore, it is not expected that the proposed action will contribute to the harassment of cetaceans. As a result, impacts on cetacean populations in Nantucket Sound would be minor.

#### *Wind Turbine Operational Sound*

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Preliminary results from underwater sound studies conducted in the United Kingdom suggest that in general, the level of underwater sounds created during the operation of offshore windfarms is very low and does not cause avoidance of the area by marine species (Nedwell, unpub. data). Even in the area directly surrounding the wind turbines, sounds was not generally found above the level of background sounds, resulting in normal activity of marine animals (Nedwell, unpub. data).

Acoustic modeling of underwater operational sound at the UK Wind Park was performed for the design wind condition (see Section 3.13 of ESS, 2007). Baseline underwater sound levels under the design wind condition are 107.2 dB. The predicted sound level from operation of a WTG is 109.1 dB at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total sound level falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m). Since the WTGs will be spaced farther apart than 360 ft (110 m) (approximately 629 to 1,000 m or 0.34 to 0.54 nautical miles apart), no cumulative impacts from the operation of the 130 WTGs in the Wind Park are anticipated.

An analysis of predicted underwater sound levels perceived by cetaceans from proposed action operation show that no injury or harassment to cetaceans are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the proposed action is operating at the design wind speed as all $dB_{ht}$ values at this minimum distance are well below 90 dB re 1µPa (Table 7 of Report No. 5.3.2-2). In fact, proposed action operation would be inaudible for toothed whales, with the perceived operation sound level at <0 dB re 1µPa. Therefore, no behavioral effects to cetaceans are anticipated even if an individual were to approach within 65.6 ft (20 m) of the structures. Proposed action operations would result in negligible acoustic impacts on cetaceans in Nantucket Sound.

***Electro Magnetic Fields (EMF)***

The cable system for the proposed action includes the inner-array cables and two submarine cable circuits, will be a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed inner-array and submarine cable systems would contain grounded metallic shielding that effectively blocks and electric fields generated by the operating cable system. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the submarine cable system and inner-array cables. The magnetic fields associated with the operation of the inner-array cables and submarine cable system are not anticipated to result in adverse impact to cetaceans or their prey (Report No. 5.3.2-3). Further, the burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables.

The research presented in Report No. 5.3.2-3 indicates that although high sensitivity has been demonstrated by certain species for weak electric fields (especially sharks), this sensitivity is limited to steady (DC) and slowly-varying (near-DC) fields. The proposed action produces 60-Hz time-varying fields and no steady or slowly-varying fields. Likewise, evidence exists for marine organisms utilizing the geometric field for orientation, but again, these responses are limited to steady (DC) and slowly-varying (near-DC) fields. The 60-Hz alternating power-line EMF fields such as those generated by the proposed action have not been reported to disrupt cetacean behavior, orientation, or migration. Therefore, it is anticipated impacts to cetaceans or their prey species during the normal operation of the cable systems are expected to be negligible.

***"Fouling Communities"***

The WTG monopile foundations would represent a source of new substrate with vertical orientation in an area that has a limited amount of such habitat, and as such may attract fish and benthic organisms. Of the cetaceans that may be found within the vicinity of the proposed action, only the prey of humpback whales, Atlantic herring (*Clupea harengus*) and menhaden (*Brevoortia tyrannus*) may potentially occur within the proposed action area. However, as these species are migratory fish they are not anticipated to aggregate around the WTGs. The remaining whale and dolphin species do not rely, but may occasionally feed, on the fish or benthic organisms that may be attracted to the WTG as prey and therefore would not be attracted to the structures for feeding purposes. Any impact to cetaceans with respect to changes in the fouling community would be expected to be negligible to minor.

***Pollution/Potential Spills***

Following the *Exxon Valdez* spill in 1989 extensive site surveys and monitoring was conducted to determine the impacts of the oil spill to cetaceans in the region of Prince William Sound.

The ESP and WTGs will contain small amounts of various lubricating oils, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment. In addition, the ESP will be the primary oil storage facility for the proposed action and will contain a maximum 42,000 gallons (158, 987 liters) at any given time. The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The WTGs will contain lesser amounts of fluids, approximately 214 gallons (810 liters) at any given time (27,820 gallons, or 105,310 liters, for all 130 turbines). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibly of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system, and during operation small leaks could occur as the result of broken gear oil hoses/pipes and/or broken coolant hoses/pipes. The submarine cables do not contain any fluids or oils; therefore, there is no risk of oil release.

In order to minimize and mitigate any minor spill incidents or leaks during routine maintenance and operation of the ESP and WTGs, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed onboard each WTG, which is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated for correct disposal once the containers are off-loaded at the dock. With the proper measures in place, any potential oil spill should be quickly contained.

As they rely on blubber for insulation, cetaceans are less vulnerable to oil spills than fur-coated marine mammals, such as seals. Cetaceans are most vulnerable to oil spills when they are surfacing for air when skin and eyes can be irritated. Direct exposure to oil spills can result in the inhalation of harmful fumes, lethargy, poor coordination and difficulty breathing which can lead to drowning (Hammond et al., 2001). Migratory cetaceans may limit their exposure to a persistent oil slick in a small geographic area by avoiding that area. Due to the low probability of an oil spill and limited cetaceans in the area, impacts during construction and decommissioning from an oil spill would be minor.

The preliminary assessment is that those activities associated with operation and maintenance would have minor impacts on the cetacean species that may be found in that area. Those that would have the greatest effect on the cetacean species are acoustical harassment from the operation of the turbines, and only in the unlikely chance of an oil spill would any impacts be greater.

***Turbidity and Total Suspended Solids***

There are potential impacts related to turbidity and total suspended solids that could result in the unlikely requirement for repair of the electric cable. Such impacts would include temporary turbidity and some localized deposition of sediments during the repair process. Turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments for reburial of the repaired cable. Cable repair procedures are discussed in Section 2.4.6. Impacts on cetaceans as a result of cable repair would be temporary and result in only minor impacts.

**Conclusion**

The operation of the proposed action is expected to have negligible to minor impacts to pinnipeds and cetaceans. Maintenance vessels would generally operate at slower speeds (less than 14 knots) and maintenance activities should not result in water quality, benthic, or water column affects that alter the habitat. A discussion of mitigation and monitoring is provided in Section 9.0 and in Section 8.1 of Appendix G.

### *5.3.2.7 Fisheries*

#### 5.3.2.7.1 Construction/Decommissioning Impacts

**Potential Impacts on Commercial and Recreational Fisheries**

There would be impacts to fisheries resources as a result of construction and decommissioning (including post lease G&G investigations). The magnitude, extent, and duration of these impacts would be highly variable. Possible direct and indirect impacts on the fishery resource and fish habitats during the various phases of the proposed action are discussed below. A discussion of possible impacts on gear types and fishing techniques used by recreational and commercial fishermen is presented along with information on possible effects related to fishery usage activities.

***Fish Habitat Disturbance and Loss***

Permanent loss of benthic habitat from the installation of WTG and ESP monopile foundations would involve an area that is approximately 0.67 acres (2,711 $m^2$) or approximately 0.0042 percent of the total area of the proposed action (see Table 5.3.2-3). Temporary impacts to the benthic habitat would be expected from activities including jet plow embedment of the inner-array cables, jet plow embedment of two circuits that comprise the 115 kV offshore transmission cable system, installation of scour protection devices, construction vessel positioning, anchoring, and the anchor line sweep that is associated with the construction of the proposed action structures. Additionally, scour protection using a scour mats at 106 WTGs and rock armoring at 24 WTGs would disturb an additional 11 acres (44,764 $m^2$) or approximately 0.071 percent of the total area of the proposed action.

Sediments disturbed during cable jetting are anticipated to settle out soon after cable embedment and refill the cable trench and the immediate surrounding area. Temporary bottom impacts are anticipated at the post lease geotechnical boring and coring locations but the area disturbed is a negligible amount of the entire site of the proposed action. Temporary impacts along the cable installation paths are associated with other components of cable installation activities such as barge positioning, anchoring, anchor cable sweep, and the pontoons on the jet plow. Impacts that are associated with the anchor cables used for positioning of the cable lay vessel are anticipated to be temporary, since the invertebrate prey community would recover and the physical characteristics of the sediments would not be altered. It is anticipated that sediments would be affected to a depth of up to 6 inches (15.2 cm) (Algonquin Gas Transmission Company, 2000). Impacts would be minimized with the use of mid-line buoys. Frequent anchor re-positioning would occur with each anchoring location having disturbances that could be up to five feet deep, but covering a small area of the seafloor. Jet plow embedment would directly disturb sediments to deeper depths of approximately 8 ft (2.4 m), through the process of injecting high pressure water. Since the jetting does not result in excavation of a trench, and the biologically active portion of the sediments are within the top 1 ft, jetting results in a narrower zone of impact to the benthic habitat of demersal fish species than mechanical or hydraulic dredging where sediments are physically removed from the seafloor and either sidecast or loaded on barges for disposal.

Benthic habitat disturbance associated with the post lease geotechnical investigations would result in a negligible and one time loss of demersal fish eggs, such as those produced by winter flounder if they occur during the time of post lease geotechnical investigations. Temporary impacts to benthic habitat may cause mortality or displacement of benthic organisms that serve as prey for fish. Thus, there may be some disruption of feeding of some fish species. During construction/decommissioning activities, the greatest area of impacts to surficial benthic habitat would be due to anchor positioning and anchor line sweep. Total expected temporary impacts to upper sediments from these activities would make up approximately 4.2 percent of the area of the proposed action (see Table 5.3.2-3). During construction and decommissioning activities demersal fish species are likely to find suitable benthic habitat in areas in proximity to the area of the proposed action. When construction activities are completed fish species are expected to return to the area of the proposed action.

Water withdrawals that would occur within the water column are another impact factor and would affect the pelagic egg and larval lifestage of certain fish species. Water pumped through the cable jetting device would entrain fish eggs and larvae and cause mortality as this water is jetted at high pressures into the sediment. The estimated impacts from cable jet plow entrainment to fish and invertebrate eggs and larvae, as well as planktonic food sources, are summarized in Table 5.3.2-6. Based on these estimates, the total number of fish eggs that could be entrained during jet plow water withdrawals is approximately 41.5 million. An additional 6.9 million fish larvae could also be entrained. Therefore, the total number of fish eggs and larvae lost to entrainment could be 48.5 million. Furthermore, an estimated 41.5 to 47.5 billion zooplankton (mostly cyclopoid copepods; Clark and Zinn, 1937) would be entrained during jet plow operation. By contrast, the US Environmental Protection Agency (2003) estimated that entrainment by a stationary water withdrawal at the relatively nearby Brayton Point Station resulted in the annual mortality of at least 16 billion fish eggs and larvae (including winter flounder, windowpane, bay anchovy and tautog).

Impacts of the jet plow water withdrawal on the five finfish species with Essential Fish Habitat (EFH) for eggs or larvae in the project area (winter flounder, summer flounder, black sea bass, Atlantic mackerel and Atlantic butterfish) are expected to be negligible to minor. This is due, in part, to the fact that the rate of egg or larval survival to adulthood is very low for many marine finfish species. For instance, given the low survival rates of winter flounder, Saila et al. (1997) estimated that only one in every 2,700 larvae survived to adulthood in coastal New Hampshire waters. Assuming a similar order of magnitude for survival of winter flounder larvae in the area of the proposed project, the estimated loss of 2,600 winter flounder larvae to jet plow entrainment is unlikely to result in the loss of more than a few adult winter flounder.

Zooplankton are an important food resource for many juvenile fish and a few planktivorous adults that may occur in the proposed action area, notably river and blueback herring, as well as American shad and alewife. As with ichthyoplankton, zooplankton populations are often patchy and vary from year to year and season to season.

Because water withdrawals associated with jet plowing will not be stationary during the construction period, the impacts to fish eggs and larvae as well as zooplankton are anticipated to be short-term and minor in any given area. Additionally, given the fact that the jet plow operations of the proposed action are expected to occur during a relatively short period of time (just over a year for the entire construction phase), the impacts to fishery resources from water withdrawals due to jet plow operation are likely to be orders of magnitude smaller over time than those associated with conventional coastal power generating stations, which may operate over multiple years or decades. Other water withdrawals would occur in association with the operation of the construction and decommissioning vessels, which need engine cooling water, hoteling water, and ballast water. Fish eggs and larvae entrained with this water are assumed to suffer mortality because of mechanical stresses associated with passing through pumps, temperature affects, and holding time.

The HDD operation would involve HDD borehole exit hole dredging activities in Lewis Bay that are expected to directly affect benthic habitat. Dredging activity would involve either sediment disturbance or sediment removal volume of approximately 840 $yd^3$ (642.2 $m^3$). This material would either be contained in a cofferdam structure measuring approximately 2,925 square ft (0.067 acre or 272 $m^2$) (see Table 5.3.2-3) or transported to an approved onshore disposal site. Sediment inside the cofferdam will be excavated and temporarily placed on a barge for storage, and ultimately used to backfill the site following removal of the cofferdam. With removal of the cofferdam sheeting the sediment surface would potentially have a depression area that is several feet deep. Clean fill material would be placed as needed to fill this area to match natural bottom contours. These activities are expected to have minor impacts due to the contained nature of the dredging activities in the cofferdam and small area disturbed.

Potential impacts from decommissioning activities are expected to be similar to the impacts described above for the construction phase. Decommissioning efforts, however, would not include pile driving or HDD activities. Monopiles would be decommissioned by removing sediments from inside the pile, cutting and removing the pile 15 ft (4.6 m) below the seabed, and then returning sediments to the sea floor to re-establish pre-project seabed conditions. For each WTG constructed in water depths less than 40 ft (12.2 m), approximately 3,744 cubic ft (106 $m^3$) of material would be mechanically dredged from inside the base of the monopile, loaded on a barge for storage until the monopile is cut and removed, and then returned into the depression. For each WTG constructed in water depths greater than 40 ft (12.2 m), approximately 4,324 cubic ft (122 $m^3$) of material would be moved and returned. During removal it is anticipated that the sediment plume at a WTG would be minimal due to the sandy nature of the sediments and the short duration. After cutting of the monopile, best practices available would be employed to minimize any sediment plume.

***Fish Mortality or Displacement***

The post lease G&G investigations and proposed action construction/decommissioning activities would have negligible direct mortality to juvenile or adult pelagic fish. These life stages have mobility within the water column, and therefore have the ability to move from or avoid areas of active construction where elevated suspended sediment concentrations are created or where increased sound levels occur. The juvenile and adult lifestages of these species would temporarily occupy the water column in nearby areas and other portions of Nantucket Sound. It is possible that displacing fish from one area to another could lead to increased competition or predation, however the zone of avoidance around construction vessels and equipment is likely to range from a few dozen feet to a few hundred feet and it is unlikely that many fish would be impacted in the small area around a WTG under construction or removal or around the jetting vessel. Details on avoidance due to sound and increased suspended sediments are discussed below.

Demersal fish species may be subject to some injury or mortality due to slower avoidance response, particularly in the colder winter construction timeframe. To protect sensitive fish species, such as winter flounder, the applicant has committed to avoid jet plow installation in Lewis Bay between January 1 and May 31 of any year. Demersal eggs and larvae of fish may be subject to minor impacts from anchor line sweep and anchor placement due to a lack of or limited mobility. Temporary impacts to demersal fish habitats related to construction stage anchoring activities are anticipated to make up less than 4.2 percent of the total area of the proposed action (see Table 5.3.2-3). As with pelagic species, displacement of demersal fish may make them more susceptible to competition and predation, when they are forced to avoid construction areas and move into adjacent habitats that are already occupied or that are less preferred. This type of displacement affect is likely to have negligible impacts on the populations of demersal fish in the site of the proposed action.

The applicant has requested that they be allowed to install the temporary cofferdam (drive sheet piling, install silt curtain and dredge the cofferdam pit) during the month of May. It is anticipated that much of the suspended sediments will be contained by a silt curtain and sheet piles, thus minimizing any impacts to winter flounder related to sediment transport and resettling.

***Elevated Total Suspended Solids***

The post lease geotechnical investigations and proposed action construction or decommissioning activities that include installation or removal of monopile foundations, scour control mats or rock armoring, the inner-array cables and the offshore transmission cable system would cause temporary increases in suspended sediment concentrations (see Section 5.3.1.6 for more information on water quality impacts). The ability of some fish to forage, navigate and find shelter can be negatively affected when suspended solid concentrations become elevated (Wilber and Clarke, 2001). Any turbidity associated with the post lease geotechnical and geophysical assessment program would include a negligible amount of sediment and is expected to be confined to immediate sampling areas. Localized turbidity related to proposed action construction or decommissioning activities is expected to be limited to the immediate area around the monopiles, inner-array cables and offshore transmission cable system circuits since sediments in the area of the proposed action of Nantucket Sound are mainly fine to coarse-grained sands. Impacts to fish species are anticipated to be minor due to temporarily elevated TSS levels that would be caused by proposed action construction and decommissioning activities.

Simulation studies related to sediment transport and deposition resulting from jet plow embedment of the inner-array cables and the offshore transmission cable system circuits were performed (Report No. 4.1.1-2). The effect of grain size was shown since the finer sediments occurring in Lewis Bay stayed in suspension longer than sediments in Nantucket Sound, primarily because they have higher silt and clay fractions. Also, because the tidal currents in Lewis Bay are weak, the model results indicated a build up of suspended sediments since dilution and dispersal was less than the Sound. The modeling revealed that sediments may remain suspended approximately 2 to 18 hours. Gravel and sand settle more quickly than silts and clays. In some locations, such as near the Yarmouth landfall, due to weak currents and occurrence of fine sediments, particles can remain in suspension for up to 48 hours. Sediment transport modeling concluded that sediment deposition from the jet plow embedment operations would be minimal compared to active sediment transport that has been observed in Nantucket Sound during natural tidal conditions (Report No. 4.1.1-2). In addition to the suspended sediment affects in the water column, deposition of these sediments can result in indirect affects at distances further away from the source. This process can result in harm or mortality of dermesal fish eggs, but can also result in changes in benthic habitat characteristics, depending upon the nature and extent of the deposition. However, throughout much of the Horseshoe Shoal area, continuously shifting sandy substrates are in evidence, and the incremental increase of sediment reworking due to proposed action activities is likely to have negligible to minor adverse affects on substrate characteristics and the demersal fish inhabiting this area.

During the excavation of the HDD exit hole in Lewis Bay, suspension of sediments is expected to be limited since these activities would be contained within a cofferdam. To help contain turbidity that would be associated with dredging for the HDD exit hole, the sheet piles used for the cofferdam would extend approximately 2 ft (0.61 m) above MHW.

***Sound Impacts***

It has been noted (Vella, 2002) that certain sounds related to the construction activities of an offshore wind farm can affect local fish populations and cause them to temporarily move from an area. The main sound from construction activities that could adversely affect fish would be the pile driving of monopiles. Use of the jet plow embedment process for laying the inner-array cables and the offshore transmission cable system does not produce sound other than that associated with vessels that are part of that operation (Center, 2003). Information on underwater sound anticipated from such vessels is discussed below in the section on “vessel traffic.” Fish in the vicinity of the post lease geotechnical and geophysical assessment activities are anticipated to either not be affected by underwater sound or exhibit a very localized avoidance behavior, since these activities only generate low and intermittent sounds. Impacts are expected to be minor and may be similar to behavior that might occur around a commercial fishing vessel, or an anchored charter or party fishing boat.

Fish are anticipated to avoid areas in proximity to monopiles while they are being driven. Using information on species-specific hearing thresholds the zone of behavioral response for pile driving activities was calculated for the site of the proposed action. Distances from the monopiles where significant avoidance reactions could be expected (where $dB_{ht}$ = 90 dB re 1 μPA) were determined for several species. Avoidance reactions to pile driving could be expected for tautog at 591 ft (180 m), for bass at 328 ft (100 m), for cod at 1,148 ft (350 m), and for Atlantic salmon at 197 ft (60 m). Injury to fish is not anticipated even if individuals were to approach as close as 98 ft (30 m) to pile driving activities since species specific hearing threshold values are below 130 dB re 1 μPa at this distance. There is very limited data with regard to how underwater noise affects such fish behaviors as swimming away from feeding or reproductive areas or changes in migration routes (Hastings and Popper, 2005). Potential impacts to fish would be reduced with use of a “soft start” of pile driving equipment that the applicant has committed to for protection of marine mammals. This would allow fish to move out of the pile driving activity area at non-harmful sound levels before the full energy of pile driving is employed.

The HDD methodology used for the transition of the offshore transmission cable system to onshore cable in Lewis Bay is anticipated to have temporary minor impacts on fish. Drilling would be conducted through unconsolidated material and it is not expected that there would be transmission of vibration from sediment to water. A low vibratory method rather than impact pile driving would be used during sheet steel installation for the cofferdam. The cofferdam installation is anticipated to have temporary, localized and minor impacts on fish in the proximity of the cofferdam.

***Vessel Traffic***

When the post lease G&G assessment and proposed action and construction and decommissioning activities are occurring there would be an increase of vessel traffic between the WTG array locale and the offshore transmission cable system route. Fish have been noted to exhibit various types of avoidance behavior when noise-emitting vessels are detected. Response to noise coming from ocean vessels includes lateral movement by demersal species and diving to greater depths in the water column by pelagic species. Increase in swimming speed has also been noted as a response to vessel noise by most fish species. Underwater sound from vessels has its peak energy below 1,000 Hz (Richardson et al., 1995). Information indicates that fish species have a narrow hearing bandwidth. The bandwidth is in the range of 16 to 1,600 Hz in which the hearing threshold ranges from 80 to 130 dB re 1 μPa. Table 5.3.2-7 (Table 5 in Report No. 5.3.2-2) shows data from several sources that have been combined to provide maximum likelihood estimations of hearing thresholds for several fish species including Atlantic salmon, bass, cod, and tautog. The sound source level for barges or tugs, typical types of construction/maintenance vessels that may be used is 162 dB re 1 μPa at 3.3 ft (1 m) (Malme et al., 1989). Maximum hearing-threshold sound levels ($dB_{ht}$ re 1 μPa) for fish at a 10 ft distance from a proposed action vessel were calculated to be 73 $dB_{ht}$ re 1 μPa. Thus, fish could hear vessels but sound levels would be well below the 130 $dB_{ht}$ re 1 μPa threshold for prevention of harassment or injury. Proposed action vessels that are a 10 ft or greater distance from fish are not expected to cause physical harm to fish species. The 73 $dB_{ht}$ re 1 μPa sound level expected at 10 ft (3 m) exceeds the 70 $dB_{ht}$ re 1 μPa threshold for avoidance by very sensitive fish individuals. Therefore, fish in the vicinity of the post lease geological and geophysical assessment, construction, decommissioning, and cable repair procedure vessels are anticipated to display avoidance behaviors when these vessels are in operation. Impacts are expected to be minor and may be similar to behaviors associated with the existing vessel activity, such as ferry traffic, pleasure boat activities, or fishing activities.

***Prey Mortality and Displacement***

During the post lease geotechnical investigations and construction and decommissioning activities some impacts to benthic habitat are anticipated to cause mortality to benthic organisms that are prey for some species of fish (see Section 5.3.2.5 for presentation of impacts on benthos). The greatest extent of area affected would include locations where anchor cable sweep occur. However, the areas of greatest impact severity are associated with the WTGs where habitat would be permanently altered and there would be extensive bottom disturbance associated with multiple visits by jack up construction/decommissioning vessels. The total area that would be directly disturbed during construction activities makes up less than approximately 5.0 percent of the total area of the proposed action (see Table 5.3.2-3). Similar benthic habitat in the proposed action locale would be available for foraging fish species. The benthic habitat disturbance would largely be short-term, with recolonization commencing shortly after the disturbances are over, through movement from adjacent less disturbed areas, as well as through recruitment via planktonic eggs and larvae. Various benthic invertebrate species have been noted to recolonize benthic sediments following disturbances such as these construction activities (Rhoads et al., 1978, van Dalfsen and Essink, 2001, Guerra-Garcia et al., 2003, Newell et al., 2004). As recolonization of benthos occurs, fish species would be expected to return to previously disturbed areas for foraging.

Mobile fish prey species such as herring, alewife, or menhaden are anticipated to exhibit similar responses to construction and decommissioning activities as other pelagic fish. In fact, since these are planktivorous feeding fish, they are more likely to avoid areas of elevated suspended sediments than predatory fish since the sediments interfere with the feeding mechanism. When construction and decommissioning activities are completed in a particular location, these fish species are expected to return to the area of the proposed action.

***Bioaccumulation from Consumption of Contaminated Prey***

Sediments found in the area of the proposed action have been reported to be mainly sand and chemical constituent concentrations have been noted to be below the established thresholds that are in applicable reference sediment guidelines. Sediment core samples that were obtained at the proposed WTG site locale and along the proposed offshore cable routes had all chemical constituent concentrations that were below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Thus, fish are not anticipated to be subject to an increased bioaccumulation of contaminants from consuming prey present in the area of the proposed action.

***Oil Spills and Other Discharges***

During construction and decommissioning, there is a possibility that an accidental oil spill could occur, either during refueling operations, as lubricants are introduced into WTGs, or as transformer cooling oil is installed on the ESP. The applicant would be required to have an OSRP that addresses containment and clean up procedures in the event of an oil spill. However, the accidental release of fuel or oils into the marine environment would have adverse affects on fish resources in and near the proposed action location. Low concentrations of hydrocarbons have been shown to have negative affects on survival and maturation of fish eggs and larvae, lifestages that are particularly vulnerable to such spills. Depending on the type of fluid, an accidental spill could also affect benthic habitats and demersal fish should some form of the fluid sink to the bottom or wash up onto shorelines. Given the low probability of occurrence for a large spill, the potential impacts on fishery resources are negligible. However, given the duration of construction and decommissioning, and the need for refueling, there is a higher probability that some small fuel spills would during the refueling process, in which case only a small area would be affected and it could be cleaned up more rapidly, resulting in only a minor impact on fishery resources.

Vessels operating during post lease G&G investigations, construction, and decommissioning would result in various forms of wastewater discharges, as described in Section 5.1.1.1. Given that these are relatively small volumes, often occurring while vessels are underway when dilution and dispersion is rapid and extensive, and would not contain toxic or contaminating elements, the impacts to fish resources would be negligible. In addition, while these discharges would represent an increase over existing levels of vessel discharges associated with the hundreds of other vessels that operate on the Sound, but only temporarily.

**Conclusion**

Post lease G&G investigations, construction, and decommissioning impacts on fisheries in general are expected to be minor as they would be short term and localized. Also, many fish would able to avoid disturbed areas. Demersal eggs and larvae of fish may be subject to minor impacts in very discrete locations due to limited mobility, but the extent of this is not likely to affect recruitment levels or future population size. Mitigation being considered at this time includes the use of "soft start" procedures for monopile installation to allow fish that may be in the area to move away as a response to construction sounds, time of year restrictions to avoid sensitive periods when spawning takes place; and post-construction monitoring for documentation of habitat disturbance and recovery progress. More discussion of mitigation is provided in Section 9.0.

**Potential Impacts to Commercial and Recreational Fishing Activities and Interaction with Commercial and Recreational Fishing Gear**

During proposed action development, several potential concerns were identified that relate to the commercial fishing industry. These concerns included potential restriction on fishing activities, potential construction impacts, and potential gear conflict due to presence of the offshore cable systems or WTGs.

During construction and decommissioning, the proposed action would not place restrictions on commercial or recreational fishing activity or create fishing exclusion zones in the proposed action locale. For protection of public safety there may be limited temporary vessel restrictions in proximity to construction sites and vessels, but these would not involve large enough areas or be in place long enough to reduce fishing opportunities. The only exception to this is the placement of fixed gear in the immediate area where WTGs, the ESP, or the cables are scheduled to be installed. The applicant would need to coordinate with lobstermen to make sure that lobster gear is not placed along a section of the cable routes that is going to be installed, since gear damage or loss would occur from the jetting equipment. Once installed, lobstermen would be able to resume placing gear within the cable routes. Similarly a short term exclusion of fixed gear would be required around a WTG to prevent damage or loss due to jack up barge operations. Once a WTG is completely installed, fixed gear could be placed in proximity to it, at the fisherman's discretion, and in a manner that does not affect maintenance vessel access.

**Conclusion**

Commercial fishing activities may be subject to temporary disruption in close proximity to construction activities. Potential impacts of construction activities are expected to be minor with regard to commercial fishing activities and commercial fishing gear. Impact minimization measures that the applicant has already incorporated into development of the proposed action, include the relocation of several WTGs away from popular commercial fishing areas, and burying the inner-array cables and the offshore transmission cable system circuits to a minimum of 6 ft (1.8 m) below the seabed to avoid the potential for conflicts with fishing vessels and gear operation. More discussion of mitigation is provided in Section 9.0.

#### 5.3.2.7.2 Operational Impacts

**Potential Impacts on Commercial and Recreational Fisheries**

***Sound and Vibration from WTGs***

Fish species are sensitive to vibrations (underwater sound waves). Fish have two main organs for detection of underwater vibrations, the inner ear and the lateral line system (Thomsen et al., 2006). Hearing capabilities among fish species have been noted to vary greatly (Fay and Popper, 1999). Thomsen et al., 2006 has indicated that more precise information on turbine emissions (particle motion and sound pressure), in situ attenuation measurements, and on hearing capabilities of different fish species are needed for detailed assessments. There are very limited data with regard to underwater noise effects on fish behavior such as swimming away from feeding or reproductive areas or changes in migration routes (Hastings and Popper, 2005). Research that has been conducted at offshore wind farms in Europe suggests that very low vibrations coming from wind turbines have minor impacts on fish in the region.

Dolphins (marine mammals) have been noted congregating for feeding around turbines at Blyth Offshore in Northumberland (Great Britain's first wind farm) (AMEC, 2002). Since dolphins were noted engaged in feeding behavior around the turbines, fish (i.e., prey of the dolphin) also may have been present.

At a Swedish wind farm, the Näsrevet Windfarm, Westerberg (*as cited in* Vella, 2001) noted that cod appeared to be more numerous in the waters immediately around wind turbines than in areas nearby. Westerberg postulated a possible habituation by this fish species to increases in the decibel level during normal operation. Such habituation has also been noted in proximity to oil rig platforms (Vella, 2002). Westerberg (*as cited in* Vella, 2001) also noted that normal wind farm operational sounds did not greatly impact eel migration.

Modeling simulations that were conducted to evaluate underwater sound during the proposed action phases (Report No. 5.3.2-2) suggest that possible impacts to fish species due to normal operation of WTGs would be negligible. Background sound levels are reached within approximately 328 ft (100 m) from an individual WTG, and levels that are a distance of 66 ft (20 m) from a WTG are usually less than 2 dB from the baseline conditions (see Table 5.3.2-8). Sound would not be emitted from inner-array cables or the offshore transmission cable system when the proposed action is operating. Based on the modeling simulations and observations noted from existing offshore wind farms in Europe (Vella, 2002; Westerberg, 1999 *as cited in* Vella, 2001), it is anticipated that sound emissions from the WTGs for this proposed action may have minor or negligible impacts and would not substantially affect fish populations in the area.

It is not anticipated that prey for fish species would be displaced due to submarine vibration while WTGs are in operation. Surveys conducted at operating European wind farms (Elsam Engineering A/S and ENERGI E2 A/S, 2005) have reported various species of fish in the turbine site areas indicating that prey organisms may be available in proximity to operating turbines.

***Vessel Traffic***

Potential vessel impacts on fish during maintenance activities are expected to be similar to the impacts previously described for vessels during the construction/decommissioning phases. During operation and maintenance activities, an increase of vessel traffic can be expected in the WTG array area. Fish are anticipated to display avoidance behaviors when these activities occur. Impacts are expected to be negligible and may be similar to behavior noted when there is ferry traffic, pleasure boat activities, or fishing activities.

***Electromagnetic/Thermal Emission from Submarine Cables***

EMF/thermal emissions from normal operation of the inner-array and the offshore transmission cable system circuits are expected to have negligible direct impacts to fish species. A review of scientific literature concerning detection of EMF by marine organisms including elasmobranchs (sharks, skates and rays) was conducted. Though high levels of sensitivity were demonstrated for weak electric fields, the sensitivity was limited to steady, slowly-varying fields. Evidence indicates that some marine organisms use the geomagnetic field for orientation, but this response is limited to steady and slowly-varying fields. The mechanism underlying this sense is not expected to respond to rapid varying (e.g., 60 Hz) AC fields. Power-line EMF was not reported as disrupting marine organism orientation, behavior or migration (Report No. 5.3.2-3). The cable system to be used for this proposed action is a three-core solid dielectric AC cable design. This cable system was selected since it minimizes potential environmental impacts and reduces any EMF. The proposed action's cable system would have grounded metallic shielding that can block an electric field generated by the cable system. With the electric field fully shielded, impacts to fish would be related to the magnetic field emitted from the cable systems, but in both situations, impacts would be negligible.

The inner-array cables and the offshore transmission cable system circuits that would connect the WTGs to the landfall would be buried 6 ft (1.8 m) below the seafloor. Thus, there would be no barrier to fish passage. Demersal fish could utilize the surface sediments and benthic organisms could colonize surface sediments. This burial depth also minimizes potential thermal impacts of the offshore cable circuits, since the heat dissipated into the surrounding sediments would result in no perceptible increase in temperature at the sediment surface.

***Heat Transfer from WTGs***

Heat that may be absorbed by the WTGs from exposure to the sun and that may be transferred to surrounding waters is not anticipated to be detectable due to tidal flow and wind driven currents in the WTG vicinity and the fact that the WTGs are spaced at distances approximately 0.39 by 0.63 miles (629 by 1000 m) apart. Thus, negligible impacts are anticipated to fishery resources.

***Shading***

Potential impacts on fish from shading from WTGs on water areas are anticipated to be negligible Shadows from the WTG structures are anticipated to move rapidly across the water surface during daylight hours. The WTGs are spaced approximately 0.39 by 0.63 miles (629 by 1000 m) apart. Presence of the ESP, with a surface area of 20,000 square ft (1,858 $m^2$) or 0.46 acre, may affect the soft-bottom benthic invertebrate communities in its immediate locale due to shading. It is expected these possible effects would be negligible since the ESP structure is to be located approximately 40 ft (12.2 m) above the MLLW datum plane in 28 ft (8.5 m) of water and sunlight would pass under the ESP, particularly at lower sun angles.

***Lighting***

Lighting for the proposed action components would include the following: FAA navigation lighting on the tops of the WTGs (257 ft [78 m] above the water, flashing red, oriented to be conspicuous to pilots in the air with negligible ground spread) and USCG navigation lighting on the WTG platforms (32 ft [9.8 m] +/- above the water, flashing low intensity amber, oriented outward to be conspicuous to mariners). The ESP would have utility lighting (in addition to navigation lighting) that would only be in operation when the platform is occupied. The platform would not often be occupied at night except during weather emergencies when crews may not be able to get off the platform. Any lighting on the ESP would be focused on the deck and work areas, and not on the water surface. There would be no steady burning illumination and no lighting focused on the water from any of the proposed action components, therefore there is negligible anticipated impact on fish from proposed action lighting.

***Alterations to Waves, Currents and Circulation***

Effects to waves, currents and circulation are not anticipated beyond the immediate locale of individual WTGs in the operating WTG array due to the spacing of the structures (Swanson et al., 2005; Report No. 4.1.1-9). The WTGs are spaced approximately 0.39 to 0.63 miles (629 to 1,000 m) apart and modeling has shown there to be no interaction between individual WTGs. Potential limited changes to waves, currents and circulation that may occur in close proximity to each WTG are anticipated to have negligible impacts to fish populations.

***Habitat Change from Non-Structure Oriented to Structure Oriented System***

The introduction of 130 WTG monopile structures and six ESP piles in Nantucket Sound would result in an increase of hard substrate that sessile organisms may colonize. Thus, there is a change expected in the immediate area around each monopile from a non-structured to a structure oriented system. The diversity of benthic communities that may colonize the monopiles is influenced by characteristics of the substrate and various environmental factors affecting colonization of most marine habitats, such as such as current, waves, scour, etc. The attached community is anticipated to include sessile animal and plant species and small invertebrates. The presence of this fouling community is expected to attract small fish species and in turn attract both larger demersal and pelagic fish species (Elsam Engineering A/S and ENERGI E2 A/S, 2005). Monopile foundations selected for the proposed action are smooth and devoid of complexity, unlike scaffolding that is often used for oil platforms (MMS, 2000). Though the monopiles would provide vertical habitat and are expected to be colonized by organisms, the degree of the colonization is expected to be minimal since they have a smooth cylindrical form.

Based on macroinvertebrate species observed during a survey on pilings of the meteorological tower (refer to Section 4.2.5.3.2 in this document) results indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized support pilings. Seven species not observed during other baseline surveys at Horseshoe Shoal were noted. These new taxa are likely to be in the area of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders. It is expected that pilings would support organisms from both the sandy substrate habitat and those that would be attracted to hard substrates.

In addition, should the applicant select the use of scour mats consisting of synthetic fronds for scour protection at the base of the monopiles, which are designed to mimic seafloor vegetation, the potential alteration of the fish community around the monopiles would be reduced compared to the use of rock armor for scour protection. Scour control mats are designed to capture and retain sediment from the surrounding sea floor and become partially buried.

Although both demersal and pelagic fish species are anticipated to congregate around the monopiles the fouling community that may form is anticipated to support organisms that already occur in Nantucket Sound. Impacts from this habitat change are anticipated to be minor and the fish species composition in the area of the proposed action is not anticipated to substantially change from the pre-project conditions.

Removal of the WTG monopile foundations and ESP piles during decommissioning would result in a local shift from structure-oriented habitat in proximity to the WTGs and ESP to the original shoals type of habitat that was present prior to installation of these structures. Impacts as a result of WTG and ESP removal are anticipated to be minor and short term, as this would be a return to the pre-construction conditions.

***WTGs Acting as Fish Attracting Devices***

As discussed above, the introduction of 130 WTG monopile structures and six ESP piles in Nantucket Sound would result in an increase of hard substrate that sessile organisms may colonize. Thus there is a change expected in the immediate area around each monopile from a non-structured to a structure oriented system. When a stable fouling community becomes established that supports certain fish species, it could be expected that fish eating birds such as great black-backed, herring, and ring-billed gulls, cormorants, several species of ducks, and terns may feed in the areas around monopiles (Report No. 4.2.5-4). It has been noted that fish species likely to benefit from artificial structures, such as monopiles include species that have territorial, demersal and reef-obligate life histories (Bohnsack, 1989). Some fish species occurring within the area of the proposed action and other shoal areas within Nantucket Sound display such characteristics in all or some of their life stages. These species include Atlantic cod, cunner, tautog, black sea bass, and scup. Research that has been conducted (Alessi, 1996) regarding artificial reef design provides some information on potential effects on fish species. Effects of different types of reef designs and spacing patterns on artificial reef populations were tested and results indicated that spacing and design are important factors. It was noted that reefs that are too close together or too far apart are not as effective (Alessi, 1996). Investigations concerning varying reef dispersion for management of targeted fishery assemblages found that approximately the same numbers of fish species were attracted to dispersed reefs and clumped reefs although higher numbers of fish were attracted to clumped reefs (Lindberg et al., 1989 – 1990).

Studies on marine reserves and ocean neighborhoods give some information on the spatial scale of marine fish populations and their management. Adult neighborhood sizes of highly fished species and larval neighborhoods are important considerations for designating marine reserve areas. Fully protected Marine Protected Areas, also called marine reserves, have generally revealed an increase in the biomass of species that are heavily fished outside the reserve boundary (Alcala and Russ, 1990 *as cited in* Palumbi; Polunin and Roberts, 1993 *as cited in* Palumbi). When multiple factors that may influence fish assemblages are studied, the presence of no-take reserves often exceed environmental factors, including habitat complexity, depth or wave exposure in determining fish abundances (Friedlander et al., 2003 *as cited in* Palumbi; McClanahan and Arthur, 2001 *as cited in* Palumbi; Bell, 1983 *as cited in* Palumbi). Observations of effects of artificially introduced hard substrates have come from some decommissioned oil platforms. To assist in assessing the influence of decommissioned oil rigs as artificial reefs on commercially harvested fish populations, information of spatio-temporal variations in catch rates in proximity to these rigs is needed. Although studies have provided evidence that there are aggregations of fish close to platforms, the responses are complex and results are inconclusive regarding species specific spatial and temporal patterns (Løkkeborg et al., 2002). For estimating potential effects of new wind farms on fish in German waters of the North and Baltic Seas, a combination of detailed long-term recordings of fish assemblages from regular survey programs together with information on habitat preference of several relevant species is being undertaken (Ehrich et al., 2006). Although it is not anticipated that structural changes introduced by wind turbine installation will have major direct impacts on populations of most fish species in German waters, long-term effects on smaller spatial scales are likely to be complex (Ehrich et al., 2006). Their analysis and management will need long-term analyses of species assemblages, investigation of mechanisms of species interactions and quantification of processes in biological and physical environments (Ehrich et al., 2006). From information noted in the described research and the fact that the WTGs would be spaced approximately 0.39 by 0.63 miles (629 by 1,000 m) apart, impacts are anticipated to be minor and the overall environment and fish species composition in the proposed action locale is not anticipated to substantially change from the pre-Project conditions.

As a result of decommissioning, removal of the structure-oriented type of habitat is anticipated to cause these species to disperse to other areas, or be eaten. If there had been any increase of fishing pressure for these species during the operational period, such fishing pressure would decline with a return of the area of the proposed action to pre-construction conditions.

#### *Cable Repair*

Procedures used to repair a segment of the inner-array or offshore transmission cable system are anticipated to be similar to those used in construction activities. The cable section would be jetted so the cable is exposed and can be cut. Then a new cable segment is spliced in and the cable section jetted into the seafloor. Potential impacts to the local fish habitat and species from repair activities are expected to be similar to the impacts previously described for the construction phase but much more limited in extent and duration, and would therefore be negligible.

#### *Oil Spills and Other Discharges*

As described above during construction and decommissioning, there is the potential for oil spills and vessel discharges to occur during project operation. Since vessel re-fueling would not happen offshore during maintenance activities, a fuel spill is unlikely. However, should a vessel collide with a monopile or the ESP, it is possible that fuel would be released. If an oil or fuel transport barge or commercial transport vessel collide with a monopile, there is the potential for a larger release. Smaller spills could occur as lubricants are raised or lowered from the nacelles during maintenance, or when material is transferred from the maintenance vessel to the storage tank on the ESP. The project would be operated with an OSRP designed to provide rapid response and clean-up in the event of a spill. Regardless, should a spill occur during operations, impacts on fish and fish habitats could range from negligible to moderate, depending upon the specific characteristics of the spill and environmental conditions at the time of the spill. Given the low probability of a major spill, the probability of moderate levels of impact are also low.

During normal operation of maintenance vessels there would be other discharges associated with engine cooling water, ballast water, and other hoteling water uses. These discharges would all be performed in accordance with applicable laws and regulations, and represent a small incremental increase over existing levels of similar discharges that occur from the hundreds of other commercial vessels that operate in Nantucket Sound every year, such as the ferries. Given the mobile nature and small volume of these discharges, impacts to fish species and habitats would be negligible.

***Monopile Collapse***

In the event of a monopile collapse, there would a small release of lubricating fluid and other fluids (about 214 gallons [810 liters] total) from the nacelle, but more importantly, there would be bottom disturbance similar to what would occur for decommissioning and construction of a WTG, just in reverse order. While the impacts would be as described above for these types of activities, they would only occur at this one location for a short duration, and impacts to fish habitats and fish populations would be negligible.

***Vessel Collisions***

As indicated under Oil Spills, collision of a vessel with a monopile or the ESP could result in the accidental release of fuel or lubricants. Oil spill plume modeling was undertaken with the scenario involving accidental release of all 40,000 gallons (151,416 liters) of oil from the ESP (Report No. 4.1.3-1). Modeling results are described in Section 5.2.3. In addition, depending upon the extent of damage, a monopile may need to be removed and replaced. Given the variety of scenarios involved in a vessel collision, it is difficult to definitely state the impact level, but when the probability of occurrence is factored in, fish and fish habitat impacts would be negligible to minor.

*Operation of Fishing Trawlers*

An important issue concerns the safety of navigating fishing trawlers inside the wind farm. Concern has been expressed particularly for squid trawlers, which fish Nantucket Sound and areas around Horseshoe Shoal in the early to mid-summer. Whether the navigation of fishing trawlers can be accomplished safely depends upon weather conditions, currents, wave height, visibility and other variable factors at the site. The following description of the trawl gear for squid is based upon information gathered from a leading squid fisherman, a fishery resource manger with experience in operating research trawls, and three trawl net manufacturers. Using this information, the maximum possible distance from the bow of a squid fishing vessel to the end of the net has been calculated.

In the Nantucket Sound squid fishery, the lengths of the trawl nets, the rigging between the nets and the doors, and the wire from the vessel to the door are highly variable. Squid trawlers working the Sound average about 50 ft in length; they cannot exceed 72 ft. Assume that a representative trawler is 72 ft long.

The length of the net itself is dependent on the vessel horsepower or bollard pull. Two "typical" lengths for squid vessels in Nantucket Sound are 90 ft or 150 ft. Assume that squid vessels use 150 ft nets.

Some fishermen rig two "legs" on each side of the trawl that attach from the ends of the net to a single cable attached to the trawl doors. The overall distance from net to doors is variable. A reasonable estimate would be 15 fathoms of legs attached to 20 fathoms of ground cable, or 210 ft overall. The distance is shorter (120 ft) if legs are not used. Assume that legs are used when trawling for squid in Nantucket Sound.

The distance from the vessel to the trawl doors depends on the depth and desired scope ratio, which can be from 2.5:1 up to 5:1. The desired scope ratio depends on the net's spread, the direction of the current, among other factors. Assume a typical depth of 35 ft for towable bottom in Nantucket Sound. Assume that the scope ratio is 5:1, which is appropriate for shallow waters. (The warp is typically longer in shallower depths.) The distance from the trawl doors to the vessel is therefore 175 feet.

Summing the length of the vessel (72 ft), the trawl warps (175 ft), the ground gear (legs plus ground cables) (210 ft), and the net (150 ft), a total length of the vessel plus ground gear is 607 ft. Note that this straight line length may be greater than the length of the gear in the water, as the legs and the groundwire approach the net on an angle, called an "angle of attack." In addition, the warps and ground gear form a catenary from the bollards to the net, further shortening the total length. Fishermen adjust the angle of attack to optimize catch for different species.

The WTGs are set up in a grid pattern with individual turbines located 0.39 miles apart in one direction and 0.63 miles apart in the other. These distances equate to 2,066 ft and 3,281 ft. Thus the length of the longest feasible squid trawl in Nantucket Sound is about 29 percent of the shortest distance between WTGs and about 19 percent of the longest distance between WTGs.

**Conclusion**

Wind turbine operations are expected to have negligible to minor impacts on fisheries. Under normal operations, the offshore cable systems should not require maintenance resulting in impacts to benthic habitats or the water column. Remote monitoring of the cable routes would occur periodically to make sure they remain buried. Maintenance of the WTGs and ESP would require daily vessel operations, weather permitting, but no planned activities resulting in disturbance of benthic habitats or the water column. Several accidental or unplanned events with low probability of occurrence could have localized minor to moderate impacts on fish or fish habitats.

**Potential Impacts to Commercial and Recreational Fishing Activities and Interaction with Commercial and Recreational Fishing Gear**

The proposed action operation is not expected to have substantial impacts to commercial or recreational fishing activities in the area. Measures for minimizing potential impacts include having no restrictions on fishing related activities in the area of the proposed action when the proposed action is in operation, other than potential restrictions in the small areas that may be occupied by defined vessel traffic management lanes that may be implemented as mitigation for navigational safety impacts. Additional measures include avoiding possible conflicts with fishing vessels and their gear operation by maintaining the burial of the cables below the seafloor. Commercial fishing vessels would have to avoid the WTGs and ESP when trawling or placing pot or trap lines. However, the affects are minor due to the WTGs being spaced 0.39 by 0.63 miles (629 by 1,000 m) apart. The individual WTGS appear to be located far enough apart to permit prudent fish trawling, particularly for squid trawlers, to occur safely. Slight course corrections may be required to avoid the WTGs. There may be changes in fishing opportunities due to the proposed action. There may be some benefit to those fishermen who utilize alternative gears including pots and hook gear. For commercial mobile gear (trawl) fishermen, species that are targeted such as summer flounder and squid may be less vulnerable to trawling efforts if they are attracted to the structure associated with the foundation areas of the WTGs.

To minimize or avoid impacts to commercial fishermen who use mobile gear, a number of proposed WTG sites that were in deeper water along the eastern portion of the array have been relocated to shallow water locations in the northwestern portion of Horseshoe Shoal. Commercial fishermen who use mobile gear had identified the deeper waters as an area where they frequently fish.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts to commercial fishing by restricting use of those small portions of the array that may be devoted to traffic management.

### 5.3.2.8 Essential Fish Habitat

Details on EFH impacts are provided in a separate EFH report in Appendix H. A short summary of EFH impacts is provided below.

#### 5.3.2.8.1 Construction/Decommissioning Impacts

During construction, impacts to EFH and EFH species would arise from activities that disturb the seafloor, that alter water quality conditions, and alter physical characteristics of the ocean environment such as noise. Activities that could disturb the seafloor include post lease geotechnical sampling (refer to post lease geotechnical and geophysical sampling procedure details in Section 2.0); installation of the monopile foundations for the WTGs and ESP within the WTG array; placement of seabed scour control systems at the base of the monopiles; installation of the inner-array cables connecting each WTG to the ESP and installation of the offshore transmission cable system circuits connecting the ESP with the landfall location that use the hydraulic jet-plow embedment technology, associated anchoring required for cable installation barge positioning; and activities related to construction of a temporary cofferdam associated with HDD installation methods.

Construction activities that could alter water quality include post lease geological and geophysical sampling, installation of the monopile foundations for the WTGs and ESP and barge activities associated with this aspect construction; installation of seabed scour control systems at the base of the monopiles; installation of inner-array cables and the offshore transmission cable system circuits that connect the proposed action and landfall location that use hydraulic jet-plow embedment technology and associated barge anchoring, pontoon and anchor line sweep effects; and construction of a temporary cofferdam associated with HDD installation methodology.

Construction activities or proposed action features that could alter the physical characteristics of the marine environment include installation of the monopile foundations, which introduce hard, vertical substrate areas, and introduction of seabed scour control systems.

An additional potential impact to early lifestages of some EFH species is entrainment along with water that is used by construction vessels for engine cooling or for operation of the jet plow during cable burial. Detailed information has been presented in Section 5.3.2.7.1. Entrainment of eggs and larvae, as well as zooplankton that are food for juveniles and adults of species such as herring, alewife, and shad, would result in the loss of individuals to these species local populations. The water withdrawn for the jet plow is injected into the sediments under high pressure. Survival of entrained eggs, larvae, and zooplankton can be assumed to be essentially zero, because of the pressure and mechanical forces that these organisms would experience. However, unlike a fixed point withdrawal, such as for cooling water at a power plant, the jet plow would typically advance at 300 feet per hour (91 m per hour) (1.5 miles per day [2.4 km per day]) such that no portion of the water column would be affected for very long (Report No. 4.1.1-2). Thus, the dispersed nature of this impact is likely to only have a minor affect on EFH species.

During decommissioning, impacts to EFH would arise from activities that disturb the seafloor, that alter water quality conditions, and alter physical characteristics such as noise. These activities would be similar to the construction phase described above, except no pile driving would occur and no HDD activities would take place. In addition, the monopiles as substrate for a fouling community would be removed, and fish associated with these small reef-like settings would disperse.

**Impacts to Benthic EFH**

The potential impacts to benthic EFH are described based on the anticipated duration of the impact. While the total area of the seafloor encompassed within the boundaries of the proposed action is large, there are extensive areas that would not be impacted by the proposed action activities and there is an even smaller area that would be impacted in a long term manner. For example, while more than 80 miles (129 km) of cable jetting are proposed in order to bury the cables, these areas would be temporarily disturbed, whereas each of the monopile locations represent a long term alteration of the benthic habitat.

The total permanent direct area of benthic habitat disturbance from construction activities is summarized in Table 5.3.2-3. Permanent benthic habitat loss would result from installation of the WTG and ESP monopile foundations. This permanent loss due to occupation of structures would be approximately 0.67 acres (2,711m$^2$) or 0.0042 percent of the total proposed action area (see Table 5.3.2-3). Similar habitat conditions are present in areas adjacent to the site of the proposed action.

The installation of the scour control, inner-array cables, and the offshore transmission cable system would physically displace sediment at specific locations. The total temporary direct area of benthic habitat disturbance from construction activities is summarized in Table 5.3.2-3.

Temporary impacts to benthic habitat would result from jet plow embedment of the inner-array cables, jet plow embedment of the two circuits comprising the 115 kV offshore transmission cable system, and installation of the scour protection devices, as well as from vessel positioning, anchoring, and anchor cable sweep associated with construction (see Table 5.3.2-3). This temporary disturbance could total up to approximately 820 acres (3.3 km$^2$) (5.1 percent of the total proposed action area) with scour protection mats and rock armor or conservatively 866 acres (3.5 km$^2$) (5.4 percent of the total proposed action area) with rock armoring at all 130 turbines and the ESP (see Table 5.3.2-3). Decommissioning-related impacts would be short-term and localized and are expected to be similar to impacts during construction (see Section 5.3.2.5.1).

The temporary benthic habitat disturbance of between 820 and 866 acres (3.3 to 3.5 km$^2$) from construction could result in the temporary loss of functions and values provided by the benthic EFH. Impacts during construction are temporary, occur over small areas, and the benthic habitat is expected to recover thus restoring the functions and values to EFH and EFH fish species. After the installation, 1.96 acres would remain altered by the addition of scour mats and 8.75 acres from rock armoring. If scour mats prove less effective in some areas they would be replaced by rock armor with the extreme case being all scour protection accomplished with rock armoring. In this case, 47.82 acres (0.19 km$^2$) of seabed would be altered (see table 5.3.2-3).

The impact from jet plow embedment of the inner-array cables and the offshore transmission cable system would be temporary, with suspended sediments anticipated to settle and refill cable trenches and areas immediately surrounding the cable trenches shortly after embedment (see Section 5.3.1.1). Impacts associated with cable installation barge positioning, anchoring, anchor line sweep, and the pontoons on the jet plow device would also be temporary. Impacts from anchor line sweep has the greatest areal impact, but would primarily affect the sediments to a depth of between 3 and 6 inches (7.6 and 15.2 cm) (Algonquin Gas Transmission Company, 2000) and impacts would be minimized through the use of mid-line buoys. An analysis of anchor penetration estimates the maximum fluke tip penetration of a 200 lb Danforth anchor in the sediments typical to the area of the proposed action to be approximately 4.5 feet at each anchor deployment, leaving a temporary irregularity to the seafloor with localized mortality of infauna (Report No. 4.4.3-1). While numerous anchor re-positionings would occur, the cumulative area is still small (see Section 5.3.2.5). Jet plow embedment would directly disturb sediments to a depth of approximately 8 ft (2.4 m), deeper than the anchoring or anchor line sweep depth disturbances.

Modeling was used (see Section 5.3.1.1) to estimate seabed scar recovery from jet plow cable burial operations. Using the assumption that three percent of the sediments in the jetted cross section could be injected back into the water column and that the coarse sediment volume is returned to the trench, it was estimated that the dimensions of the scar left along the cable routes would be 6 ft (1.8 m) wide and from 0.75 to 1.7 ft (0.23 to 0.53 m) deep. Information from a number of relevant studies at similar sites was reviewed, and by applying those findings to site specific conditions for Nantucket Sound and Horseshoe Shoal, approximate recovery times were estimated for the trench scars. The methodology of van Rijn (1993) was used to calculate bedload sediment flux at core locations along the proposed 115kV cable outside the Horseshoe Shoal area. Bedload transport rates at the core locations range from 0.18 to 25 cubic ft/day per foot (0.017 to 2.3 $m^3$/day per meter) of seabed. Together the flux rates from Horseshoe Shoal and the rates calculated using the method of van Rijn represent the range of sediment flux throughout Nantucket Sound. Based on these transport rates, recovery rates for jetting scars along the cable route are estimated to be between 0.2 and 38 days. Recovery of jetting scars on Horseshoe Shoal is anticipated to occur within a few days. Areas of low wave and tidal current energy and a predominately mud bottom such as Lewis Bay are typically dominated by suspended sediment load. In these areas it is likely that seabed scars from cable burial would last months or until a major storm (hurricane or major nor'easter) occurs. Deposition rates in estuaries in southern New England typically range from 0.079 to 0.79 in/yr (0.2 to 2.0 cm/yr) (King, 2005). Refer to Section 5.3.2.5 for further details on benthic substrate recovery.

Egg and larval stages of demersal EFH species would be temporarily affected by benthic habitat disturbance if present during the time of year of construction. EFH species with pelagic eggs and larvae would be less affected by temporary benthic habitat disturbance. The temporary displacement of benthic habitat would also likely result in the mortality and/or dispersal of some benthic organisms (i.e., prey for some EFH species) in the footprints of the construction activities, thereby temporarily disrupting feeding for some benthic-oriented juvenile and adult EFH species in the area. Pelagic-oriented juveniles and adult EFH species would be less affected by permanent and temporary benthic habitat loss. The greatest areal impacts to surficial benthic habitat and therefore to early demersal life stages and benthic prey species of demersal adults and juvenile EFH species would occur from anchor positioning and anchor line sweep. As discussed in Section 5.3.2.5, the total anticipated temporary impact to the upper sediments from anchoring would comprise less than 4.2 percent of the total proposed action area. Therefore, sufficient food base is expected to be available for foraging fish species. In fact, during actual construction disturbance activities affecting the benthos, injured or displaced benthic invertebrates may provide a short-term opportunity for increased feeding by fish.

In the nearshore Lewis Bay environment, benthic EFH could be directly affected by the HDD borehole end dredging activities within Lewis Bay; however, dredging would be limited to a volume of

840 yd³ (642.2 m³) and would be contained within the cofferdam. The area enclosed by the cofferdam would be approximately 2,925 square ft (272 m²), a minimal area compared to surrounding habitat in Lewis Bay. The dredged sediments from within the cofferdam pit would be temporarily removed and replaced upon completion of the offshore transmission cable system. Due to the limited and contained nature of the HDD installation activities within the cofferdam and the limited area affected by the backfilling of the dredged material, no substantial impacts to benthic EFH are expected. These activities would not be required during decommissioning. See Section 2.3.6 for additional information on HDD construction and installation methodologies.

Disturbance of the benthic environment from construction would be short-term because many benthic invertebrate species are capable of opportunistically recolonizing benthic sediments after disturbance (Rhoads et al., 1978; van Dalfsen and Essink, 2001; Guerra-Garcia, 2003; Newell et al., 2004). It has been generally assumed that benthic communities that are adapted for survival in high-energy environments would recover more quickly following disturbance (Dernie et al., 2003). Dalfsen and Essink (2001) have noted with sand extraction and/or nourishment that assessment of direct effects is difficult as benthic organisms may survive the dredging activities and colonization occurs almost instantaneously with recruitment and immigration. Further benthic community response after sand extraction and/or nourishment tends to follow well defined patterns with rapid development of "opportunistic" species and then subsequent recovery of community composition and structure. Dalfsen and Essink (2001) indicated that in dynamic coastal areas such as those off the Netherlands that recovery of the benthic community is relatively fast. The naturally dynamic environment of the proposed action area is already subject to fluctuations in suspended sediment concentrations at the seabed/water interface as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Consequently, benthic organisms in the proposed action area are adapted to relatively wide fluctuations in water column suspended sediment concentrations and are not expected to be substantially impacted by short-term sediment resuspension associated with construction and decommissioning. Therefore, affected benthic invertebrate populations are expected to recover as quickly as they are capable of reproducing. Many shellfish species generally spawn on an annual basis; however, depending on the water temperature and time of year, shellfish may spawn more than once per year. Therefore, benthic invertebrate populations at the proposed action's site are expected to begin recovery within months following disturbance but may continue infaunal re-establishment for up to four years (Byrnes et al., 2004a, van Dalfsen and Essink, 2001 Newell et al., 2004).

In addition, because benthic habitats similar to those in the proposed action area are present in Nantucket Sound, similar benthic communities (i.e., prey organisms) would be located in many areas and EFH species would be able to find suitable prey in areas adjacent to the proposed action area and other regions of the Sound. Pelagic species are likely to be able to occupy the water column in other parts of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, EFH species would resume foraging in those areas as prey items become more abundant. Therefore, impacts to EFH species from mortality or displacement of prey species would be expected to be negligible to minor.

During decommissioning activities, benthic EFH would be disturbed once again. Temporary impacts to that habitat would be similar to those described above. In addition, benthic communities that have recolonized sediments initially disturbed during construction, such as along the inner-array cable and the offshore transmission cable system and over the filled-in scour control mats, would be disturbed once again. Post-decommissioning recolonization is expected, and in the interim, EFH species in the proposed action area are likely to be able to find similar prey items in adjacent areas or in other areas of the Sound, and impacts would be expected to be legible to minor.

**Potential for Sediment Contamination of Benthic EFH**

Recent studies indicate that sediments in the proposed action area are predominantly sand, and that chemical constituent concentrations are below established thresholds in applicable reference sediment guidelines. Specifically, all of the chemical constituents detected in sediment core samples obtained from the proposed WTG array site and along the offshore transmission cables system, route had concentrations below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995) (see Section 4.1.6.3). Therefore, the temporary disturbance and suspension of these sediments during construction and decommissioning is not likely to result in increased incorporation of contaminants in the benthic substrate or at low trophic levels. EFH species are thus unlikely to experience increased bioaccumulation of contaminants via consumption of prey items or exposure to benthic substrate classified as EFH.

During the near shore installation in Lewis Bay, the HDD operation would be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay. The drilling fluid would consist of water (approximately 95 percent) and an inorganic, bentonite clay (approximately 5 percent). Although it is anticipated that drilling depths in the overburden would be sufficiently deep to avoid pressure-induced breakout of drilling fluids through the seafloor bottom, a bentonite monitoring program would be implemented for the detection of possible fluid loss (see Section 2.3). In the unlikely event of drilling fluid release, the bentonite fluid density and composition would cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment; thereby minimizing any long-term impacts to EFH or EFH species. Short-term impacts would consist of the covering of benthic organisms in the immediate area of release. These activities would not be required during decommissioning and thus would not be an associated impact risk. In summary, sediment contamination of benthic EFH is expected to be negligible to minor.

**Impacts to Eelgrass Habitat in Lewis Bay**

As discussed in Section 4.2.2.4 of this FEIS, one SAV eelgrass bed has been mapped within Lewis Bay, located to the west of Egg Island in the Town of Barnstable. To avoid impacts to this habitat which also serves as an HAPC for summer flounder and is located within EFH for species in the proposed action's area (black sea bass, scup, summer flounder), the offshore transmission cable system would be no closer than 70 ft (21.3 m) from the edge of the eelgrass bed located near Egg Island.

In the area of the eelgrass bed in Lewis Bay, the bottom sediments are relatively coarse. Simulations of sediment transport and deposition from jet plow embedment predict that sediments suspended by the jet plow would fall along the route with bottom deposition predicted to be in the range of 0.04 to 0.1 inches (1.0 to 3.0 millimeters) at the western edge of the eelgrass bed (Report No. 4.1.1-2). The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations. Suspended sediment concentrations in this area are predicted to be in the range of 50 to 500 mg/liter, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/liter are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route. At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/liter are predicted to remain for up to 4 hours.

Many sessile or bottom-oriented aquatic organisms (including eelgrass) encounter some level of sedimentation under natural conditions as a result of tidal currents, waves, and storms. As a result, many organisms have morphological, behavioral, and/or physiological means of dealing with exposure to deposited sediments. Regrowth of seagrasses such as eelgrass can occur if sediment deposition only results in a light covering of sediment material and if the rhizome system is not damaged (USACE DOER, 2005). Since the majority of the eelgrass bed is expected to experience little or no deposition as a result of jet plow operations, it is anticipated that the natural means of seagrass adaptation to changing sedimentation conditions would allow the eelgrass bed to withstand the short-term jet plow operations that would pass the eelgrass bed, and impacts would be negligible to minor.

### Impacts to Submerged Aquatic Vegetation on Horseshoe Shoal

Potential impacts to SAV on Horseshoe Shoal as a result of the construction and decommissioning of the proposed action are expected to be limited in nature. Section 4.2.2.4 summarizes the extent of SAV within Horseshoe Shoal. Field surveys have shown the proposed action area to include only sparse areas of SAV. Most of the habitat surveyed within Horseshoe Shoal was shown to be bare sand and the areas that did include SAV assemblages were mostly comprised of macro-algae, not eelgrass. Impacts to the limited SAV assemblages in the proposed action area are expected from activities associated with installing the inner-array cables, the offshore transmission system cables, the WTGs, the ESP, and the scour control around the monopile foundations. Overall, these activities are anticipated to impact a total of 686 acres (2.8 $km^2$) of Nantucket Sound although only a fraction of this area has the potential for SAV to occur (see Table 5.3.2-3).

Impacts to SAV resulting from the above listed activities (including anchor cable sweep) are expected to be temporary and similar to impacts seen during coastal storm events. These impacts would include the damage and/or displacement of SAV found within the specific working areas for these individual components.

The only permanent impacts to SAV anticipated are those associated with the installation of the WTGs, ESP, and the scour control mats. The physical presence of the monopile towers would result in a loss of available habitat within the tower footprint for the duration of the proposed action. Once installed however, the towers themselves would provide a substrate area greater than that being impacted for the attachment and subsequent growth of macro-algae.

Once construction has moved to a new site, natural re-colonization of the disturbed areas, by both eelgrass and macro-algae, should begin immediately. However, complete recolonization of disturbed areas by seagrass may take a decade or longer (Neckles et al., 2005), while macro-algae would recolonize considerably faster due to their reproductive dispersal mechanisms, fast growing nature, and opportunistic growth strategies. Based upon the species composition observed during the ground-truthing field study (Report No. 4.2.2-2 and Villalard-Bohnsack, 2003) it is expected that within 12-24 months of installation macro algae would have significantly re-colonized areas which previously supported these communities, as well as the monopile foundations of the WTGs. As a result, SAV impacts are expected to be minor.

### Impacts to Water Column EFH

#### *Impacts to EFH from Degraded Water Quality*

Construction activities associated with installing the monopile foundations, scour control mats, and the inner-array cables and the offshore transmission cable system would result in a temporary increase in suspended sediment concentrations which could affect EFH that is defined as within the water column. Decommissioning-related impacts would be short-term and are expected to be similar to impacts during construction. Elevated TSS can negatively impact the ability of some finfish to navigate, forage, and find shelter. The pile driving hammer and jet plow technology that would be used to install the monopile foundations and the offshore cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sand in Nantucket Sound, localized turbidity associated with construction or decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles, the inner-array cables, and the offshore transmission cable system circuits. Sediments disturbed by construction or decommissioning activities are expected to settle back to the sea floor within a short period of time (see Section 5.3.1.1). In addition, the proposed action area is situated in a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Therefore, marine organisms, including EFH species, in this area are accustomed to periodic increases in suspended sediments and should not be substantially impacted by a temporary increase in turbidity from construction and decommissioning activities.

Simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were performed (Report No. 4.1.1-2). These simulations, which used two models (HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations), estimated the suspended sediment concentrations and deposition that could result from jet plow embedment of the cables. The model results demonstrate that concentrations of suspended sediment in the water column resulting from jet plow embedment operations (i.e., concentrations above natural background conditions) are largely below 50 mg/liter. The effect of grain size distribution is evident since the finer sediments present in portions of the Lewis Bay area, the area at the southern half of the north-south portion of the route, and the area just northwest of the ESP, remain in suspension longer due to higher silt and clay fraction.

In Lewis Bay, suspended sediments are predicted to remain in suspension considerably longer than in Nantucket Sound as a result of weak tidal currents. As a result, water column concentrations are predicted to build-up rather than quickly disperse. The model results demonstrate that concentrations of suspended sediment in the water column resulting from jet plow embedment operations (i.e., concentrations above natural background conditions) in Lewis Bay are largely below 500 mg/liter. Suspended sediment concentrations in excess of 100 mg/liter are generally predicted to remain for less than 2 hours with the exception of some sections along the offshore transmission cable system route showing durations at 6 hours. Suspended sediment concentrations in excess of 10 mg/liter are generally predicted to remain for less than 24 hours after the jet plow has passed a given point along the route, except near the Yarmouth landfall where concentrations in excess of 10 mg/liter are predicted to remain for up to 2 days after the jet plow passes as a result of very weak currents and fine bottom sediments.

These TSS concentrations are still minimal when compared to the active bed load sediment transport known to exist in Nantucket Sound (between 45 and 71 mg/liter under natural tidal conditions and up to 1,500 mg/liter as a result of trawling operations. Sediment suspension during construction and decommissioning activities are not anticipated to result in long-term or environmentally significant elevations in water column TSS. Demersal eggs and larvae of EFH species in the immediate vicinity of construction and decommissioning activities may experience mortality or injury through burial and smothering. Pelagic eggs and larvae of EFH species may be temporarily affected or displaced from elevated TSS in the immediate vicinity of construction and decommissioning activities. Juvenile and adult EFH species are mobile and capable of moving away from disturbed areas and elevated TSS concentrations. Zooplankton or fish species may be temporarily affected or displaced in the immediate vicinity of the area of the activity; however, they are likely to rapidly return to these areas once construction in the specific area ceases or is completed. As a result, impacts to EFH resources in the water column are expected to be minor.

Sediment suspension during excavation of the HDD borehole ends in Lewis Bay is expected to be minor since these activities would be partially contained within the cofferdam and the top of the sheet piles for the cofferdam would help contain turbidity associated with dredging for the HDD borehole end transition and subsequent backfilling. Therefore, impacts to EFH species would be minor. These activities would not be required during decommissioning.

***EFH Species Mortality/Injury/Displacement***

Construction/decommissioning is not expected to result in measurable direct mortality or injury to adult and juvenile pelagic EFH finfish species since these life stages are mobile in the water column, capable of avoiding or moving away from the disturbances associated with construction, and not as closely associated with the bottom as demersal finfish. Adult and juvenile demersal EFH finfish species and adult and juvenile benthic EFH invertebrate species in the direct path of bottom disturbing construction and decommissioning activities may experience some direct mortality or injury. During winter construction periods, demersal finfish may experience higher levels of injury or mortality since avoidance of anchors and anchor cables may be hampered due to sluggish response under cold water conditions. However, no measurable effects on populations would be expected. Displacement of juvenile and adult EFH finfish species is likely to be temporary, as no stressor is likely to extend great distances or for long durations associated with any of the construction activities. Displacement of juvenile and adult EFH finfish species is likely to primarily result from increased turbidity.

Because they lack motility, demersal EFH eggs or larvae that lie within the direct footprint of construction disturbance would likely experience mortality. Demersal EFH eggs and larvae may also experience localized increases in physical abrasion, burial or mortality from elevated suspended sediments during construction. The greatest areal impacts to demersal eggs and larvae would occur from anchor positioning and anchor line sweep during construction. However, the total anticipated temporary impact to the upper sediments from anchoring would comprise less than 4.2 percent of the total proposed action area. Larvae in the latter stages of development are capable of some motility, which may allow for movement from the construction area. Pelagic EFH eggs and larvae are likely to be less affected than demersal early life stages since they are not as closely associated with the bottom; however, those in the immediate area of construction could experience some injury or mortality. Eggs within the water column would be transported by prevailing currents, with larvae being transported to a lesser degree. Predatory fish species, which may feed on larvae, may be temporarily displaced from the area as a result of disturbance during construction or decommissioning activities. Decommissioning-related impacts are expected to be similar to impacts during construction.

***Potential Impacts from Impingement/Entrainment of Fish Eggs/Larvae from Vessel Water Withdrawals/Water Withdrawals Associated with Cable Jetting***

Vessel water withdrawals during jet plow embedment of the offshore cable systems are anticipated to be minimal, consisting only of periodic withdrawal of near-surface water for ballast water exchange and for engine cooling. Such vessel water withdrawals would also occur during decommissioning activities and during operation when any maintenance activities would be required. Construction vessels withdrawing surface water for ballast water exchange would be required to adhere to all USCG regulations and requirements for water withdrawal and discharge. This process of withdrawing water for ballast water exchange is commonly practiced and is no different than the processes practiced by other vessels already operating in the area. Water withdrawals associated with engine cooling occur for essentially all motor vessels, and this would be the case for construction vessels, tugs, crew boats, etc. For vessels underway, the water withdrawals occur along the transit route, and would include entrainment of small marine organisms, which typically occur in a patchy manner throughout the ocean. A certain percentage of these organisms would be injured or suffer mortality as a result of passage through pumps and heat exchangers, both from mechanical forces as well as possibly thermal increases.

The jet plow itself would require additional water withdrawals in order to operate. The intake for the jet plow is expected to be located off of the surface vessel that supports jet plow operations. Water withdrawals for use in the jet plow embedment operation would be withdrawn from the near-surface area. Any early life stages of fish (eggs or larvae) that may be present in the immediate area of water withdrawal have the potential to be entrained during this process. Those eggs or larvae entrained during water withdrawal would likely suffer 100 percent mortality as the water is forcefully injected into the sediments to loosen and liquefy them. Millions of fish eggs and larvae may be present in the withdrawn water, depending on the season. However, given the fecundity of fish, the loss of eggs and larvae only represents a small fraction of equivalent adults of the species that are present. Given that commercial fishing vessels and ferries have traversed Nantucket Sound for years with engine cooling water withdrawals occurring, impacts from the incremental increase from the jetting is short term and minor.

The species that could potentially be impacted by these water withdrawals include those with planktonic egg and/or larval stages at the time of jet plow operation. Early life stages that are benthic or demersal in nature are not expected to be impacted since water withdrawal would occur at or near the water surface. Since the jet plow process is expected to progress relatively rapidly, impacts are expected to be short-term and minimal in any one area. Impacts to these early pelagic life stages that have designated EFH in the proposed action's area would also be limited to those months of the year where jet plow operation coincides with the occurrence of particular life stages in the area. In general impacts from these water withdrawals would be minor.

***Acoustical Impact***

Information on the hearing thresholds for finfish and potential risk of acoustic disturbance that could result in injury or disturbance to finfish is evaluated below for sounds emitted during monopile construction, other construction, and vessel transit.

*Hearing Thresholds for Fish*

The hearing threshold is the minimum sound level in a 1/3-octave band that can be perceived by an animal in the absence of significant background noise (Report No. 5.3.2-2). The hearing bandwidth for an animal is the range of frequencies over which an animal can perceive sound. Finfish have a relatively narrow hearing bandwidth, in the range of 16 to 1,600 Hz, in which their hearing threshold is 80 to 130 dB re 1 μPa. Data from nine sources (Nedwell et al., 2004; Hastings and Popper, 2005) have been combined to produce maximum likelihood estimates of hearing thresholds, summarized in Table 5.3.2-7 for tautog, bass, cod, and Atlantic salmon.

*Monopile Pile Driving*

The maximum submarine sound generated during offshore construction would occur during installation of the monopile foundations. Sound levels measured during impact pile driving operations at the Utgrunden Wind Park in Sweden were used to model underwater sound expected from installation of the monopiles since the size of the monopiles and the installation techniques proposed are the same as for the Utgrunden Wind Park (Report No. 4.1.2-1). The Utgrunden data show a maximum sound level of 178 dB at 1,640 ft (500 m). Frequency plots from the Utgrunden data show the peak energy from pile driving occurred between 200 and 1,000 Hz, with underwater sound levels falling below background levels (inaudible) for frequencies below 5 Hz.

In order to determine the actual underwater sound level that is heard by finfish from monopile installation, a hearing threshold sound level ($dB_{ht}$) was calculated for three fish species for which data were available. The $dB_{ht}$ for a given species is calculated following the method developed by Nedwell and Howell (2004) by passing the frequency spectrum of underwater sound produced by a source through a filter that mimics the frequency-dependent hearing thresholds of that species. The benefit of this approach is that it enables a single number to describe the effects of sound on that species, thereby allowing one to compare acoustic effects among species. The $dB_{ht}$ represents the level of sound perceived by a certain species by taking into account its frequency-dependent hearing thresholds. For estimating the zone of injury for marine species, a sound pressure level of 130 $dB_{ht}$ re 1 μPa (i.e., 130 dB above an animal's hearing threshold) is recommended (Nedwell and Howell, 2004; University of California, 2005). Of the five groups of marine animals considered in the underwater sound analysis, toothed whales (dolphins, porpoises, pilot and minke whales) have the lowest hearing thresholds in the frequency range where construction sounds would occur. Those thresholds are around 50 dB re 1 μPa, and 130 dB above that hearing threshold level is a sound level of 180 dB re 1 μPa, which is the present NMFS guideline for preventing injury or harassment to all marine species (Kurkul, 2002). The 180 dB re 1 μPa sound level guideline is also highly protective to finfish since it is equal to 100 dBht re 1 μPa (180 minus the 80 dB minimum finfish hearing threshold) and is thus 30 dB below the 130 $dB_{ht}$ re 1 μPa threshold for injury.

Note that since the NMFS 180 dB re 1 μPa guideline is designed to protect all marine species from high sound levels at any point in the frequency spectrum, it is a very conservative criterion. The $dB_{ht}$ calculated for each combination of proposed action activity and marine species is a more accurate measure of acoustic effects than simply comparing the sound level to the NMFS 180 dB criterion because the $dB_{ht}$ method takes into account the frequency distributions of both the sound source and the receiving animal's hearing thresholds.

Research shows significant marine animal avoidance reactions occur and mild behavioral reactions occur at 70 $dB_{ht}$ re 1 μPa (Nedwell and Howell, 2004; Nedwell et al., 2004). Using the hearing threshold data from Table 5.3.2-7, $dB_{ht}$ sound levels were calculated for finfish for the proposed action's loudest construction noise (pile driving) and the results are provided in Table 5.3.2-9. Construction noise results are given for the NMFS safety radius of 1,640 ft (500 m) and two closer distances, 1,050 ft (320 m) and 98 ft (30 m), where source measurements were made at the Utgruden wind park (Report No. 4.1.2-1). Pile driving sound levels cannot be reliably estimated for distances closer than 30 m (98 ft) due to near-field effects. The 1,640 ft (500 m) safety radius is based on a condition in the USACE Permit granted to the applicant for construction and operation of a SMDS (Permit No. 199902477). The condition requires that sound level monitoring during pile driving procedures be conducted at an initial safety zone radius of 1,640 ft (500 m) to determine compliance with the 180-dBL NMFS threshold. A similar safety radius was established by NMFS for pile installation at the San Francisco-Oakland Bay Bridge (Illingworth & Rodkin, Inc. 2001; SRS Technologies, 2004).

The results of this $dB_{ht}$ analysis (Report No. 5.3.2-2) show that no injury to finfish are predicted if an individual were to approach as close as 98 ft (30 m) to the pile driving because all $dB_{ht}$ values at this minimum distance are well below 130 dB re 1 μPa. Fish that remain in immediate proximity to the monopile 0 to 30 feet (0 to 9 m) have a greater likelihood of injury at the start of pile driving.

The $dB_{ht}$ data presented in Table 5.3.2-9 were then used to calculate the zone of behavioral response for pile driving at the proposed action site. These results, summarized in Table 5.3.2-10, give the distance from the monopile where a significant avoidance reaction would occur for each species, i.e., where $dB_{ht}$ = 90 dB re 1 μPa. Avoidance by a minority of individuals would be expected at lower levels and hence at slightly greater distances than those listed in Table 5.3.2-10. If finfish are in the proposed action's construction area, they are likely to temporarily avoid the zone of behavioral response around the monopile being driven. Table 5.3.2-10 reveals that behavioral effects (avoidance) would occur at a range of 60 to 350 m (197 to 1,148 ft) by finfish.

Acoustical impacts to fish within 1,640 ft (500 m) would be minimized by using a "soft start" of the pile driving equipment (use of a low energy start) to allow fish to move away from the area in response to construction sound. Avoidance effects are temporary, limited to a relatively small area around the one monopile being driven at any one time, and avoidance effects disappear only hours after pile driving ceases. Only two pieces of pile driving equipment would be present at any one time, and they are unlikely to be operating simultaneously in close proximity to each other.

As an added protection measure, underwater sound monitoring would be performed during initial monopile construction (the first three monopiles - as was done to ensure protection of marine mammals during the installation of the SMDS foundation piles). Underwater sound pressure level measurements would be made at an Initial Safety Zone radius of 1,640 ft (500 m) to determine compliance with the 180 dB NMFS threshold. Hydrophone measurements would use the Lmax RMS "fast" setting, and data would be analyzed on a real-time basis to ensure continuing compliance. The SMDS permit stipulated that if measured levels exceeded the threshold, a site-specific Safety Zone radius corresponding to the 180dB threshold would be established and the NMFS approved observer would be advised of the expanded action area for observation of marine mammals. Similar measures would be followed for the installation of the monopiles. These measures would also have benefits to any finfish species in the vicinity of the proposed action. During installation of the SMDS, measured sound levels did not exceed the 180dB threshold at or beyond the initial Safety Zone radius.

Effects of pile driving noise on marine invertebrates are expected to be negligible. An evaluation of the BATHOLITHS airgun seismic surveys off the coast of British Columbia predicted only minor, short-term, sub-local and insignificant impacts on invertebrates (LGL Ltd. and JASCO Research Ltd., 2006). It should be noted that airguns produce some of the loudest peak human-made underwater noises (NMFS) and are designed to penetrate to great depths; therefore predicted impacts to invertebrates from local monopile driving are expected to be much less than that anticipated from the BATHOLITHS program.

*Other Construction Sounds*

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound. No substantial underwater sound would be generated during HDD operations used to transition the offshore transmission cable system to the upland cable system in Lewis Bay. Due to the sound-insulating qualities of saturated sediment***s***, and the fact that the drilling would take place through unconsolidated material, the HDD transition is not anticipated to transmit vibration from the sediment to the water (i.e., it would not add appreciable sound into the water column). The installation of sheet steel for the cofferdam would utilize a low-noise vibratory method and would not use impact pile driving.

*Vessel Sounds*

Construction would result in increased vessel traffic between the WTG array site, the transmission cable system route, and Quonset, RI (where construction laydown is planned to occur). The sound source level for a tug and barge traveling at low speed, the typical construction vessels for the proposed action is 162 dB re 1 μPa @ 1 m (3.3 ft) (Malme et al., 1989). Using the reported sound source level for tugs and barges, the maximum perceived underwater sound level was evaluated at 10 ft (3 m) for finfish using the hearing-threshold data presented in Table 5.3.2-7. The maximum hearing-threshold sound level ($dB_{ht}$ re 1 μPa) for finfish at a distance of 10 ft (3 m) from a vessel was calculated as 73 dBht re 1 μPa. Finfish would be able to hear the vessel but the sound levels are safely below the 130 $dB_{ht}$ re 1 μPa threshold for preventing injury or harassment. Therefore, vessels that are 10 ft (3 m) or greater from finfish should not cause physical harm. The 73 dBht re 1 μPa sound level at 10 ft (3 m) is above the 70 dBht re 1 μPa threshold for avoidance by the most sensitive finfish individual, and thus finfish in the vicinity may display avoidance behaviors to vessels. These behaviors, however, would be short-term and would likely be similar to the behaviors observed during activities that regularly occur in Nantucket Sound such as pleasure boat use, ferry traffic, and fishing. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. Vessel traffic generated by proposed action activities is not expected to have a significant effect on the early life stages of fish species, as it would be typical of vessel traffic already occurring in Nantucket Sound.

**Conclusion**

Post lease geotechnical and geophysical sampling, and construction/decommissioning activities, are expected to have negligible to minor impacts on EFH. The applicant and MMS would continue to work with NOAA Fisheries and MassDMF to ensure that impacts to EFH and EFH species are minimized and mitigated if necessary. Mitigation being considered at this time includes performing surveys to delineate eelgrass beds, avoidance of anchoring in locations with eelgrass beds and developing a Before After Control Impact (BACI) plan. More discussion of mitigation is provided in Section 9.0.

#### 5.3.2.8.2 Operational Impacts

During operation of the proposed action, impacts to EFH and EFH species would arise from activities that disturb or alter the seafloor, that alter water quality conditions, and alter physical characteristics such as noise. Such activities may include cable repairs, maintenance of scour protection, and associated vessel activity where water withdrawals and discharges occur and noise is produced. Other impacts include the continued presence of a vertical structure which would alter the benthic environment and habitat in the area.

Unplanned and accidental events have the potential to adversely affect EFH and EFH species. Vessel collisions and collapse of a monopile would necessitate repair and/or replacement activities, including mobilization of similar vessels and equipment used to construct a WTG. Oil spills could occur if a monopile collapses, or if a transformer on the ESP leaks and multiple features of the ESP's containment system are ruptured. Small spills could occur during handling of lubricants and fuels during maintenance activities. In general, the small quantity or low probability of these events occurring results in a negligible potential for impact on EFH and EFH species.

**Impacts to Benthic/Demersal EFH**

***Impacts from Creation of Vertical Structure***

Research on the potential effect of the monopile foundations on fish species, including those with designated EFH in the area, was conducted. This research included in-depth discussion of possible fish aggregation, reef effects, and spacing considerations for the monopiles. The vertical structure that would be created from the installation of wind turbine towers is not anticipated to result in adverse impacts to the ecology of the immediate proposed action area or to Nantucket Sound. Organisms that may settle on such structures include a number of species of algae, sponges, tunicates, anemones, hydroids, bryozoans, barnacles and mussels that are common to the coastal waters of Nantucket Sound. Colonization would largely occur through the planktonic larvae released by these organisms known to occur on other hard substrates in and around Nantucket Sound.

The proposed monopile structures would provide a high profile but cylindrical structure of poor complexity and low rugosity. Thus, fish attraction to the monopile structures is not expected to be as marked as that for planned artificial reefs or complex steel structures such as oil and gas platforms (Wilson et al., 2003) which have a high profile, open latticework structure. Wilson et al. (2003) found that fish biomass per cubic meter and density around a standing oil and gas platform was higher than artificial or natural reefs. Certain demersal EFH species in Nantucket Sound that show territorial or reef-obligate life histories may be attracted to the monopiles including, but not limited to: Atlantic cod, black sea bass, and scup. In addition, it should be noted that the distance between the monopile structures is within the sensory range for flatfish. Flatfish such as flounder, sole and dab have been shown to be attracted to submarine structures at distances of 1,969 ft (600 m) and flounder have been shown to move between 2 reef structures at a distance of 2,953 ft (900 m) (Grove et al., 1989). Because of their relatively high mobility between underwater structures, these species may become more vulnerable to fisheries, increasing the exploitable biomass. In addition, flatfish species have been found to be attracted to artificial reefs (Polovina and Sakai, 1989), although it is believed that they visit the reefs primarily to forage.

In general, it is not likely that the addition of new hardened structures in Nantucket Sound would introduce species that aren't currently there, because artificial hard substrate can already be found throughout the harbor and port areas within the Sound in the form of pilings associated with wharfs and breakwaters. Some studies have shown that artificial reefs simply redistribute the resources without increasing the biomass (Polovina and Sakai, 1989). A conclusion more specific to wind parks may be drawn from research done in support of the Horns Rev windmill park in Denmark. A study was conducted to describe the possible artificial reef impact on fish of the monopile foundations of the planned marine windmills (DIFR, 2000). The Horns Rev project is on a smaller scale than the proposed action, being only 80 units forming an 8 x 10 grid, 1,804 ft (550 m) apart. However the two projects are similar enough to draw conclusions on potential reef effect impacts. The Horns Rev project concluded that "Considering the hydrography and material and design of the Horns Rev structures, there is no indication that the windmill foundations would provide a significant food-chain basis" even though monopiles at the Horn's Rev wind farm were found to be colonized by bryozoans, sea anemone, sea squirts, starfish and the common mussels (*Mytilus edulis*) within five months of its construction (S.E Ltd., 2002). Based on the design similarities of the proposed action and the Horns Rev project, it would be reasonable to conclude that the proposed action, a comparable project, would not have significant impact on the food-chain or the ecology of Nantucket Sound.

In addition, several isolated rocks and areas of coarse glacial till do exist in shoal areas throughout Nantucket Sound, and are likely to support benthic communities similar to those that may become established on the WTGs. Although the monopile foundations would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates, the additional amount of surface area being introduced (approximately 1,200 ft² [0.03 acre or 111 m²]) per tower, assuming an average water depth of 30 ft (9.1 m) would be a minor addition to the hard substrate that is already present. Therefore, it is likely that these isolated structures would generate a relatively small amount of additional patch reef type habitat, common in the Sound, further supporting the conclusion that the monopiles would have a minor impact on the fish community or ecology of Nantucket Sound. Other types of similar artificial hard substrate can be found throughout harbor and port areas within the Sound that have pilings associated with wharfs and breakwaters constructed over the decades for the protection of anchorages and harbors.

Removal of the monopiles would eliminate the vertical structure-oriented habitat offered by the monopiles that some species prefer and may cause these species to disperse elsewhere. If any of these fish species were subject to increased fishing pressure during the life of the proposed action, removal of the monopiles may allow subsequent dispersal of the aggregated fish, thereby reducing fishing pressure on these species in the area.

***Impacts to Benthic EFH from Repair of Submarine Cable***

In the unlikely event a submarine cable has to be repaired, a segment of the cable would have to be excavated, repaired and then backfilled again (see construction procedures for repairs at Section 2.4.6). Impacts associated with submarine cable repair work would be similar to those benthic EFH impacts described above for installation of the submarine cable in Section 5.3.2.8.1. Such impacts are expected include disturbance to the seafloor and benthos, which would be temporary and result in negligible to minor impacts.

*Impacts to Benthic EFH during Maintenance Work*

Maintenance work on the WTGs would require vessels to operate in the area to deliver maintenance workers and or supplies to the WTGs. This work would result in anchoring of vessels that would cause temporary disturbance to the benthic EFH, which would result in minor impacts. Maintenance of scour mats and or riprap, if needed, would result in temporary impacts to benthic resources in the vicinity of the work, and such impacts would be minor.

*Impacts from Underwater Electromagnetic Fields (EMF)*

Potential impacts to fish species, including those with designated EFH in the proposed action area, from electromagnetic/thermal emissions during the normal operation of the inner-array cables and the offshore transmission cable system circuits are expected to be negligible. The cable system (for both the inner-array cables and the offshore transmission cable system circuits) is a three-core solid dielectric AC cable design. The proposed inner-array and offshore transmission cable systems would contain grounded metallic shielding that effectively blocks any electric field generated by voltages on the conductors within the cable systems. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the offshore transmission cable system and inner-array cables. As described in Report No. 5.3.2-3, the magnetic fields associated with the operation of the inner-array cables or the offshore transmission cable system are anticipated to result in negligible impacts to marine organisms, including EFH species and their prey.

**Water Column Impacts**

*Impacts from Suspended Sediments*

In the event a cable repair is required, impacts to the water column would be similar to those experienced during installation of the cable as described above in Section 5.3.2.8.1. Impacts would include temporary turbidity as a result of suspended sediments caused from excavation of the cable and or backfilling of the cable, plus anchoring impacts and anchor line sweep impacts. Marine organisms, including EFH species, in the water column are accustomed to periodic increases in suspended sediments and should not be substantially impacted by a temporary increase in turbidity that cold be caused by repair work or other maintenance work, and thus impacts to the water column as a result of suspended sediments are expected to be negligible to minor.

*Acoustical Impacts*

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Acoustic modeling of underwater operational sound at the offshore proposed action area was performed for the design wind condition (see Section 4.1.2.3). Baseline underwater sound levels under the design wind condition are 107.2 dB re 1 µPa (see Section 4.1.2.3 for more information on baseline sound data). The predicted sound level from operation of a WTG is 109.1 dB re 1 µPa at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB re 1 µPa above the baseline sound level), and this total sound level falls off to 107.5 dB re 1 µPa at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m). Since the WTGs would be spaced farther apart than 361 ft (110 m), cumulative impacts from the operation of the 130 WTGs are not anticipated.

In order to determine the actual underwater sound level that is heard by finfish during operation, a $dB_{ht}$ was calculated. Using the hearing threshold data from Table 5.3.2-7, $dB_{ht}$ sound levels were calculated for proposed action's operation. Operation sound results are given for the two distances where source measurements were made in the Utgruden and Gotland wind parks, 65.6 ft (20 m) and 328 ft (100 m) (Report No. 4.1.2-1). Operation sound levels cannot be reliably estimated for distances closer than 65.6 ft (20 m) due to near-field effects. The results indicate that at 328 ft (100 m) and 65.6 ft (20 m), perceived operational sound levels for finfish were 7 $dB_{ht}$ re 1 μPa and 21 $dB_{ht}$ re 1 μPa, respectively. Since operational sound would be only barely audible to finfish at the extremely close distance of 65.6 ft (20 m), it is also unlikely to have any adverse effect on fish eggs or larvae.

The results of this $dB_{ht}$ analysis (Report No. 5.3.2-2) show that no injury or behavioral effects to EFH finfish species are predicted even if an individual were to approach as close as 66 ft (620 m) to a monopile when the proposed action is operating at the design wind speed because all $dB_{ht}$ values at this minimum distance are well below 130 and 90 dB re 1 μPa. Operational sounds would only be slightly audible to finfish at the extremely close distance of 66 ft (20 m). Research conducted at offshore wind farms in Europe suggest that the very low vibration from wind turbines does not impact fishes in the region (AMEC, 2002). At the Näsrevet Windfarm in Sweden, Westerberg (*as cited in* Vella, 2001) reported that the normal operational sounds of a wind farm did not greatly impact the migration of eels.

Based on the $dB_{ht}$ analysis and observations from offshore wind farms in Europe (Vella, 2002; Westerberg, 1999 *as cited in* Vella, 2001), underwater sound levels from the WTGs for the proposed action are not anticipated to cause physical harm or behavioral changes to finfish, including those with designated EFH in the area.

***Impacts to EFH from Rotor Shadows***

As fish swim into the area affected by rotor shadow, they are unlikely to be startled because they would be able to see the periodic motion of the shadows ahead of time. Furthermore, shadows cast by wind turbine blades are unlikely to be perceived by fish as rapidly growing shapes, which is the primary cause of their startling (Webb, 1982) since this does occur with avian predation. Rather, the shadow shape should remain fairly constant at any given point in the water, even as the blades spin. When the blades are not spinning, the shadow would be relatively static. As the blades spin faster, the shadows of each individual rotor blade would become less distinct and harder to perceive. Additionally, the speed of the rotor shadow, as perceived by finfish, would remain fairly constant over short periods of time. This should preclude a sense of shadow acceleration (the looming threshold), as might be expected with avian predation from above (Paglianti and Domenici, 2006). As such, the number of energy-intensive predator evasion responses due to rotor shadow movement is expected to be minimal, and impacts from rotor shadows on EFH species would be negligible.

In addition, the fact that water is denser than air causes light to be refracted toward the water surface. Because the surface of marine water is inevitably wavy, this leads to a dappling effect of light and dark through the water column and on the seafloor. Marine fishes are accustomed to these shifting patterns of light from above—in fact, many fish species (e.g., whale shark and lanternfish) have developed camouflage that mimics these patterns (Harcourt and Stanley, 2007; Shedd, Aquarium 2007). Therefore, the relatively thin, shifting shadows cast by wind turbine rotors are not expected to significantly contribute to a sense of top-water predation.

***Impacts to EFH as a result of Spills and Accidental Releases of Potential Contaminants***

The WTGs have been configured to contain any fluid leakage and prevent overboard discharges. Well-maintained equipment and training of personnel would help prevent any spills from occurring. However, in the case of a spill, all service vessels would be equipped with spill handling equipment to minimize and mitigate any impacts. In addition, waste collection systems would be installed on board each WTG. The waste would be separated for proper disposal once the containers are off-loaded at the dock.

The ESP would have sealed, leak-proof decks, which would serve as fluid containment. In addition, spill containment kits would be available near all equipment. Furthermore, the applicant would develop an OSRP Plan in accordance with MMS regulations.

Oil would be stored in greater quantities than any other potential contaminant. To address this, a comprehensive OSRP is under development. The OSRP is likely to provide finfish with a level of protection that is equal to or greater than marine mammals or sea turtles. This follows from the fact that, in the unlikely case of an oil spill, finfish are generally less likely than marine mammals and sea turtles to surface and come into direct contact with the spill. Unlike marine mammals and sea turtles, finfish do not surface in order to breathe and many marine finfish species never surface during the free-swimming stages of their life history.

The areal extent of an oil spill associated with the wind turbines or maintenance vessels would be small such that a significant ecological impact would be unlikely. The only significant source of oil is associated with the ESP. If an oil spill were to occur within the proposed action area, including a mineral oil spill from the ESP, juvenile and adult finfish would be likely to avoid the area directly affected by oil spills, thereby minimizing direct mortality from contact with oil. Some commercial finfish species have floating egg and larval life stages, which are more susceptible to injury or mortality from oil spills than the free-swimming juvenile and adult stages. However, these species also typically spawn over large areas and produce hundreds of thousands to millions of eggs per fish each season. Therefore, a small oil spill from the turbines, maintenance vessels or the ESP in Nantucket Sound would be unlikely to have a significant impact on recruitment from early life stages. Finfish with demersal eggs and larvae are even less likely to be affected by oil spills.

**Conclusion**

Wind turbine operations are expected to have negligible to minor impacts on EFH, other than the very low probability occurrence of an accidental scenario, such as a commercial oil transport vessel colliding with a monopile and spilling a large quantity of cargo.

**Species Specific Impact Summary**

Potential impacts discussed above that may affect the benthic and pelagic fish and invertebrate species with designated EFH in the proposed action area are summarized in Tables 5.3.2-11 through 5.3.2-13. In order to assess impacts more efficiently, target species were grouped into four categories: early life stages (eggs and larvae) of benthic-oriented species (Table 5.3.2-11), early life stages of pelagic-oriented species (Table 5.3.2-11), older life stages (juveniles and adults) of benthic-oriented species (Table 5.3.2-12) and older life stages of pelagic-oriented species (Table 5.3.2-12). Since potential impacts to all species is highly dependent on the time of year that activities occur, Tables 5.3.2-11 and 5.3.2-12 also describe the potential season(s) when these life stages may be present in Nantucket Sound. Potential impacts to species with designated EFH in the proposed action area are summarized by the four categories described above in Table 5.3.2-13. This table describes the level of impact to each category using the MMS definitions of impact levels and provides a brief description of the potential impact. This table serves to address impacts to the fish and invertebrate species with designated EFH by categorizing them into four groups for comparison. As can be seen in Table 5.3.2-13, all impacts are projected to be minor or negligible.

### *5.3.2.9 Threatened and Endangered Species*

This section provides an overview of the impacts on threatened and endangered species protected under the ESA that have the potential to occur in the site of the proposed action as well as two candidate species, the red knot and the eastern cottontail rabbit.

### 5.3.2.9.1 Construction/Decommissioning Impacts

**Sea Turtle Species**

The ESA/MESA protected sea turtle species described in Section 4.2.9.2 may be impacted by a number of activities associated with proposed actions construction and decommissioning. Review of scientific literatures, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of sea turtles have been conducted within Nantucket Sound. For the purpose of documenting the presence of marine mammals in Nantucket Sound, incidental observations during aerial surveys were combined with a comprehensive literature search, stock assessments, sighting, strandings and population studies information. There are limitations to the use of incidental observations to document the presence of sea turtles in Nantucket Sound and should not be considered as an absolute documentation of the occurrence of any particular species, because the results are dependent in part on the level of effort that is expanded in looking for sea turtles and there is potential for misidentifying species. However, this information, combined with the best available scientific and commercial information, serve as a general indicator of where sea turtles are likely versus unlikely to occur in order to make an adequate informed evaluation regarding potential impacts to sea turtles.

***Underwater Sound***

An introduction to underwater sound is provided in Section 5.3.2.6, including a description of the analyses used to calculate the hearing thresholds of sea turtles.

The underwater sound effects of construction would be associated with the installation of 130 16 to 18 ft (4.8 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of offshore cables. According to divers experienced in jet plow installations, the jet plow itself produces no audible sounds other than the sound of water exiting the nozzles, which is only audible when immediately adjacent to the nozzles. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles using a drop hammer.

While very little published data on hearing thresholds for sea turtles exist, unpublished research results from an Office of Naval Research hearing threshold study being done at New England Aquarium on Green Turtles were obtained (New England Aquarium, 2005) and these data were combined with other information (Ruggero and Temchin, 2002) to present the hearing thresholds for sea turtles (Table 4 of Report No. 5.3.2-2). These are the best estimates available for green, loggerhead, Kemp's ridely and leatherback sea turtles. The hearing bandwidth for turtles is relatively narrow, 50 to 1,000 Hz with a maximum sensitivity around 200 Hz. These animals also have very high hearing thresholds, over 100 dB re 1µPa, in the low frequencies where construction sound is concentrated.

*Pile Driving*

The predicted underwater sound level perceived by sea turtles from project construction is 56 $dB_{ht}$ re 1 µPa at 1,640 ft (500 m), 60 $dB_{ht}$ re 1 µPa at 1,049 ft (320 m), and 80 $dB_{ht}$ re 1 µPa at 98 ft (30 m) (Table 6 of Report No. 5.3.2-2). Based on the analysis, even if a sea turtle got as close as 98 ft (30 m) to the pile driving operations, no injury would occur as all $dB_{ht}$ values at this minimum distance are below 130 dB re 1 µPa. However, if sea turtles are in the proposed action area, they are likely to temporarily avoid the zone of behavioral response around the monopile being driven.

The principal sound from construction would be pile driving of monopiles, one monopile at a time. Using the $dB_{ht}$ for sea turtles, the zone of behavioral response for pile driving at the project site was calculated (Table 8 of Report No. 5.3.2-2). During pile driving, it is anticipated that at <98 ft (30 m) sea turtles may experience a behavioral response, specifically avoidance. Avoidance by a minority of individuals would be expected at lower levels and hence at slightly greater distances than on average.

In addition to pile driving sounds, the post lease G&G investigation would result in sound associated with vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus underwater sound impacts on sea turtle species are expected to be negligible or insignificant with respect to G&G activity.

*Vessels*

The sound source level for a tug and barge at low speed, they typical construction vessel for the proposed action, is 162 dB re 1 µPa at 3.3 ft (1 m) (Malme et al., 1989). Using the reported sound source for tugs and barges, the maximum perceived underwater sound level was evaluated at 100 feet (30.5 m) for sea turtles using the hearing-threshold data (Table 4 of Report No. 5.3.2-2).

To represent a worst-case scenario, the maximum hearing-threshold sound levels ($dB_{ht}$ re 1 µPa) for a proposed action vessel were calculated at 100 ft (30.5 m), which gave a hearing threshold of 17 $dB_{ht}$ for sea turtles. The sea turtle would be able to hear the vessel but the sound levels are safely below the 130 $dB_{ht}$ re 1 µPa threshold for preventing injury or harassment to marine animals at the 90 $dB_{ht}$ re 1 µPa threshold for significant behavioral response (i.e., annoyance, disturbance). Therefore, sounds from the proposed action vessels are unlikely to cause physical harm or behavioral effects in sea turtles.

*Decommissioning*

Underwater sounds produced by the decommissioning of the proposed action are expected to be similar to those produced during construction. Proposed action decommissioning would not require pile driving activities, which cause the highest sound levels of any activities associated with any phase of the proposed action.

Any sea turtles are likely to temporarily avoid a given area around the construction, and, given the known areas that the sea turtles inhabit within Nantucket Sound, only minor impacts would be anticipated due to proposed action construction generated sounds. Any sound should not affect the migration, nursing/breeding, feeding/sheltering, or communication of sea turtles.

***Increased Vessel Traffic***

The proposed action would temporarily increase the number of vessels within the vicinity of the construction/decommissioning work areas, especially in the route between Quonset, Rhode Island and the area of the proposed action. Several shipping lanes and two navigational channels exist within the vicinity of the area of the proposed action. During construction activities, especially during pile driving activities, it is estimated that 4-6 stationary or slow moving vessels would be present in the general vicinity of the pile installation. Vessels delivering construction materials or crews to the site would also be present in the area between the mainland and the site of the proposed action. The post lease G&G field investigation would also require the use of vessels in the area (see Section 2.7). The barges, tugs and vessels delivering construction materials would be limited to speeds below 10 knots (5.1 m/s) and may range in size from 90 to 400 ft (27.4 to 122 m), while the vessels carrying construction crews would be traveling at a maximum speed of 21 knots (10.8 m/s) and would typically be 50 ft (15.2 m) in length.

*Vessel Strike*

Although sea turtles are likely to dive at the approach of a vessel, they are still at risk of boat-related injuries. Between 1987 and 1993, up to 17 percent of all stranded sea turtles on the U.S. Atlantic coast had boat-related injuries (Teas, 1994a, b). Ship strikes appear to be a significant source of mortality for sea turtles, and vessel-related injuries have increased in recent years (Teas, 1994a, b). However, vessels moving at slower speeds, such as those associated with the proposed action's construction, are less likely to cause collisions (NMFS, 2001; NMFS, 2002). In addition, sea turtles present in Nantucket Sound are likely to be foraging and their feeding behaviors may also reduce the risk of collisions. While feeding, these turtles spend most of their time submerged. Ridleys and loggerheads can spend more than 57 minutes of each hour submerged (Thompson, 1988) and between 25 and 58 percent of their time is directly on the bottom (Standora et al., 1994). Feeding dives last from about four minutes to as long as two hours (Renaud and Carpenter, 1994). During these long periods of submergence, loggerhead and ridley turtles are not particularly vulnerable to collisions with barges.

Although vessel collisions are a significant cause of sea turtle mortality in the western North Atlantic, the Project is not expected to put sea turtles at increased risk for vessel collisions. As stated earlier, vessels moving at slower speeds (less than 14 knots), such as the construction vessels to be used for the Project, are less likely to cause collisions (Laist et al., 2001). As such, any impact to sea turtles from vessel strikes are anticipated to be insignificant or negligible.

*Vessel Harassment*

Loggerhead, Kemp's ridley, leatherback, and green turtles are known to seasonally migrate between their fall/winter mating and nesting grounds, and their spring/summer feeding grounds. Typically in the late spring and summer months turtles migrate in the Gulf Stream to feed between the continental shelf and the coastlines of New England, New York, and the mid-Atlantic states (NOAA, 2005a; Epperly et al., 1995a,b; Keinath et al., 1987; Schmid, 1995; Morreale et al., 1989; Shoop and Kenney, 1992; Morreale and Standora, 1989; Lazell, 1980; Musick and Limpus, 1997; Goff and Lien, 1988; Prescott, 1988; Shoop et al., 1981; Thompson, 1988; Collard, 1987; Márquez, 1994). As northern water temperatures begin to drop in the fall and winter, turtles migrate to the warmer coastal waters south of the Carolinas, particularly the eastern coast of Florida, the Gulf of Mexico, and the Caribbean Sea (Thompson, 1988; Shoop and Kenney, 1992; Coles et al., 1994; CeTAP, 1982; Henwood and Ogren, 1987).

Loggerhead turtles nest primarily along the beaches of Florida, the Yucatan Peninsula, and the Dry Tortugas (TEWG, 1998, 2000; NMFS-SEFSC, 2001), while nearly all reproduction of the Kemp's ridley takes place along a single stretch of beach near Rancho Nuevo, Mexico (NRC, 1990). Leatherback turtles nest primarily on beaches of Florida (NRC, 1990; Meylan et al., 1994), the U.S. Virgin Islands (Boulon et al., 1994), and isolated beaches throughout the Caribbean (Tucker, 1990). Within the United States, green turtles nest in small numbers in the U.S. Virgin Islands, Puerto Rico, and the southern Atlantic states including the Carolinas, Georgia, and Florida, where the nesting aggregation is recognized as a regionally significant colony (USFWS, 2002a).

Loggerheads and Kemp's ridleys are primarily bottom feeders, foraging in shallow coastal waters where they feed on benthic invertebrates, particularly several crab mollusk species in New England's coastal waters (Burke et al., 1989; Morreale and Standora, 1992, 1989; Bjorndal, 1985). During the summer, groups of dozens of young ridleys are observed frequently in the coastal waters of Vineyard Sound, Buzzards Bay, MA, and in the eastern Bays of Long Island, NY (Carr, 1967; Lazell, 1980; Morreale and Standora, 1992, 1989). During feeding, both the loggerheads and the ridleys spend approximately an hour submerged (Thompson, 1988; NMFS, 1988). Although loggerheads appear to feed primarily on the bottom, they also have been observed feeding in the pelagic zone (Ruckdeschel and Shoop, 1988), similar to the leatherback turtle, which feeds primarily on jellyfish and other gelatinous zooplankton (Eckert et al., 1989; Limpus, 1984). There are numerous records of leatherback turtles in New England, and as far north as Nova Scotia and Newfoundland (Goff and Lien, 1988). Their seasonal inshore movements in New England waters have been linked to inshore movements of their prey (Lazell, 1980; Payne and Selzer, 1986).

Adult green turtles differ from the other three species in several ways. They are primarily herbivorous, and feed on shallow-growing algae and sea grasses in the protected waters of reefs, bays, inlets, lagoons, and shoal areas (USFWS, 2002a; Crite, 2000). As the green turtle is largely distributed in tropical and subtropical waters worldwide, there are no known records of documented green turtle feeding grounds along the beaches of New England, or more specifically, Nantucket Sound.

Due to species-specific ranges, leatherback and Kemp's ridley turtles, rather than loggerhead and greens, are more commonly encountered in Nantucket Sound (Lazell, 1980; Shoop and Kenney, 1992; Goff and Lien, 1988; Prescott, 2000). Minimal recordings exist of the green turtle as far north as Cape Cod (Prescott, 2000); and during the summer, loggerheads are encountered more frequently in Long Island Sound, New York Harbor-Raritan Bay, and along the south coast of Long Island (Morreale et al., 1989). Turtle sightings off Massachusetts are most frequent in the late summer months (Shoop et al., 1981; CeTAP, 1982; Shoop and Kenney, 1992), when the turtles migrate north to feed. Both loggerheads and ridleys are primarily benthic feeders, and are not as likely as the pelagic-feeding leatherbacks to be observed feeding at or near the water's surface. Therefore, the proposed action's vessels have a greater likelihood of interacting with leatherback turtles since they primarily feed at or near the water's surface. Kemp's ridley turtles are bottom feeders and would spend less time at or near the water's surface.

It is unlikely that the physical presence of vessels associated with the construction, operation and decommissioning of the proposed wind farm in Nantucket Sound would contribute to the harassment of feeding and migrating turtles. Additionally, since the turtles do not nest along the beaches of New England, particularly those located along Nantucket Sound, the physical presence of vessels associated with the construction, operation, and decommissioning of the proposed wind farm will not contribute to the harassment of nesting turtles. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with sea turtles. Therefore, it is not expected that the proposed action will contribute to the harassment of sea turtles. As a result, impacts on sea turtle populations in Nantucket Sound would be insignificant or negligible.

***Prey and Habitat Reduction***

Activities related to proposed action construction and decommissioning may cause a temporary reduced availability of habitat for sea turtles in the vicinity of the area of the proposed action. The main anticipated impact would be part or complete avoidance of areas of pile driving and areas of high traffic, specifically the route the proposed action-vessels would use to and from the proposed action. Proposed action construction is not anticipated to result in permanent changes in sea turtle prey abundance or distribution. Some temporary displacement may occur during periods of underwater sound or elevated suspended sediment concentrations, such as near the cable jetting, but this would be limited to areas directly surrounding the given activities, causing both prey species and sea turtles to move away. Benthic habitat disturbance due to construction activities may cause mortality to benthic organisms in the disturbed area, but similar benthic communities are found throughout Nantucket Sound, enabling sea turtles to find suitable prey in other areas, and the effect is temporary as the disturbed areas would become recolonized. Therefore, the potential for temporary habitat reduction will have insignificant or negligible impact on sea turtles.

***Habitat Shift (Non-structure Oriented to Structure)***

The presence of 130 monopile foundations, six ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from a soft sediment, open water habitat system to a structure-oriented system, with potential localized changes to sea turtles, namely the establishment of "fouling communities" within the Wind Park and an increased availability of shelter among the monopiles. The scour mats rock armor at the base of the monopiles will be designed to minimize any risk of entrapment and drowning to sea turtles.

The WTG monopile foundations will represent a source of new substrate with vertical orientation in an area that has a limited amount of such habitat, and as such may attract finfish and benthic organisms, potentially affecting sea turtles by causing changes to prey distribution and/or abundance. While the aggregation of finfish around the monopiles will not attract sea turtles, some sea turtle species may be attracted to the WTGs for the fouling community and epifauna that may colonize the monopiles as an additional food source for certain sea turtle species, especially loggerhead and Kemp's ridley turtles. All four species may be attracted to the monopiles for shelter, especially loggerheads that have been reported to commonly occupy areas around oil platforms (NRC, 1996).

More specifically, loggerheads and Kemp's ridleys could be attracted to the monopiles to feed on attached organisms since they feed on mollusks and crustaceans. According to USFWS (2005), loggerheads are frequently observed around wrecks, underwater structures and reefs where they forage on a variety of mollusks and crustaceans. Leatherback turtles and green turtles, however, should not be attracted to the monopiles for feeding since leatherbacks are strictly pelagic and feed from the water column primarily on jellyfish (OBIS-SEAMAP, 2002) and green turtles are primarily herbivores feeding on sea grasses and algae. In addition, green turtles are much more likely to be found in shallow, warmer waters and are not expected to frequent the Nantucket Sound area with any regularity. All four species of sea turtles have been observed around oil platforms, especially loggerheads which are reportedly the most common species sighted around oil platforms and have been observed sleeping under platforms or next to support structures (NRC, 1996). Kemp's ridley turtles, however, appear to prefer more sheltered areas along the coast or in estuaries, bays and lagoons (FWIE, 1996). Therefore, although it is possible that any of the four sea turtle species could be attracted to the monopiles for shelter, the loggerhead is the most likely species to be attracted to the structures for both food and shelter.

Although the monopile foundations would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates and additional structure that may attract certain finfish species, the additional amount of surface area being introduced (approximately 1,200 square feet [111 $m^2$] per tower, assuming an average water depth of 30 feet [9.1 m] below mean high water [MHW]) would be a minor addition to the hard substrate that is already present (see Section 3.9 of ESS, 2007). Due to the small amount of additional surface area in relation to the total area of the proposed action and Nantucket Sound and the spacing between WTGs (0.39 to 0.62 miles [0.63 to 1.0 km] apart), the new additional structure is not expected to affect the overall environment, benthic community composition, finfish species composition, or populations of foraging sea turtles in the area. The habitat shift from non-structure oriented to structure oriented as a result of the proposed action will have insignificant or negligible impacts to sea turtles in Nantucket Sound.

***Habitat Shift (Structure to Non-structure Oriented)***

Removal of the WTG monopile foundations and ESP piles at the time of decommissioning would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoal-oriented habitat present prior to construction. However, as the addition of the monopiles would be a minor addition to the hard substrate that was present prior to construction of the proposed action facilities, the removal of the WTGs and ESPs would not cause a great impact in the overall habitat structure.

Therefore, sea turtle populations that consume colonizing benthic invertebrate prey are not likely to increase due solely to the presence of the monopiles and hence would not be greatly affected by their removal. The habitat shift from structure oriented to non-structure oriented as a result of the proposed action's decommissioning will have insignificant or negligible impacts to sea turtles in Nantucket Sound.

***Water Quality***

*Turbidity and Total Suspended Solids*

The primary water quality concern to sea turtles during construction activities is elevated concentrations in total suspended solids (TSS). Construction activities associated with installing the monopile foundations, scour control, and submarine cables will result in a temporary and localized increase in TSS concentrations. The pile driving hammer and jet plow technology that will be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sands in Nantucket Sound, localized turbidity associated with Project construction and decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles and the submarine cable route. In Lewis Bay, suspended sediments are predicted to remain in suspension considerably longer than in Nantucket Sound due to weak tidal currents.

An increase in the TSS within the water can impact the foraging abilities of the sea turtles, decreasing the visibility of prey species. The suspension of sediments produced by proposed action construction is expected to be temporary and localized, as pile driving does not generate much suspended sediments and jet plow technology in sandy sediments results in minimal sediment release. The post lease G&G field investigation would also result in negligible sediment disturbance associated with the taking of vibracores and drilling of boreholes. Further, the physical composition of the sands and the physical characteristics of the sound environment provide reason to assume that any localized turbidity would settle back to the sea floor within a short period of time (one to two tidal cycles). Simulations of sediment transport and deposition for the proposed action demonstrate that jet plow embedment operations would result in a sediment plume below 50 mg/liter, and would settle in less than 2 to 3 hours. Within Lewis Bay, suspended sediments are expected to remain in suspension for longer periods due to the weak tidal currents, with a plume in excess of 100 mg/liter remaining for 2 to 6 hours depending on location and period of cycle. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

Sea turtles that forage within the area of Nantucket Sound are naturally accustomed to substantial amounts of suspended sediment on a regular basis, from storms and strong tidal currents, and should be minimally impacted by a temporary increase in turbidity from proposed action activities, including the sea turtles that may inhabit or forage within Lewis Bay. Further, sea turtles are mobile and can move away from any disturbance, including any increases in suspended sediments. The impacts of increased turbidity on the foraging abilities of sea turtles are expected to be insignificant or negligible.

*Contaminated Sediments*

Sea turtles bioaccumulate contaminants from their ocean environment, almost exclusively through their food sources. The potential mechanism by which sediments suspended during the proposed action's construction can harm sea turtles is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey (indirectly).

An analysis of sediment core samples obtained from the area of the proposed action indicate that sediment contaminant levels were below established thresholds in reference Effect Range-Low (ER-L) and Effects-Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995). Therefore the temporary and localized disturbance and suspension of these sediments during the proposed action's construction activities are not anticipated to result in increased contaminants in lower trophic levels. Therefore, sea turtles are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the vicinity of the proposed action, and any impacts are expected to be insignificant or negligible. (See Section Table 3.2 of Report No. 4.1.1-1 for a complete analysis of the sediment core samples).

During the near shore installation, the release of contaminants from the HDD operation within Lewis Bay will be minimized through a drilling fluid fracture or overburden breakout monitoring program, minimizing the potential of drilling fluid breakout into the water. The drilling fluid will consist of water (approximately 95 percent) and an inorganic, bentonite clay (approximately 5 percent). The bentonite clay is a naturally occurring hydrated aluminosilicate composed of sodium, calcium, magnesium, and iron. In the unlikely event of drilling fuel release, the bentonite fluid density and composition will cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment; thereby minimizing any long-term impacts to protected sea turtles.

Decommissioning-related impacts will be short-term and localized and are expected to be similar to or less than impacts during construction. The suspension of solids are expected to be temporary and localized, as the removal technology that will be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Further, the physical composition of the sands and the physical characteristics of the sound environment provide reason to believe that any localized turbidity will settle back to the sea floor within a short period of time (one to two tidal cycles).

Impacts on sea turtles from contaminated sediments as a result of the proposed action are anticipated to be insignificant or negligible.

***Geotechnical and Geophysical Investigations***

Many of the types of disturbances that would occur during the geotechnical and geophysical investigations are short term and very localized. A very small area of the sea floor would be disturbed by coring activities, either at the core hole or associated with the coring vessel anchor placements. It is likely that the duration of activity at any one coring location would be no more than a few days. The high resolution geophysical survey work, including collection of shallow (Chirp) and intermediate depth (Boomer) subbottom profiler data and sidescan sonar and magnetometer data, uses mobile gear towed behind a vessel, and would not result in bottom disturbance, nor does it result in activity at a fixed location. The geotechnical investigations would result in a negligible temporary loss of some benthic organisms, and a localized increase in disturbance due to vessel activity, including sound and anchor cable placement and retrieval. While the towed gear has the potential to result in interaction with sea turtle, the speed of towing, typically about 1 knot, minimizes the potential for entanglement or vessel strikes. Given the small area of disturbance, short duration of activities, and slow speed of mobile surveys, potential adverse impacts from geotechnical and geophysical investigations to the sea turtles would be negligible or insignificant (Additional details on geotechnical and geophysical field investigations are presented in Section 2.7 of the FEIS).

**Cetaceans**

Potential impacts to endangered and threatened cetaceans are described in more detail in the BA in Appendix G. In addition, impacts to endangered and threatened cetaceans are in many instances similar to those described for non-ESA cetaceans (see Section 5.3.2.6). Review of scientific literatures, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of whales have been conducted within Nantucket Sound. For the purpose of documenting the presence of whales in Nantucket Sound, siting data were combined with a comprehensive literature search, stock assessments, strandings and population studies information. There are limitations to the use of sightings data to document the presence of whales in Nantucket Sound and should not be considered as an absolute documentation of the occurrence of any particular species, because the results are dependent in part on the level of effort that is expanded in looking for whales and there is potential for misidentifying species. However, this information, combined with the best available scientific and commercial information, serve as a general indicator of where whales are likely versus unlikely to occur in order to make an adequate informed evaluation regarding potential impacts to whales.

***Underwater Sound***

The underwater sound effects of construction would be associated with the installation of 130 16 to 18 ft (4.8 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of offshore cables. According to divers experienced in jet plow installations, the jet plow itself produces no audible underwater sound other than the sound of water exiting the nozzles, which is only audible when immediately adjacent to the nozzles. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles using a drop hammer.

Baleen whales (mysticetes) have very different and less sensitive hearing capabilities, than toothed whales. Due to their immense size, these mammals cannot be kept in captivity for study like toothed whales. In the limited studies done, baleen whales reacted primarily to sounds at low frequencies in the 20 Hz to 500 Hz range (Richardson et al., 1995). While this is their most sensitive hearing range, the hearing bandwidth for baleen whales is thought to range from 5 Hz to 20 kHz. The hearing threshold for baleen whales at low frequencies is limited by the relatively high background sound in the ocean under quiet weather conditions without any nearby industrial activity. Those levels range from 82 dB re 1 μPa at 500 Hz to 88 dB re 1 μPa at 20 Hz (Nedwell et al., 2004). It is reasonable to assume that baleen whale hearing thresholds are no lower than these quiet ocean background levels. With that assumption and the limited research data available, a single set of hearing thresholds for baleen whales similar in shape to those for other marine mammals but shifted to their low frequency range was constructed and is given in Table 2 of Report No. 5.3.2-2. These data are applicable to humpback whale, fin whale and North Atlantic right whale.

The vocalization frequency of baleen whales ranges from the tens of Hz for “moans” to kHz for “songs” (Cummings and Holliday, 1987). Sound levels have been estimated as ranging from 130 to 190 dB re 1 μPa at 3.3 ft (1 m) (Medwin and Clay, 1997). In a study conducted by the Western Austrailian Division of Minerals and Energy, baleen whales were tested for their threshold levels to low-frequency underwater air gun noise (Western Australian Division of Minerals and Energy). Humpback whales exhibited a significant behavioral reaction at sound levels above 179 dB re 1 μPa, or roughly 90 db above the minimum hearing threshold of 90 dB re 1 μPa listed for baleen whales in Table 2 of Report No. 5.3.2-2. This is consistent with NOAA/NMFS guidelines on low-frequency impulse sound below 250 Hz that define the zone of behavioral response (i.e., annoyance, disturbance) for marine mammals as a sound pressure level 80 to 100 dB above the animal’s hearing threshold.

Measurements of actual underwater sound levels taken during the construction of the five offshore windparks in the United Kingdom indicate that there are two areas at which protected whales may be adversely impacted, the area of noise injury and the area of behavioral effect (Nedwell, et al. unpub. data). Physical effects (injury) to whales may occur at a distance when $dB_{ht}$=130 re 1μPa, while behavioral effects (avoidance) may occur at a distance when $dB_{ht}$=90 dB re 1 μPa (Nedwell, et al. unpub. data). The area in which physical injury could occur may extend to a few hundred meters from the piling driving operations, while the area in which behavioral changes may occur may extend to a kilometer or greater (Nedwell, et al. unpub. data). Therefore, based on the mitigation and monitoring measures required during pile driving activities for the proposed action, although marine mammals may hear the underwater construction sounds they are not expected to cause physical harm to cetaceans. However, if an individual were to remain unobserved and move inside the safety zone, behavioral effects could occur due to construction sounds (See Section 9 of description of observation protocols and safety zones).

*Pile Driving*

The predicted underwater sound level perceived by baleen whales from project construction is 86 $dB_{ht}$ re 1 µPa at 1,640 ft (500 m), 90 $dB_{ht}$ re 1 µPa at 1,050 ft (320 m), and 110 $dB_{ht}$ re 1 µPa at 98 ft (30 m) (Table 6 of Report No. 5.3.2-2). Based on the analysis, even if a whale got as close as 98 ft (30 m) to the pile driving operations, no injury would occur as all $dB_{ht}$ values at this minimum distance are below 130 dB re 1 µPa. However, if whales are in the proposed action area, they could alter their behavior to temporarily avoid the zone around the monopile being driven.

The principal sound from construction would be pile driving of monopiles, one monopile at a time. Using the $dB_{ht}$ for whales, the zone of behavioral response for pile driving at the project site was calculated (Table 8 of Report No. 5.3.2-2). During pile driving, it is anticipated that at 3,674 ft (320 m) baleen whales may show a behavioral response to the underwater sound, specifically avoidance. Avoidance by a minority of individuals would be expected at lower levels and hence at slightly greater distances than on average.

In addition to pile driving sound, the post lease G&G investigation would result in underwater sounds associated with vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus underwater sound impacts on sea turtle species are expected to be negligible or insignificant with respect to G&G activity.

*Vessel Underwater Sounds*

The sound source level for a tug and barge at low speed, they typical construction vessel for the proposed action, is 162 dB re 1 µPa at 3.3 ft (1 m) (Malme et al., 1989). Using the reported sound source for tugs and barges, the maximum perceived underwater sound level was evaluated at 100 ft (30.5 m) for whales using the hearing-threshold data (Tables 1 through 4 of Report No. 5.3.2-2).

To represent a worst-case scenario, the maximum hearing-threshold sound levels ($dB_{ht}$ re 1 µPa) for a proposed action vessel were calculated at 100 ft (30.5 m), which gave a hearing threshold of 42 $dB_{ht}$ for whales. The whale would be able to hear the vessel but the sound levels are safely below the 130 $dB_{ht}$ re 1 µPa threshold for preventing injury or harassment to marine animals at the 90 $dB_{ht}$ re 1 µPa threshold for significant behavioral response (i.e., annoyance, disturbance). Therefore, sound from proposed action vessels would not cause physical harm or adverse behavioral effects in whales.

*Decommissioning*

Underwater sounds produced by the decommissioning of the proposed action are expected to be similar to those produced during proposed action construction. Proposed action decommissioning would not require pile driving activities, which cause the highest sound levels of any activities associated with the proposed action. Pile driving only takes place during the construction phase of the proposed action. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities which approach the underwater sound level of pile driving. During decommissioning, the monopiles and transition pieces would be cut off at approximately 15 ft (4.6 m) below the seabottom. As such, the underwater sound impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be insignificant or negligible.

During construction of the proposed action, whales are likely to temporarily avoid a given area around the pile driving operation, and only minor impacts would be anticipated due to the proposed action's construction generated underwater sounds. Any sound should not affect the migration, nursing/breeding, feeding/sheltering or communication of whales. In addition, given the probable infrequency of whales occurring in the area of the proposed action, impacts to listed whales are expected to be insignificant or negligible.

***Increased Vessel Traffic***

*Vessel Strikes*

Vessel strikes to cetaceans can result in injury or death of the animal. The potential risk to whale species from collisions with proposed action-vessels is evaluated below.

Ship collisions are a significant threat to large cetaceans and is considered the single important source of human-caused mortality in some species (Jensen and Silber, 2003; Waring et al., 2006). While ship strikes occur throughout the world, several studies document that the greatest number of incidents occur within the North American east coast (Laist et al., 2001; Jensen and Silber, 2003; Waring et al., 2006). Along the North American east coast there is a high concentration of large cetaceans and a significant volume of vessel traffic, enabling a greater chance of a collision but also the greater likelihood of reporting of any strikes possibly biasing any assumptions (Jensen and Silber, 2003). The greatest known current cause of right whale mortality in the western North Atlantic is collision with large ships such as container ships, military vessels and tankers. There were 27 documented deaths from 1970 through 1991 (NMFS, 2005). From 1991 through the beginning of 1993, an additional 3 deaths were reported as a result of collisions with vessels (NMFS, 2005). According to a recently published large whale ship strike database based on public information collected by NOAA Fisheries from 1975 to 2002 (Jensen and Silber, 2003), finback whales are the most often reported species hit by ships (75 records of strike) followed by humpback (44 records), North Atlantic right (38 records), gray (24 records), minke (19 records), southern right (15 records), and sperm whales (17 records).

The majority of vessels that have documented whale strikes are large, fast moving vessels such as container ships, tankers or military vessels (Jensen and Silber, 2003). There are several documented collisions of cetaceans with smaller vessels (less than 65 ft [19.8 m]); however, all of these collisions were with boats traveling at higher speeds (Right Whale News, 2005). Collisions with vessels that are moving at slower speeds (less than 14 knots [7.2 m/s]), such as the construction vessels to be used for the proposed action, are less likely, and there only a few recorded ship strikes from vessels traveling less than 10 knots (5.1 m/s) (Laist et al., 2001).

Extensive efforts at ship strike reduction have been developed to locate whales, to notify ships of whale locations, and even to redirect vessel traffic. Vessels in certain areas off the northeastern and southeastern coasts of the United States are required to report when they enter one of these areas and are then notified of the locations of recent whale sightings. The Northeast Fisheries Science Center (NEFSC) has developed protocols for determining large whale serious injuries and human-caused mortalities and provides annual reports that describe determinations made for events involving stocks of right, humpback, fin, sei, blue, minke, and Brydes whales along the eastern seaboard of the United States and adjacent Canadian Maritimes. During the period of 2001 to 2005 a total of 417 unique large whale events was reported during the period, including carcasses (both beached and at sea) and live whales sighted at sea (Nelson et al. 2007). Of this number, there were 48 reports of ship strikes. Nine (21 percent) of the ship strike events were determined to have not caused serious injury or death; and 2 (5 percent) ship strike events lacked sufficient evidence for determination (Nelson et al. 2007). Right whales and fin whales both had 8 mortalities from ship strikes (Nelson et al., 2007). These human-caused mortality and serious injury rates represent the minimum levels of impact to these stocks. Humpback, right and fin whales should be able to detect any tugboat, barge and other slow-moving vessels within the area of the proposed action, as baleen whales can detect and respond to sounds of the frequency range and intensity of those produced by tugboats and barges (Miles et al., 1987; Richardson et al., 1991; McCauly, 1994).

Whale response, however, is unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vehicles. Humpback whales are relatively tolerant of boats, but, due to this habituation they may be more susceptible to ship collisions. And despite the expected ability of right whales to hear approaching vessels, they continue to die from vessel collisions (Richardson et al., 1995; Nowacek et al., 2004). A study by Nowacek et al., (2004), reported that right whales did not respond to the sounds of approaching vessels or the actual vessels. Why they did not move out of the way of oncoming vessels is unknown (Laist et al., 2001). Some anecdotal observations suggest that right whales only respond when vessels approach to within a very close range. Right whales off the eastern coast of North America are frequently exposed to vessels, and they may have habituated to the sounds of approaching vessels at great distances (Richardson et al., 1995; Terhune and Verboom, 1999; Laist et al., 2001). However, whales are also struck in areas of low vessel traffic (Alzeta et al., 2001; Gerig et al., 2001). Some alternative explanations considered is that whales may get confused if sound is disoriented or attenuated at the surface, or that the whales at the surface may swim within a critical distance around the haul of the vessel and become entrained in the low-pressure area and be pulled back towards the vessel's propeller (Knowleton et al., 1995 and 1998).

Humpback whales are relatively tolerant of boats, but, due to this habituation, may be more susceptible to ship collisions. Right whales continue to die from vessel collisions, even though they can theoretically hear approaching ships (Richardson et al., 1995; Nowacek et al., 2004). A study by Nowacek et al. (2004), reported that right whales did not respond to the sounds of approaching vessels or the actual vessels. Some anecdotal observations suggest that right whales only respond when vessels approach to within a very close range. Right whales off the eastern coast of North America are frequently exposed to vessels, and they may have habituated to the sounds of approaching vessels at greater distances (Richardson et al., 1995; Terhune & Verboom, 1999; Laist et al., 2001).

During decommissioning activities, as during construction activities, it is estimated that 4 to 6 stationary or slow moving vessels would be present in the general vicinity of the pile removal. Vessels delivering demolition materials or crews to the site would also be present in the area between the mainland and the site of the proposed action. The barges, tugs and vessels carrying materials would be limited to speeds below 10 knots (5.1 m/s) and may range in size from 90 to 400 ft (27.4 to 122 m), while the vessels carrying crews would be traveling at a maximum speed of 21 knots (10.8 m/s) and would typically be 50 ft (15.2 m) in length. The vessels used for the decommissioning of the proposed action would be smaller, slower moving vessels than those that regularly cruise Nantucket Sound, with expected impacts on cetacean populations in Nantucket Sound to be insignificant or negligible.

Although vessel collisions are a primary cause of large whale mortality in the western North Atlantic, the Project is not expected to put whales at increased risk for vessel collisions. As stated earlier, vessels moving at slower speeds (less than 14 knots [7.2 m/s]), such as the construction vessels to be used for the Project, are less likely to cause collisions (Laist et al., 2001). In addition, the vessel routes proposed to be used by Project vessels do not occur in areas where there have been high concentrations of whale sightings.

*Vessel Harassment*

Any impact on marine species due to the physical presence of the proposed action-vessels is expected to be minor. There have been many studies of the effects of vessels on cetaceans, particularly the underwater sounds they make (Richardson et al., 1985, 1991). It is likely that whales and dolphins react primarily to the sound generated by vessels, and not their physical presence (NMFS, 2001; NMFS, 2002). Moreover, the central portion of Nantucket Sound and the vessel routes proposed to be used by the proposed action vessels are not within what is considered a high-use area for whale species. If any MMPA protected animals are present in the area of the proposed action, potential behavior changes in response to proposed action-related vessel traffic would be short-term and would likely be similar to the behaviors observed during regularly occurring activities in Nantucket Sound such as the personal boat use, whale watching cruises, ferry traffic and fishing. Close encounters between proposed action vessels and species are likely to be rare and result in minimal physical disturbance to the animals.

The effects of vessel harassment on the migration, breeding and feeding behaviors of cetaceans are expected to be minor. Based on the undeveloped source of whale prey in Nantucket Sound, it is highly unlikely that cetaceans would be migrating through, nursing or feeding in Nantucket Sound, but further offshore. The physical presence of vessels associated with proposed action construction would not contribute to the harassment of migrating, nursing or feeding humpback, fin or right whales. These large migratory whales are only expected to be within the vicinity of New England waters during the spring and summer feeding seasons. However, preferred whale prey is not found abundantly within Nantucket Sound, rather most feeding grounds for these species are further offshore and would not be directly impacted by proposed action construction. Some seasonal residents of Nantucket Sound, such as harbor porpoises, may experience some displacement from traditional feeding grounds, however this should be temporary and most species found within the vicinity of the proposed action are habituated to high volumes of vessel traffic.

Humpback, fin, and right whales are known to seasonally migrate between their fall/winter mating, birthing, and nursing grounds in the southern waters of the West Indies and the mid- and south-Atlantic states (including the Carolinas, Georgia, and Florida), and their spring/summer feeding grounds in the western North Atlantic (Clapham, 1992; Baraff and Weinrich, 1993; Waring et al., 2006; NMFS, 2005; CeTAP, 1982; USEPA Region 1, 1988). While the endpoints of the whales' migration are well established (Martin et al., 1984; Mattila et al., 1989; Waring et al., 2006), the exact route between the summer and wintering grounds is unknown, although it is likely to be well offshore (Clapham and Mattila, 1990). Once the north-bound migrating whales (cow-calf pairs included) reach their feeding grounds in New England waters, their fine-scale movements have generally been observed to follow dense aggregations of their preferred prey species, which are not developed in Nantucket Sound, and tend to occur in greater abundance in waters further offshore, around Stellwagen Bank, Jeffreys Ledge, Browns and Bacaro Banks, and in the Great South Channel (Kenney and Winn 1986). Additionally, both feeding and nursing behaviors have been observed in Cape Cod Bay and the lower Bay of Fundy (Schevill et al., 1986; Hamilton and Mayo, 1990; Marx and Mayo, 1992; Kraus and Kenney, 1991; NMFS, 1994; NMFS, 2005; Waring et al., 2006).

It has been reported that vessel traffic also may physically displace some whale species from feeding areas. There is evidence that some whales may have been displaced from traditional feeding and wintering areas due to increased vessel traffic in Pacific waters (Baker et al., 1982; Forestell, 1986). Hawaiian research of Pacific humpback populations have observed cow-calf pairs to move away from areas presumed to be favored habitat where human activities were also common (Lien, 2005). Canadian research regarding humpbacks' response to whale watching activities also observed cow-calf pairs to be especially sensitive to human presence (Lien, 2005). However, evidence from whale watching and fishing activities in Massachusetts waters indicates that humpback and fin whales readily habituate to the presence of large and small motor vessels (Watkins, 1986).

Based upon the underdevelopment of whale prey species in Nantucket Sound, it is highly unlikely that whales would be migrating through, nursing, or feeding in Nantucket Sound. Therefore, the physical presence of vessels associated with the construction, operation, and decommissioning of the proposed wind farm in Nantucket Sound will not contribute to the harassment of migrating, nursing, or feeding humpback, fin or right whales. In addition, the vessel routes proposed to be used for the proposed action do not occur in areas where there have been high concentrations of whale sightings. In addition, all vessels will be required to follow NOAA Fisheries Regional Viewing Regulations while in transit to and from the WTG array site as described in Section 9.0 of this document. Vessel operators and crew will be required to undergo training to ensure they are familiar with NOAA regional viewing guidelines and ways to minimize encounters and interactions with cetaceans. As a result, impacts on cetacean populations in Nantucket Sound would be insignificant or negligible.

***Reduced Habitat***

Activities related to proposed action's construction may cause whales to avoid habitat areas in the vicinity of the proposed action. The main anticipated impact would be avoidance of areas where pile driving is occurring or where project-related vessels may be present. However, the increase in vessel traffic associated with the project is minimal and is not anticipated to displace whales for long periods of time. Some avoidance may also occur during construction activities due to acoustical harassment (i.e., from pile driving), as mentioned previously, however this disturbance will be temporary and will not result in any major effects on the whales. Studies at off-shore Danish Wind Farms showed that harbor porpoises temporarily avoided the area in the vicinity of the turbines only during construction, and mainly during pile driving activities (Danish Offshore Wind – Key Environmental Impacts, 2006). Abundances for harbor porpoises slowly returned to close to pre-construction values for most of the area, with only a limited area with strong negative impacts mainly detected as permanent avoidance of that specific area. Although effects are expected to be temporary, there is the potential for whales to permanently avoid portions of the area of the proposed action. However, given the probable infrequency of whales occurring in the vicinity of Horseshoe Shoals, overall impacts are expected to be minor and mainly temporary.

Activities under the proposed action are only anticipated to result in minor changes in whale prey abundance or distribution. Some temporary displacement may occur during periods of sounds or high suspended sediments, but this will be limited to areas directly surrounding the given activities, causing both prey species and whales to move to an undisturbed area. Pelagic prey tends to be highly variable and animals foraging on these sources move with the food source, as seen with many whales and their prey species. Any temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and is likely available in other areas of Nantucket Sound and surrounding waters for foraging by whales. However, as stated previously, based on the underdevelopment of whale prey species in Nantucket Sound, it is highly unlikely that whales would be feeding in the proposed action area.

***Habitat Shift (Non-structure to Structure Oriented)***

The presence of 130 monopile foundations, 6 ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system, with minor effects to whales. Additional amounts of surface area that are being introduced, approximately 1,200 square ft (0.03 acre or 111 $m^2$) per tower with 30 ft (9.1 m) as an assumed average water depth, for a total of about four acres, would be a minor addition to the hard substrate that is already present. The addition of rock scour armor would increase this acreage compared to that of the monopiles alone, but representing a small fraction of change in the overall site of the proposed action. Due to the small amount of additional surface area in relation to the total proposed action area and Nantucket Sound and the spacing between WTGs (0.39 to 0.62 miles (0.63 to 1.0 km) apart), the new additional structure is not expected to affect the overall environmental, benthic community composition or seal populations. Furthermore, the whale species are not anticipated to be attracted to the WTGs for feeding purposes. All three whale species occur only rarely in Nantucket Sound and therefore are not expected to be influenced by potential finfish or benthic organism aggregations at the individual WTG monopiles. Their primary feeding grounds are located further offshore from Nantucket Sound at Stellwagen Bank, in Cape Cod Bay, and in the Gulf of Maine. In addition, it is anticipated none of the whale species would be attracted to the WTGs as potential shelter. Therefore, the habitat shift from non-structure oriented to structure oriented will have insignificant or negligible impacts on whales in Nantucket Sound.

***Habitat Shift (Structure to Non-structure Oriented)***

At the end of the proposed action's lifespan, removal of the WTG monopile foundations and ESP piles at the time of decommissioning would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoal-oriented habitat present prior to construction of the proposed action. However, as the addition of the monopiles would be a minor addition to the hard substrate that was present prior to the construction of the Wind Park, the removal of the WTGs and ESPs will not cause a great impact in the overall habitat structure. As described above, the whale species are not anticipated to be attracted to the WTGs for feeding purposes or as potential shelter. Therefore, removal of the WTGs and ESPs will have insignificant or negligible impacts on whale feeding or distribution.

***Geotechnical and Geophysical Investigations***

Many of the types of disturbances that would occur during the geotechnical and geophysical investigations are short term and very localized. A very small area of the sea floor would be disturbed by coring activities, either at the core hole or associated with the coring vessel anchor placements. It is likely that the duration of activity at any one coring location would be no more than a few days. The high resolution geophysical survey work, including collection of shallow (Chirp) and intermediate depth (Boomer) subbottom profiler data and sidescan sonar and magnetometer data, uses mobile gear towed behind a vessel, and would not result in bottom disturbance, nor does it result in activity at a fixed location. The geotechnical investigations would result in a negligible temporary loss of some benthic organisms, and a localized increase in disturbance due to vessel activity, including sound and anchor cable placement and retrieval. Given the small area of disturbance, short duration of activities, and infrequency of occurrence of whales in the area of the proposed action, potential adverse impacts from geotechnical and geophysical investigations to the whales would be insignificant or negligible (Additional details on geotechnical and geophysical field investigations are presented in Section 2.7 of the FEIS).

**Piping Plover**

The following provides a summary of the proposed action construction and decommissioning impacts on the piping plover. Federally Threatened piping plover breed along the mainland and island shores of

Nantucket Sound. Potential impacts to piping plover associated with construction and operation of the proposed action may include loss of habitat, disturbances associated with the presence or activity of construction or decommissioning equipment, disturbances such as barriers to flight paths due to the presence of the turbines, and risk of collision. Additional sources of impact include oil spills and disturbances associated with submarine cable repair.

***Habitat Loss or Alteration***

Habitat loss or alteration associated with construction/decommissioning or operation is not anticipated. The proposed WTGs would be located offshore, at least 5 miles (8 km) from the nearest nesting or staging habitat (Figure 5.3.2-1). The proposed landfall of the offshore transmission cable system would not occur within breeding habitat. The proposed action would not impact critical habitat as there are no designations in Massachusetts.

The proposed location of the landfall of the offshore transmission cable system is on the northeastern side of Lewis Bay at the end of New Hampshire Avenue in Yarmouth. Neither the proposed cable nor landfall would cross piping plover breeding habitat. The closest nesting location to the proposed landfall is approximately 1.5 miles (2.4 km) at Kalmar Beach/Dunbar Point in Hyannis. The closest distance of the offshore transmission cable system to the nearest piping plover nest site on the seaward side of Great Island is 0.8 miles (1.3 km) (Figure 5.3.2-1). The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. In addition, since the shoreline would be drilled under for cable placement, there would be no disturbance of beach areas.

***Disturbance***

High disturbance levels around nest sites can result in the abandonment of nests, and ultimately, decreased breeding success. Causing parents or juveniles to flush while foraging may stress juveniles enough to negatively influence critical growth and development. Potential disturbances during construction and decommissioning associated with increased human activity, the presence and operation of large equipment, and increased boat traffic offshore of nesting sites located closest to the proposed landfall, would be temporary and are not anticipated to impact breeding piping plover. It is possible that a tracking system consisting of a wire, for the operation of the drill head may be placed across the beach. This would be a minor, temporary activity that would not disturb the area more than a person walking on the beach.

Available data on disturbance distances suggest that flushing distances of incubating birds vary among sites and individuals. Disturbances resulting in flushing occurred as far away from nests as 689 ft (210 m), 984 ft (300 m), and 571 ft (174 m) at Nova Scotia, Virginia, and Maryland beaches, respectively (USFWS, 1996). The recommended disturbance buffer around nest sites is typically a 164 ft (50 m) buffer; however, at Maryland sites it is 738 ft (225 m) (USFWS, 1996). The mean flushing distance at Massachusetts nest sites is 24 m (USFWS, 1996). For non-incubating birds, the maximum disturbance distances reported for pedestrian, vehicles, pets, and kites are 197 ft (60 m), 230 ft (70 m), 328 ft (100 m), and 394 ft (120 m), respectively (USFWS, 1996).

Due to the 820 ft (250 m) (or greater) separation of the offshore transmission cable system from the nearest nesting beaches, disturbances associated with offshore construction or operation activities are not anticipated for nesting piping plover. In addition, since the shoreline would be drilled under for cable placement, there would be no disturbance of beach areas. The placement of a wire on the beach (and seafloor) to help guide and track the drill head would result in disturbance essentially equal to a person walking on the beach. The proposed landfall site is 1.5 miles (2.4 km) from the nearest nesting beach and, therefore, onshore construction or decommissioning activities are not anticipated to impact nesting piping plover.

**Roseate Tern**

The following provides a summary of proposed action construction and decommissioning impacts on the roseate tern. For a detailed analysis, refer to the BA in Appendix G, which provides information on T&E species and potential effects to T&E species. The potential impacts associated with the proposed action construction, and decommissioning include loss of habitat, habitat modification or prey displacement during construction, barriers to flight paths due to the presence of WTGs, collisions with proposed action structures, increased predation, and/or disturbances associated with increased vessel traffic during construction and decommissioning.

***Habitat Loss or Modification***

Terns traveling or foraging in the proposed action area could potentially be impacted by habitat loss or modification during construction and decommissioning activities. Some species of birds are more sensitive to disturbances than others and can be displaced up to hundreds of meters from the source of the activity (Gill, 2005). Breeding terns would be most sensitive to construction disturbances during the breeding season when they have increased energy demands.

There is no available breeding habitat within or in close proximity to the proposed action area boundary, and the offshore transmission cable system and proposed landfall would not cross breeding locations. All points along the transmission cable would be greater than 15 miles (24 km) to the nearest breeding location in Nantucket Sound on Monomoy Island. The center of the turbine array in HSS would be greater than 19.8 miles (31.8 km) to Monomoy Island and 11.5 miles (18.5 km) from the closest potential breeding habitat on Muskeget Island. Therefore, construction and decommissioning activities would not result in the loss of breeding habitat. As there are no critical habitat designations for roseate terns in Massachusetts, critical habitat areas will not be impacted.

Terns travel substantial distances (16 to 19 miles [25.8 to 30.6 km]) from their breeding locations to access foraging habitat and terns may be affected as they travel or forage in the vicinity of the proposed action area.

Construction and decommissioning activities could directly deter roseate terns or their prey from the proposed action area resulting in the temporary or permanent loss of habitat. Baseline surveys conducted in Nantucket Sound documented relatively minimal tern use of the HSS area in relation to other locations in the Sound: during the breeding period, of the total number of terns observed in 2003 during the MAS surveys, 1.5 percent occurred in HSS, 5.3 percent in Monomoy-Hankerchief Shoals (MHS), 2.5 percent in Tuckernuck Shoals (TS), and 90.7 percent were outside of shoal study areas (Perkins et al., 2004a; Sadoti et al., 2005a). In 2004, of all the terns observed, 0 percent occurred in HSS, 0.7 percent in MHS, 0 percent in TS, 99.3 percent were outside of the shoal study areas. Of the 2,888 total terns observed during the Proponent's breeding season surveys, 9.6 percent occurred in HSS, 2.6 percent in MHS, 5.7 percent in TS, and 82.1 percent were outside of the shoal study areas (USACE 2004, Report Nos. 4.2.4-3, 4.2.4-8, and 4.2.4-10). During the staging and migration periods, in 2002, 6 percent of the total terns observed were within the shoal study areas; in 2003, 8 percent were observed within the shoals; and in 2004, 7 percent were observed within the shoals (Perkins et al., 2003; Perkins et al., 2004b; Sadoti et al., 2005b). During surveys, the majority of terns were observed over shallow waters close to the shorelines of Cape Cod, Martha's Vineyard, and Nantucket. HSS is not considered a primary foraging location for roseate terns (refer to the Biological Assessment Section 4.1.3.2, *Results of Surveys and Available Information* for a summary of additional results and information used in this assessment).

Terns are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Roseate terns would likely continue to forage and travel in the vicinity of construction activities, assuming that their food sources are not displaced.

Roseate terns have been observed to have decreased breeding success during periods of low food availability (Safina et al., 1988). The effects of habitat loss due to development are dependent on the amount of habitat lost and the food resources available at alternative sites (Maclean, 2006). The roseate tern's primary food source is sand eel (*Ammodytes americanus*) and its locations are variable. Important foraging habitat in the area varies seasonally and on a daily basis with the tide cycle.

***Changes Related to Underwater Construction Activities***

Vibrations from pile-driving could startle and temporarily displace prey fish from the proposed action area. Increases in turbidity from offshore cable trenching could temporarily impede fish foraging and navigation in disturbed areas (Jarvis, 2005). Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill, 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized. A jack-up barge with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving.

Sediment suspended by trenching during offshore cable installation is expected to be localized (20 milligrams/liter within 1,500 feet [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours) (Report No. 4.1.1-2). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms would be stirred up and prey fish may be attracted to the area to forage. This in turn could attract roseate terns to forage.

Scour protection at the base of monopiles will either be rock armor or scour mats. The rock or scour mats and the monopiles would increase the available surface area and provide substrate for the colonization of benthic invertebrates and habitat for prey fish. Fish may concentrate around turbine foundations similar to how invertebrates cluster around oil platforms (Vella, 2002 *as cited by* Jarvis, 2005). Habitat with more 'physical heterogeneity' can result in greater fish abundance (Jenkins et al., 1997 and Charbonnel et al., 2002 *as cited by* Gill, 2005). The underwater structures could create a localized 'artificial reef effect', providing foraging habitat for terns. Wide spacing of turbines (0.39 to 0.62 miles [0.63 to 1.0 km] apart) would allow for tern foraging between turbines (see Risk of Collision).

Due to the small amount of additional surface area in relation to the total proposed action area in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant affect on the benthic community, the presence of prey fish, or foraging terns. However, the additional substrate would be oriented vertically in the water column, and could result in a localized and minor increase in certain prey fish species. The increase in prey fish may ultimately attract tern species to the area to forage (see Risk of Collision).

The available baseline survey data suggests that HSS is not a primary foraging location or traveling corridor for breeding or staging roseate terns; rather, during surveys the majority of terns were observed over shallow waters close to the shorelines of Cape Cod, Martha's Vineyard, and Nantucket. Given the small footprint of the actual development area, negligible habitat loss is anticipated during the proposed action's construction activities. Impacts associated with displacement of prey fish during construction are anticipated to be negligible and temporary.

The natural benthic substrate and prey fish communities would be maintained to the extent practicable after a short recovery period; therefore, major impacts associated with loss of habitat or modification are not anticipated. Changes to the underwater substrate may result in increased foraging habitat for roseate terns. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005).

Refer to 5.3.2.9.2 Operational/Maintenance Impacts for discussion of potential increases in perching habitat for roseate terns and for predatory peregrine falcon.

***Vessel Traffic***

Increases in vessel traffic could result in impacts to roseate terns during the construction, operation, and decommissioning phases. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction. During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the proposed action area. Additionally, small vessels from Falmouth, Massachusetts, and a maintenance support vessel from New Bedford would make regular trips to HSS during the construction period. While the proposed turbines are in operation, there would be regular vessel trips made from Falmouth and New Bedford harbors to the proposed action area. The expected maintenance schedule would be approximately 2 vessel trips per day for 252 days per year (5 maintenance days per turbine per year) (see Section 2.0 of the FEIS for a description of maintenance activities).

During high surf conditions, workers may be transported by helicopter to the platform on the ESP. There may also be occasional helicopter landings at the ESP in association with some regular maintenance activities. An increase in recreational fishing may occur around the WTGs if fish populations aggregate around foundations. The arrival of vessels and helicopters could temporarily displace terns from localized areas within the larger proposed action area. This type of disturbance already occurs to some extent within and adjacent to the proposed action area due to existing levels of vessel activity, and the temporary incremental increase is likely to have only a minor affect on roseate tern use of the construction areas.

**Northeastern Beach Tiger Beetle**

The only beetle habitat within the proposed action area is found on the eastern shore of Martha's Vineyard, at a distance of at least 5 miles from the closest facility component. At this distance, there is no potential for direct effects from normal construction or operation activities. As noted in the FWS September 30, 2008 letter, the only effect of potential concern involves an accidental oil spill which might reach this location, and that such an oil spill could occur during construction or operation of the facilities. Report No. 5.2.1-1 presents the probability of a worst-case scenario from a large oil spill resulting from the proposed action being less than one in one million. There is a higher potential for small spills over the life of the project, with a 90 percent chance of a spill up to 50 gallons and a 1 percent chance of a spill 10,000 gallons or more. However, the probability of a spill reaching the shoreline of Martha's Vineyard where the beetle habitat occurs must also be taken into consideration of the potential effects of the proposed action on this species.

Therefore, given either the small size of higher probability spills or the low probability of larger size spills, combined with the probability for a spill to travel in the exact direction to reach these particular beaches on the east shore of Martha's Vineyard, results in a conclusion that while there is the potential to affect the northeastern beach tiger beetle from an oil spill resulting from the proposed action, this is not likely to adversely affect this species. This conclusion is further supported when life history traits are considered, such that outside of summer months, an oil spill would not affect adults, as only the buried larval stage occurs during the other months of the year. As the larvae develop, they move higher in the intertidal zone but remain buried, making them less susceptible to the affects of an oil spill.

The determination of not likely to adversely affect is supported by the FWS Biological Opinion (BO) issued on November 21, 2008, which concurred with the findings presented in the BA amendment, and which are summarized above.

**Red Knot**

The red knot is not a listed threatened or endangered species, but since it is a Candidate species and there is a possibility that it may be listed as one in the near future, it has been included in this section to allow for full consideration of impacts.

In North America, the red knot breeds in arctic zones of Alaska and Canada. The red knot does not breed in Massachusetts; however it occurs as a migrant at stop-over locations, and some individuals over-winter in Massachusetts. Staging areas are known to occur along the mainland shores of Cape Cod during migration; however, patterns of activity in Nantucket Sound are poorly understood. The preferred foraging habitat of red knot is associated with inlets to estuaries and bays and in proximity to salt marshes. The closest known staging area in the general vicinity of the proposed action is Monomoy Island, approximately 20 miles (12 km) east of HSS (USFWS, 2006).

The red knot spring migration occurs from mid-February to mid-June. Fall migration occurs from mid-July to mid-November. Red knot peak occurrence in the region during northward migration is mid-May, and in mid-July during southward migration, when the birds may occur at staging locations after long distance, non-stop flights from breeding or wintering grounds. The birds would remain at coastal stop-over locations for a few weeks to build up their fat reserves before resuming their dispersal (O'Brien et al., 2006).

The red knot may occur over areas of Nantucket Sound during migration. One red knot was observed during one boat survey during the 2002 to 2006 survey periods. No other individuals were observed in the study area during aerial or boat surveys conducted by the applicant or by MAS.

The potential impacts to red knot during construction and decommissioning include habitat loss or modification and disturbances associated with increased vessel activity.

Changes in sediment drift and deposition processes caused by construction may affect inter-tidal habitat structure and prey bases onshore. Any type of sediment removal, or disruption of normal coastal erosion and redeposition processes, may impact suitable habitat available within and adjacent to the area of the proposed action. Since it is only the offshore transmission cable system that would be constructed near shore, and it would be buried beneath the seabed, it is unlikely that a measurable change in coastal erosion or deposition processes due to construction activities would occur.

***Habitat loss or Modification***

The shoreline where the offshore transmission cable system would make landfall is primarily artificial shoreline, comprised of concrete and stone with minimal sandy areas. Habitat loss for the red knot is not expected because the inter-tidal area directly impacted by the offshore transmission cable system landfall in Yarmouth would be drilled under for installation of the cables. This area is not likely to provide habitat for red knot during migration and/or wintering periods. The beach habitat on Great Island represent the closest potential stopover habitat near the cable landfall construction area, and these beaches are not expected to be impacted by any of the construction or decommissioning activities as the shoreline would be drilled under for cable installation. These beaches occur in a developed area and experience high human activity.

The landfall site of the offshore transmission cable system in Lewis Bay is not known to provide stopover or wintering habitat for red knot. Specific construction techniques, including horizontal drilling, would minimize the impact of the proposed action on the inter-tidal community within the vicinity of the landfall site. The laying of submarine cables in Lewis bay and near the inlet of the bay are not expected to cause long term changes in inter-tidal habitat structure or prey availability. The increase in suspended solids and the relocation of sandy sediments would be temporary and would result in no lasting changes in the coastal areas of interior Lewis Bay, or the beaches on either side of the inlet.

Because of the inherent dynamic nature of all marine environments within the area of the proposed action, including the inter-tidal zone, disturbances created during construction and decommissioning are not expected to cause lasting or harmful effects. Small mortality events of infaunal organisms are likely to occur, but effects on local inter-tidal assemblages would be negligible. Disturbance of the sea floor within Lewis Bay may provide for opportunistic colonization by disturbance tolerant benthos after construction, and similarly after decommissioning activities; however, these changes are not expected to influence inter-tidal areas. Impacts associated with changes in inter-tidal habitat during installation of the offshore transmission cable system in Lewis Bay are anticipated to be negligible.

***Vessel Traffic***

There would be an increase in vessel activity associated with construction and decommissioning activities. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction. During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the area of the proposed action. Additionally, smaller support vessels would make regular trips from nearby ports to HSS during the construction period.

A study investigating shorebird roost site selection at an important shorebird staging and over-wintering site in South Carolina indicated that out of eight species studied, red knots were relatively sensitive to vessel traffic. The authors determined that red knots avoided roosting at sites that experienced high average boat activity, and red knots responded to boat activity within 3,280 ft (1,000 m) (Peters and Otis, 2007). Disturbances associated with increased boat traffic could deplete red knot energy reserves during critical pre-migratory periods. However, boat and other construction activities would mainly occur at offshore locations greater than 5 miles (8 km) from potential staging habitats along the mainland coast or along island shores. The closest distance of the offshore transmission cable system to potential staging habitat on the seaward side of Great Island is 0.8 miles (1.3 km). Near shore construction activities in Lewis Bay would be temporary and would occur outside of the known 3,280 ft (1000 m) vessel disturbance distance.

Therefore, construction and decommissioning vessel activity is expected to have negligible impacts to red knot.

**New England Cottontail**

Small populations of New England cottontails were observed in Barnstable County during a 2000-2003 survey (MDFW, 2003). The upland work associated with the installation of the underground cable would be located within either streets or an existing previously disturbed utility ROW. As such, construction impacts to New England cotton tails are expected to be negligible. Construction of the WTGs would not have an impact on New England cottontails as the WTGs would be located far offshore.

**Conclusion**

The overall impacts from construction and decommissioning activities associated with sea turtle species, cetacean species and the red knot are expected to range from negligible to minor as these impacts would be for the most part confined to the duration of the proposed action and the area of the proposed action activities. Onshore impacts to the piping plover would be negligible, as would onshore impacts to roseate terns. These impacts are principally related to habitat disturbance, vessel movement and construction activities. Some mitigation measures considered at the time of the DEIS included construction techniques, requiring a NMFS-approved observer on-site during all pile driving activities, the use of a bubble curtain, and restricting construction to less sensitive periods. Construction impacts associated with the New England cottontails are expected to be negligible since upland work associated with the installation of the underground cable would take place in streets or an existing utility ROW.

MMS initiated formal consultation under Section 7 of the ESA with NOAA Fisheries on May 20, 2008. NOAA Fisheries issued its BO on November 13, 2008 (see Appendix J) which concluded that the proposed action would not jeopardize the continued existence of any threatened or endangered species. In particular, the NOAA Fisheries's BO analyzed the proposed action construction activities and found that the hawksbill turtle and the sperm, blue and sei whales do not occur in the action area and needed no further analysis, yielding a determination that the proposed action will not affect these species. For the right, humpback and fin whales, NOAA Fisheries concluded that since "all effects to whales from the proposed project are likely to be insignificant or discountable, this action is not likely to adversely affect listed whales in the action area," and, therefore, is not likely to jeopardize the continued existence of these whale species. The NOAA Fisheries BO assessed the potential for incidental take and determined that the proposed action has the potential to directly affect loggerhead, Kemp's ridley, green and leatherback sea turtles by causing them to be exposed to potentially harassing levels of sound during pile driving activities. NOAA Fisheries determined that only sea turtles located within 3.4 km of the pile being driven will be exposed to noise levels greater than 160 dB. NOAA Fisheries has estimated that between 3 and 7 sea turtles are likely to be exposed during each pile driving event. As pile driving will occur for approximately four hours a day over a period of approximately eight months, the total potential for exposure will be limited to that time period only. During the geophysical survey, any sea turtles within a 0.5 to 1.5 km distance from the survey vessel may be exposed to noise levels between 160 and 180 dB. Based on the 148 $km^2$ survey area, NOAA Fisheries estimates that between 13 and 28 sea turtles would be exposed to disturbing levels of noise during the survey. NOAA Fisheries concludes that this level of incidental take is reasonable given the likely seasonal distribution and abundance of sea turtles in the action area and the modeling results provided by MMS. Exposure of sea turtles to sound levels greater than 160 dB will be considered harassment because that level of noise will disturb sea turtles and their normal behaviors (i.e., resting, foraging or migrating through the area) will be interrupted. In its BO, NOAA Fisheries determined that this level of anticipated take is not likely to result in jeopardy to these species, however Reasonable and Prudent Measures were specified to minimize and reduce the potential adverse effects of the proposed action.

MMS initiated formal consultation under Section 7 of the ESA with the FWS on May 20, 2008. The consultation ultimately covered the following endangered and threatened FWS trust species: (1) threatened Atlantic Coast piping plover (*Charadrius melodus*) population, (2) endangered northeastern population of the roseate tern (*Sterna dougallii dougallii*), and (3) threatened northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*). There is no habitat designated as critical pursuant to Section 4 of the ESA within the Horseshoe Shoal marine environment or elsewhere within the area of the proposed action for these species. Similarly, there are no species currently proposed for ESA listing as threatened or endangered that may be present in the area of the proposed action. Consultation with the FWS was completed on September 19, 2008, and the final BO was issued on November 21, 2008 by the FWS. In the BO, the FWS determined that the level of take from the proposed action was not likely to jeopardize the continued existence of the piping plover and roseate tern. Furthermore, the FWS stated in the BO that the Bird Island restoration project will offset any potential roseate tern mortality that may occur from the Cape Wind Project (See Appendix J). The FWS Reasonable and Prudent Measures designed to minimize impacts to the Atlantic Coast piping plover (*Charadrius melodus*) and the roseate tern (*Sterna dougallii dougallii*) are outlined in Section 9.0.

#### 5.3.2.9.2 Operational Impacts

**Sea Turtle Species**

***Vessel Harassment/Strikes***

The proposed action operation and maintenance activities are expected to require two vessel trips per working day for 252 days of the year. The vessels are anticipated to consist of small crew boats and slower moving supply vessels, similar to the smaller vessels to be used during proposed action construction.

It is possible that some increased fishing effort could occur after the Wind Park is operational, but that is difficult to predict. It is not likely that increased trawling activity would occur after construction of the monopile structures since the fish attracted to these structures would tend to remain fairly close to each monopile. For safety reasons and to protect their gear, trawlers would not want to deploy their gear immediately next to a monopile. Trawlers would, however be able to continue trawling in the general vicinity and between the monopiles leaving enough room to safely navigate their vessel and gear.

If there is increased fishing effort, it is more likely to consist of private and charter recreational boats. It is true that this could result in increased fishing effort and boat traffic which may increase the risk of boat collisions and/or impacts from fishing gear to sea turtles. However, recreational fishing gear is likely to consist primarily of hook and line which would likely have only minor impacts to any sea turtles in the proposed action area.

Loggerhead and Kemp's ridley sea turtles could be attracted to the monopile foundations for food (such as crabs, shellfish, sponges, sea stars and fish) and shelter. Any sea turtles that may be attracted to the area of the proposed action are likely to remain near each monopile except for the times transiting the proposed action area. While close to the monopile, they are less likely to be subject to vessel interaction since prudent vessel captains would reduce speeds when approaching a monopile. It is possible that sea turtles could be at risk of interaction with vessels while transiting from one place to the next within the area of the proposed action; however, this risk should be similar to risks that turtles face throughout Nantucket Sound.

Sea turtles do not appear to be exceedingly disturbed by the physical presence and sound produced by vessels, and the vessel traffic itself (NMFS, 2001; NMFS, 2002). Sea turtles should be able to detect and move away from any proposed action vessel by diving into deeper waters. Any impact would be limited to temporary avoidance of an area; however, this is unexpected due to the high volumes of vessel traffic that normally travel the waters of Nantucket Sound. Therefore, the impacts of increased vessel traffic should have insignificant or negligible impacts on sea turtles.

***Wind Turbine Operational Sound***

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Preliminary results from underwater sound studies conducted in the United Kingdom suggest that in general, the level of sounds created during the operation of offshore windfarms is very low and does not cause avoidance of the area by marine species (Nedwell, unpub. data). Even in the area directly surrounding the wind turbines, sound was not generally found above the level of background sound, resulting in normal activity of marine animals (Nedwell, unpub. data).

Acoustic modeling of underwater operational sound at the UK Wind Park was performed for the design wind condition (see Section 3.13 of ESS, 2007). Baseline underwater sound levels under the design wind condition are 107.2 dB. The predicted sound level from operation of a WTG is 109.1 dB at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total sound level falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m). Since the WTGs will be spaced farther apart than 360 ft (110 m) (0.39 to 0.62 miles [629 to 1,000 m] apart), no cumulative impacts from the operation of the 130 WTGs in the Wind Park are anticipated.

An analysis of predicted underwater sound levels perceived by sea turtles from proposed action operation show that no injury or harassment to sea turtles are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the proposed action is operating at the design wind speed as all $dB_{ht}$ values at this minimum distance are well below 90 dB re 1µPa (Table 7 of Report No. 5.3.2-2). In fact, proposed action operation would be inaudible for all sea turtles at the close distance of 65.6 ft (20 m) with the perceived operational sound level at <0 $dB_{ht}$ re 1µPa. Therefore, it is anticipated that underwater operation sounds from the proposed action would result in insignificant or negligible impacts on sea turtles in Nantucket Sound.

***Electric and Magnetic Fields***

The cable system for the proposed action includes the inner-array cables and two submarine cable circuits, will be a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed inner-array and submarine cable systems would contain grounded metallic shielding that effectively blocks and electric fields generated by the operating cable system. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the submarine cable system and inner-array cables. The magnetic fields associated with the operation of the inner-array cables and submarine cable system are not anticipated to result in adverse impact to sea turtles or their prey (Report No. 5.3.2-3). Further, the burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables.

The research presented in Report No. 5.3.2-3 indicates that although high sensitivity has been demonstrated by certain species for weak electric fields (especially sharks), this sensitivity is limited to steady (DC) and slowly-varying (near-DC) fields. The proposed action produces 60-Hz time-varying fields and no steady or slowly-varying fields. Likewise, evidence exists for marine organisms utilizing the geometric field for orientation, but again, these responses are limited to steady (DC) and slowly-varying (near-DC) fields. The 60-Hz alternating power-line EMF fields such as those generated by the proposed action have not been reported to disrupt sea turtle behavior, orientation, or migration. Therefore, it is anticipated impacts to sea turtles or their prey species during the normal operation of the cable systems are expected to be insignificant or negligible.

Therefore, it is anticipated impacts to sea turtles or their prey species during the normal operation of the cable systems are expected to be minor.

***WTGs as Fish Attracting Devices***

The WTG monopile foundations will represent a source of new substrate with vertical orientation in an area that has a limited amount of such habitat, and as such may attract finfish and benthic organisms, potentially affecting sea turtles by causing changes to prey distribution and/or abundance. While the aggregation of finfish around the monopiles will not attract sea turtles, some sea turtle species may be attracted to the WTGs for the fouling community and epifauna that may colonize the monopiles as an additional food source for certain sea turtle species, especially loggerhead and Kemp's ridley turtles. All four species may be attracted to the monopiles for shelter, especially loggerheads that have been reported to commonly occupy areas around oil platforms (NRC, 1996).

More specifically, loggerheads and Kemp's ridleys could be attracted to the monopiles to feed on attached organisms since they feed on mollusks and crustaceans. According to USFWS (2005), loggerheads are frequently observed around wrecks, underwater structures and reefs where they forage on a variety of mollusks and crustaceans. Leatherback turtles and green turtles, however, should not be attracted to the monopiles for feeding since leatherbacks are strictly pelagic and feed from the water column primarily on jellyfish (OBIS-SEAMAP, 2002) and green turtles are primarily herbivores feeding on sea grasses and algae. In addition, green turtles are much more likely to be found in shallow warmer waters and are not expected to frequent the Nantucket Sound area with any regularity. All four species of sea turtles have been observed around oil platforms, especially loggerheads which are reportedly the most common species sighted around oil platforms and have been observed sleeping under platforms or next to support structures (NRC, 1996). Kemp's ridley turtles, however, appear to prefer more sheltered areas along the coast or in estuaries, bays and lagoons (FWIE, 1996). Therefore, although it is possible that any of the four sea turtle species could be attracted to the monopiles for shelter, the loggerhead is the most likely species to be attracted to the structures for both food and shelter.

***Unplanned and Accidental Events***

Accidental and unexpected events associated with the proposed action could impact sea turtles. Such impacts would primarily be the result of oil spills, but may also relate to cable repair, collapse of a monopile, and vessel collision with a project structure.

The ESP and WTGs will contain small amounts of various lubricating oils, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment. In addition, the ESP will be the primary oil storage facility for the proposed action and will contain a maximum 42,000 gallons (158, 987 liters) at any given time. The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The WTGs will contain lesser amounts of fluids, approximately 214 gallons (810 liters) at any given time (27,820 gallons, or 105,310 liters, for all 130 turbines). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibly of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system, and during operation small leaks could occur as the result of broken gear oil hoses/pipes and/or broken coolant hoses/pipes. The submarine cables do not contain any fluids or oils; therefore, there is no risk of oil release.

In order to minimize and mitigate any minor spill incidents or leaks during routine maintenance and operation of the ESP and WTGs, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed onboard each WTG, which is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated for correct disposal once the containers are off-loaded at the dock. With the proper measures in place, any potential oil spill should be quickly contained.

While improbable, an oil spill would have minor to moderate impacts on sea turtles within Nantucket Sound. The type of oil, length of exposure, condition of the oil in terms of weathering and life stage at which the sea turtle is exposed to the spill would all play a role in the impact on the animal. While some oil products would be present within the proposed action structures, the relatively small amount of oil being used would tend to produce a small plume in the event of a spill.

Sea turtles are vulnerable at all life stages, with the most vulnerable stages being the eggs, embryos and hatchlings, which do not occur in Nantucket Sound or in the Northeast. Adult sea turtles are also extremely vulnerable to oil spills. Sea turtles can be harmed if they surface in an oil slick to breath. Oil can affect their eyes and damage airways or lungs, can absorbed through their skin and can be ingested through contaminated foods. Sea turtles also seem unable to distinguish between food and tar balls, and show no avoidance behavior when encountering oil slicks (Report No. 5.2.1-1). Of the species that may occur within the vicinity of the area of the proposed action, Kemp's ridley sea turtles may be most impacted by an oil spill, as it has a small population size and limited nesting distribution. However, the overall potential for an oil spill from the proposed action is very low, and the amount of oil being used and the distance to shore would lead to less severe impacts in any case of oil spill from proposed action facilities.

The exception to this is in the event of a commercial oil transport vessel collision with a WTG, should a cargo container rupture. In such an event, tens of thousands of gallons of oil could be released. Recent experience with the *Bouchard No. 120* grounding in Buzzards Bay provides an example of the extent of dispersal that can occur. However, the low probability of such an event would suggest that the potential for harm or injury to sea turtles would be insignificant or negligible.

The extent of potential impacts that could result from a vessel collision with a monopile largely depends on the extent of damage to the monopile or vessel, as well as the nature of the vessel. Some smaller vessels would merely strike a glancing blow and suffer some hull damage but not sink. Other vessels may suffer enough damage to sink, causing a small release of fuel and debris. A larger vessel, such as an oil tanker, would most likely cause a collapse of the monopile, resulting in a small release of lubricating fluid. If oil being transported were to be released, then depending upon the quantity released, an oil spill that escapes Nantucket Sound could directly affect sea turtles (see Section 5.2.1.1). Repair of a damaged or collapsed monopile would create short term and localized disturbances to the benthos, water column, and pelagic organisms similar to the construction and decommissioning of a single monopile, albeit in reverse order and combined in a single event. Since these disturbances are localized to the monopile they are unlikely to adversely affect whale species, and therefore potential adverse impacts resulting from a vessel collision with a monopile and the associated repair activities on the whales would be insignificant or negligible.

Many of the types of disturbances that would occur during cable repair activities are smaller and shorter duration, but of similar type, to those that would occur during cable installation. A relatively short distance along the sea floor would be disturbed by the jetting process used to uncover the cable and allow it to be cut so that the ends could be retrieved to the surface. In addition to the temporary loss of some benthic organisms, there would be increased turbidity for a short period, and a localized increase in disturbance due to vessel activity, including underwater sound and anchor cable placement and retrieval. Given the small area, short duration, and infrequency of occurrence of sea turtles in the proposed action area, potential adverse impacts from cable repair activities on the sea turtles would be insignificant or negligible.

**Cetacean Species**

The impacts from proposed action operations on endangered and threatened cetaceans are essentially the same as those described for non-ESA cetaceans in Section 5.3.2.6.

***Wind Turbine Operational Sound***

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Preliminary results from underwater sound studies conducted in the United Kingdom suggest that in general, the level of sound created during the operation of offshore wind farms is very low and does not cause avoidance of the area by marine species (Nedwell, unpub. data). Even in the area directly surrounding the wind turbines, sound was not generally found above the level of background sound, resulting in normal activity of marine animals (Nedwell, unpub. data).

Acoustic modeling of underwater operational sound at the UK Wind Park was performed for the design wind condition (see Section 3.13 of ESS, 2007). Baseline underwater sound levels under the design wind condition are 107.2 dB. The predicted sound level from operation of a WTG is 109.1 dB at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total sound level falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft [110 m]). Since the WTGs will be spaced farther apart than 360 ft (110 m) (0.39 to 0.62 miles [629 to 1,000 m] apart), no cumulative impacts from the operation of the 130 WTGs in the Wind Park are anticipated.

An analysis of predicted underwater sound levels perceived by whales from proposed action operation show that no injury or harassment to whales are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the proposed action is operating at the design wind speed as all $dB_{ht}$ values at this minimum distance are well below 90 dB re 1µPa (Table 7 of Report No. 5.3.2-2). The proposed action's operation would be inaudible for all whales at a distance of 328 ft (100 m) with the perceived operational sound level at <0 $dB_{ht}$ re 1µPa. AT 65.6 ft (20 m) the perceived operation sound level for whales would be 14 $dB_{ht}$ re 1µPa. Therefore, it is anticipated that underwater operation sounds from the proposed action would result in insignificant or negligible impacts on whales in Nantucket Sound.

***Unplanned and Accidental Events***

Accidental and unexpected events associated with the proposed action could impact whales. Such impacts would primarily be the result of oil spills, but may also relate to cable repair, collapse of a monopile, and vessel collision with a project structure.

The ESP and WTGs will contain small amounts of various lubricating oils, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment. In addition, the ESP will be the primary oil storage facility for the proposed action and will contain a maximum 42,000 gallons (158,987 liters) at any given time. The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The WTGs will contain lesser amounts of fluids, approximately 214 gallons (810 liters) at any given time (27,820 gallons, or 105,310 liters, for all 130 turbines). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibility of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system, and during operation small leaks could occur as the result of broken gear oil hoses/pipes and/or broken coolant hoses/pipes. The submarine cables do not contain any fluids or oils; therefore, there is no risk of oil release.

In order to minimize and mitigate any minor spill incidents or leaks during routine maintenance and operation of the ESP and WTGs, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed onboard each WTG, which is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated for correct disposal once the containers are off-loaded at the dock. With the proper measures in place, any potential oil spill should be quickly contained.

Little species-specific information is available regarding the effects of oil spills on whales. Past studies suggest that large whale species do not seem to be particularly sensitive to oil spills. Because they rely on blubber for insulation, whales are less vulnerable to oil spills than fur-coated marine mammals which can die from hypothermia when coated in oil. In addition, humpback whales, fin whales and right whales are all migratory which may limit their exposure to a persistent oil slick in a small geographic area. Although most research suggests that whales do not appear to be especially sensitive to spills, other studies have shown that there are negative long-term effects to whales from exposure to oil. When surfacing, oil may irritate whale's eyes and skin and they may breathe in harmful fumes. Other symptoms of acute exposure to oil include lethargy, poor coordination and difficulty breathing which can lead to drowning (Hammond et al., 2001).

The extent of potential impacts that could result from a vessel collision with a monopile largely depends on the extent of damage to the monopile or vessel, as well as the nature of the vessel. Some smaller vessels would merely strike a glancing blow and suffer some hull damage but not sink. Other vessels may suffer enough damage to sink, causing a small release of fuel and debris. A larger vessel, such as an oil tanker, would most likely cause a collapse of the monopile, also resulting in a small release of lubricating fluid. If oil being transported were to be released, then depending upon the quantity released, an oil spill that escapes Nantucket Sound could directly affect whales (see Section 5.2.1.1). Repair of a damaged or collapsed monopile would create short term and localized disturbances to the benthos, water column, and pelagic organisms similar to the construction and decommissioning of a single monopile, albeit in reverse order and combined in a single event. Since these disturbances are localized to the monopile they are unlikely to adversely affect whale species in the vicinity of the proposed action, and therefore potential adverse impacts resulting from a vessel collision with a monopile and the associated repair activities on the whales would be insignificant or negligible.

Many of the types of disturbances that would occur during cable repair activities are smaller and shorter duration, but of similar type, to those that would occur during cable installation. A relatively short distance along the sea floor would be disturbed by the jetting process used to uncover the cable and allow it to be cut so that the ends could be retrieved to the surface. In addition to the temporary loss of some benthic organisms, there would be increased turbidity for a short period, and a localized increase in disturbance due to vessel activity, including underwater sound and anchor cable placement and retrieval. Given the small area, short duration, and infrequency of occurrence of whales in the proposed action area, potential adverse impacts from cable repair activities on the whales would be insignificant or negligible.

**Piping Plover**

The site of the proposed action does not occur within piping plover breeding or staging habitat. The proposed project will not affect breeding, feeding, or staging habitat. It is possible that the proposed project area is within a piping plover migration route. It is not known to what extent piping plovers migrate offshore, or where these offshore movements occur. However, it is reasonable to suspect that they will fly over near-shore coastal waters, like Nantucket Sound, as they migrate up and down the Atlantic Coast.

There are no features that would funnel piping plover across the site of the proposed action if their movements were to result in crossings of Nantucket Sound during the breeding season or migration season. Therefore, the presence and operation of the WTGs is not expected to present a major barrier to the flight paths of transient plovers. Piping plover that encounter turbines during crossings of the Sound are generally expected to avoid collisions with WTG structures depending on visibility. These avoidance behaviors are expected to result in minor changes to piping plover flight behavior and minimal increases in energy expenditure. Therefore, the presence of WTGs in HSS may affect piping plover, but minor impacts are anticipated.

***WTG Presence and Rotor Movement***

During the breeding season, piping plover remain in close proximity to nests as they forage on invertebrates in the inter-tidal zone near nest sites. During this period, plovers mainly travel by walking or running between foraging and nearby breeding sites. Their regular daily movements would not result in crossings of the proposed action area. However, there have been some observations of plovers during the breeding season departing land and heading for the horizon. There are no known flight corridors for plovers over the Sound during the breeding season. There are no topographical features such as shortest crossings that would direct occasional flights over the Sound into HSS. Therefore, the presence and operation of turbines is not anticipated to present a major barrier to the flight paths of piping plover.

Other unusual crossings of Nantucket Sound during the breeding season could include the crossings of failed breeders or unpaired birds seeking alternate habitat or a mate (Strauss, 1990). Although aerial and boat surveys conducted in 2002, 2003 and 2004 in Nantucket Sound did not detect such movements by plovers in any of the study areas, there is still potential for this to occur. There is no data available that suggest piping plover would cross HSS during such movements; therefore, the WTGs are not anticipated to create a major barrier to the flight paths of piping plover.

The majority of Atlantic Coast piping plover migratory movements is believed to take place along the outer beaches of the coastline (USFWS, 1996). Most movements are believed to occur along a narrow flight corridor, and offshore and inland observations are rare (USFWS, 1996). Some birds may occur inland or offshore if blown off course by weather events. The birds that breed or stop-over on islands in Nantucket Sound and Vineyard Sound would make over-water crossings while accessing these locations. Therefore, there is a potential that piping plover could occur in the proposed action area during migratory or post-breeding dispersal movements. However, there are no topographical features that would funnel piping plover through HSS. Therefore, the presence of the WTGs is not expected to present a major barrier to the flight path of migrating piping plover.

***Risk of Collision***

Piping plover cross areas of Nantucket Sound to access breeding locations during migration or dispersal, and individual birds may sporadically cross the Sound during the breeding period. Crossings of Nantucket Sound during the breeding season could include the crossings of failed breeders or unpaired birds seeking alternate habitat or a mate (Strauss, 1990). If these ‘floating” birds pass through HSS, they may be exposed to collision risk.

However, the flight paths of piping plover through the Sound are not known. The migration flight paths of piping plover along the Atlantic Coast are expected to occur within a narrow corridor along the coast but some birds may occur offshore or inland. Piping plover migrate both day and night and could travel during periods of inclement weather when visibility is reduced. However, studies suggest that migration of birds is reduced during periods of inclement weather (Petersen et al., 2006). Some species of waterbirds have demonstrated turbine avoidance behaviors while foraging (Everaert, 2004). If piping plover were to occur within the area of the proposed action, they would generally be expected to visually detect and avoid collisions due to FAA lighting on the nacelles as well as sources of natural lighting. More information is required to assess the effects of refracted light during periods of rain or fog to traveling piping plover. There are no topographical features that would funnel piping plover through HSS, therefore, crossings of the site of the proposed action are expected to be few in relation to the number of birds that could potentially cross Nantucket Sound over the course of a year.

Hatch and Brault (2007) (Report No. 5.3.2-1) estimated the number of piping plover turbine encounters per crossing of the wind turbine array, assuming all turbines were aligned perpendicular to each bird's path, based on three different flight height scenarios: If all individuals fly below 30 m, the expected encounters per crossing would be 0.07; if all birds fly in the rotor swept zone (75.5 to 440 ft [23 to 134 m]), there would be 0.67 encounters; and if flights are evenly distributed from 98 to 1968 ft (30 to 600 m) then there would be 0.13 encounters. The authors suggest that, based on high avoidance rates estimated for other species, the likelihood of collision resulting from encounters is low (see Collision Probability Modeling for description of avoidance rates). The authors assume that all encounters with stationary monopiles would be avoided.

Hatch and Brault (2007) (Report No. 5.3.2-1) used the Band Collision Risk Model to estimate a 91 to 99 percent plover turbine avoidance rate based a range of known avoidance rates calculated for other species. These avoidance rates are consistent with rates calculated at a few existing wind farms in the U.S. where mainly geese and raptor species were estimated to have avoidance rates greater than 95 percent. Fernley et al., (2006) calculated the avoidance rates of geese at four operating land-based wind farms in the U.S. using the Band Collision Risk Model. The avoidance rates calculated at the four facilities ranged from 99.82 percent to 100 percent despite high usage by geese at these wind farm sites. Whitfield and Madders (2006) used the Band Collision Risk Model to estimate the avoidance rate of hen harriers (*Circus cyaneus*) at eight wind farms in the U.S. Estimates were: 100 percent at 6 sites, 99.8 percent at 1 site, and 93.2 percent at 1 site. Other avoidance rates reported include: 99.62 percent mainly for gull species at Blyth Harbor in Northeast England, 99.5 percent for golden eagle (*Aquila chrysaetos*) at a U.S. facility, and 99.98 percent for passerines at the Oosterbierum wind farm in the Netherlands (Chamberlain et al., 2006). There are, however, limitations to the Band Collision Risk Model, as it does not account for differences among bird activities and behaviors under a range of conditions, and because avoidance rates exhibited by a range of species are understudied (Chamberlain et al., 2006).

Chamberlain et al., (2006) warned against the inaccuracies that can result in collision models that are based on the avoidance rates calculated for other species. Hatch and Brault (2007) (Report No. 5.3.2-1) provided an estimate of the number of plover crossings of the proposed action area per year. This estimate was based on the number of breeding plovers from Massachusetts northwards, including the Atlantic Canada population. It was estimated that 2,458 plovers cross the Massachusetts coastline over the course of a year (based on adults in spring and fall, and fledglings). MassWildlife hypothesized that fewer than 200 piping plover would cross HSS in a year (Report No. 5.3.2-1). This figure was applied to the model with varying scenarios of flight height and collision probability. Based on an avoidance rate of 98 percent, if all flights occurred in the rotor zone, one piping plover collision would occur in 5.5 years; if all flew below 98 ft (30 m), there would be one collision in 50 years; if flight heights were distributed between 98 to 1,968 ft (30 to 600 m), there would be one collision in 28 years. Using the avoidance rate of 91 percent, there would be 1.2 collisions per year if birds flew exclusively in the rotor zone, 1 collision in 12 years if all birds flew below 98 ft (30 m), and 1 collision in 6 years if flight heights were distributed between 98 and 1,968 ft (30 and 600 m). The authors emphasize the uncertainties surrounding the model including the lack of information regarding piping plover occurrence and flight behavior in HSS, as well as the lack of a species-specific avoidance rate.

A population viability analysis (PVA) was developed by Brault (2007) (Report No. 5.3.2-4) using the most recent breeding population trends of both the Atlantic Canada and New England population. The model estimated a range of mortality associated with the proposed action that could be tolerated by the population without increased risk of extinction or decreased probability of recovery goals (the author used 600 breeding pairs for New England, although the current recovery goal is 625 pairs; the correct recovery goal of 400 pairs was used as the Atlantic Canada threshold). The author modeled varying kill rates with no growth and intermediate growth scenarios. It was estimated that a take of up to 5 piping plover per year would not influence the likelihood of achieving Atlantic Coast recovery goals, or influence the probability of extinction. It was estimated that the increase in the risk of extinction was low over a period of 50 years with wind farm fatalities up to 20 birds per year, given that there are no changes in available breeding and wintering habitat. It was determined that changes in the annual survival rate had 2.25 times the effect on population dynamics than did changes in productivity. The author emphasized that the potential impacts associated with the proposed action are greatly dependent on the level of management efforts. The PVA used a New England recovery goal of 600 breeding pairs instead of the actual 625 breeding pairs. This discrepancy in 25 birds is likely an insignificant factor to the wide range of parameters factored into the model; however, it represents a flaw in the model.

Assuming the estimated worst case scenario of 1.2 wind farm-related piping plover fatalities per year with the low turbine avoidance rate of 91 percent, calculated by Hatch and Brault (2007) (Report No. 5.3.2-1), the recent PVA model suggests that the proposed action would not significantly impact the probability of achieving recovery goals or the influence the probability of extinction. However, there is a large range of uncertainty surrounding the collision mortality estimate. The actual number of crossings of the proposed action area per year, the average height of flight during crossings, and the turbine avoidance rates specific to piping plover are not known. The estimate of 1.2 wind farm-related fatalities is conservative because it assumed that piping plover exhibit a low turbine avoidance rate and that all birds fly through HSS at rotor height. It is unlikely that all piping plover would cross the proposed action area at rotor height; however, it is appropriate to be conservative until more data is available.

***Non-Routine, Unplanned and Accidental Events***

Piping plover may be impacted by oil spills, monopile collapse, cable repair, and pre-construction geotechnical and geophysical investigations. Depending on the season, and the size and location of the area affected by an oil spill, a spill in Nantucket Sound could result in the decreased breeding success or mortality of piping plovers. However, an oil spill is an unlikely event and due to the distance of the area of the proposed action from the major breeding areas, negligible impacts are anticipated to result from oil spills. Furthermore, if a spill were quickly detected and contained, negative impacts could be minimized or avoided. Most potential affects from monopile collapse would occur offshore and not affect shoreline areas used by the piping plover.

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions, and possibly oil spills. Contamination may result from the release of fluids from vessels, or from the WTG or EPS structures themselves. Depending on the size and location of an area impacted by an oil spill, spills could result in the direct mortality or decreased breeding success of piping plovers. If the feathers become coated with oil, birds lose their ability to repel water and to insulate (Jarvis, 2005). Potential impacts include mortality from heat loss, starvation, or drowning. Some birds may lose their ability to fly. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Piping plover were impacted by the oil spill, particularly at Barney's Joy, Dartmouth. Two piping plover were reported dead as a result of oil slicking. However, overall nesting success that year was not believed to be adversely impacted (BBNEP, 2003).

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the loss of piping plover adults or could lead to decreased nesting success. Oil spills that occur outside of the breeding or dispersal periods could result in no impact to piping plover. Due to the distance between the WTG area and the closest piping plover nesting location (approximately 5 miles [8 km]), as well as the low probability of occurrence, the potential for impacts from an oil spill are minor.

The disturbances associated with cable repair activities are expected to be of a similar type but shorter and less extensive than during cable construction. Regular maintenance activities are not anticipated for the submarine cables. Due to the 250 m (or greater) buffer of the offshore transmission cable system from the nearest nesting beaches, disturbances including increased human presence and vessel traffic associated with offshore maintenance activities are not anticipated for nesting or foraging piping plover, and overall cable repairs would have a negligible effect on piping plover.

**Roseate Tern**

The Federally Endangered roseate tern breeds at limited colony locations within Buzzards Bay and Nantucket Sound (see the BA in Appendix G, which provides information on T&E species and potential effects to T&E species). The potential impacts associated with proposed action operation include habitat loss or modification, barriers to flight paths due to the presence of WTGs, collisions with proposed action structures, increased predation, and/or disturbances associated with increased vessel traffic. Additional sources of proposed action impacts include oil spills, monopile collapse, cable repair, and geotechnical and geophysical investigations.

***Habitat Loss or Modification***

There is a potential for the creation of habitat for prey fish due to changes of the substrate. As stated previously in Section 5.3.2.4.2, terns may be attracted to turbine bases if the monopile bases create reef-like conditions and become FADs. If this becomes the case, then terns are anticipated to increase foraging and traveling activities in the vicinity of the area of the proposed action. This would increase the collision risk potential for roseate terns. It is important to note that terns have been observed exhibiting turbine-avoidance behavior exhibited by terns at the majority of existing offshore and near-shore facilities (Petersen et al., 2006; Pettersson, 2005); however, terns have experienced high collision mortality at turbines sited within a hundred meters of a tern colony (Everaert and Stienen, 2006). (An explanation of these observations is provided in Section 5.3.2.4.2, the discussion of potential operation effects to marine birds.)

The monopiles may also create perching habitat for foraging or resting roseate terns. Similarly, the project structures may also result in perching opportunities for predatory peregrine falcons.

There is no available breeding habitat within or in close proximity to the proposed action area boundary, and the offshore transmission cable system and proposed landfall would not cross breeding locations. All points along the transmission cable would be greater than 15 miles (24 km) to the nearest breeding location in Nantucket Sound on Monomoy Island. The center of the turbine array in HSS would be greater than 19.8 miles (31.8 km) to Monomoy Island and 11.5 miles (18.5 km) from the closest potential breeding habitat on Muskeget Island. Therefore, operation of the project would not result in the loss of breeding habitat. There are no critical habitat designations for roseate terns in Massachusetts; therefore, critical habitat will not be impacted.

Terns travel substantial distances (16 to 19 miles [25.8 to 30.6 km]) from their breeding locations to access foraging habitat and terns may be affected as they travel or forage in the vicinity of the proposed action area. Operation theoretically could directly deter roseate terns or their prey from the proposed action area resulting in the temporary or permanent loss of habitat. Baseline surveys conducted in Nantucket Sound documented relatively minimal tern use of the HSS area in relation to other locations in the Sound. Most terns were observed traveling; fewer were seen actively foraging (refer to 5.3.2.9.1 Construction/Decommissioning Impacts for a summary of survey results). Terns are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Roseate terns would likely continue to forage and travel in the vicinity of operating WTGs, assuming that their food sources are not displaced.

***Changes Related to Underwater Structures***

Scour protection at the base of monopiles will either be rock armor or scour mats. The rock or scour mats and the monopiles would increase the available surface area and provide substrate for the colonization of benthic invertebrates and habitat for prey fish. Fish may concentrate around turbine foundations similar to how invertebrates cluster around oil platforms (Vella, 2002 *as cited by* Jarvis, 2005). Habitat with more 'physical heterogeneity' can result in greater fish abundance (Jenkins et al., 1997 and Charbonnel et al., 2002 *as cited by* Gill, 2005). The underwater structures could create a localized 'artificial reef effect', providing foraging habitat for terns. Wide spacing of turbines (0.34 to 0.54 nautical miles [0.63 to 1.0 km] apart) would allow for tern foraging between turbines (see *Risk of Collision* for discussion of impacts due to encounters with turbines).

The boundary of the proposed action area would include approximately 25 square miles (64.7 $km^2$) of WTGs and ESP (electrical service platform) foundations, and 5.89 acres (23,485 $m^2$) of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area: including approximately 1 acre (4,046 $m^2$) for the 130 turbines, 100 by 200 ft (30.5 to 61 m) for the ESP platform, and over 45 acres (0.18 $km^2$) for rock scour protection (Jarvis, 2005). The additional amount of surface area (approximately 1,200 square feet [111 $m^2$] per tower would result in a minor addition to the substrate that is currently available. Due to the small amount of additional surface area in relation to the total proposed action area in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant effect on the benthic community, the presence of prey fish, or foraging terns. However, the additional substrate would be oriented vertically in the water column, and could result in a localized and minor increase in certain prey fish species. The increase in prey fish may ultimately attract tern species to the area to forage (see *Risk of Collision* for discussion of collision impacts).

The available baseline survey data suggests that HSS is not a primary foraging location or traveling corridor for breeding or staging roseate terns; rather, during surveys the majority of terns were observed over shallow waters close to the shorelines of Cape Cod, Martha's Vineyard, and Nantucket. Given the small footprint of the actual development area, negligible habitat loss is anticipated during the proposed action's operation activities. The natural benthic substrate and prey fish communities would be maintained to the extent practicable after a short recovery period post-construction; therefore, major impacts associated with loss of habitat or modifications are not anticipated. Changes over-time to the underwater substrate may result in increased foraging habitat for roseate terns.

### *Increased Perching Habitat*

A flight behavior that could put roseate terns at a greater risk of collision with the proposed WTGs is aerial courtship displays which typically involve flights at heights of 98 to 980 ft (30 to 300 m) (Gochfeld et al., 1998). However, provided that the perch deterrent devices and monitoring for adaptive management (as described in Section 9.4.2; see also Section 8 of the Biological Assessment, Appendix G) are effective in preventing opportunistic use of the WTG and ESP structures, terns would not be expected to launch these high risk flight behaviors in the vicinity of HSS. If the perch deterrent devices are faulty, it is possible that roseate terns may initiate courtship flights from the ESP and WTG structures which would result in an increased risk of collision.

Some courtship behaviors have been observed at the edge of colonies or at resting areas far from the colonies (Gochfeld et al., 1998); and observations of courtship aerial displays have been made at foraging locations (Nisbet, pers. comm.; C. Mostello, pers. comm.; M. Amaral, pers. comm.). These displays have infrequently been seen at foraging locations but this behavior has not been studied for terns foraging offshore; these flights are not usually initiated by a bird with a fish, so they could happen at HSS (M. Amaral, pers. comm.). Observations made at Bird Island indicate that high flights are conducted throughout the season and may serve the purpose of mate selection for the following year (Gochfeld et al., 1998). The approach of vessels or helicopters associated with the proposed action's construction and maintenance or other unassociated vessels or aircraft could cause terns to quickly depart the proposed action area. Fleeing behavior could increase the risk of roseate tern collisions with the WTG structures. If the perch deterrent devices are faulty, Nisbet (2005) notes that the wires and fences used on the ESP and WTG platform in an effort to deter birds may pose a risk to birds fleeing the structures (refer to Section 5.3.2.9.2 Increased Predation for discussion of increased perching habitat for predatory peregrine falcon).

### *WTG Presence and Rotor Movement*

The presence of wind turbines and the spinning of the blades could present barriers to the flight paths of birds and could potentially affect or restrict access to breeding, staging, or foraging habitat. A wind farm could potentially lead to significant impacts if it were to occur in an area of high use by birds (Drewitt and Langston 2006). Barriers can result in increases in energy expenditure if birds are forced to travel greater distances while accessing foraging habitats or while undertaking migration movements. However, based on limited available studies, there are no known situations where a wind farm has created a 'barrier effect' resulting in an avian population level impact (Drewitt and Langston 2006).

Terns have been observed to continue using WTG areas at existing offshore and near-shore facilities during both migration and breeding periods and to nest nearby (see below). Post-construction radar studies during migration at the Nysted and Horns Rev wind farms in Denmark indicate that although the greatest levels of movement occurred outside of the wind farms, terns continued to migrate through the wind farm areas (Petersen et al., 2006). The facility is located 8.7 mile (14 km) offshore and is comprised of 80 turbines with a rotor zone of 98 to 360 ft (30 to 110 m). The turbines are spaced 1,640 ft (500 m) apart, half the distance of the proposed action's turbines. Visual data collected at the Nysted and Horns Rev facility indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 mile (2 km) zone surrounding the facility (Petersen et al., 2006). Terns were observed foraging at the outer edges of the facility around turbine structures. Small flocks flew into the farm, but then exited the area after passing through the second row of turbines (Petersen et al., 2006). Sandwich terns (*S. sandvicensis*) entered the wind farm between two turbines more frequently when one or both of the turbines were not active (Petersen et al., *2006).*

Common and arctic terns (*S. paradisaea*), observed flying in the vicinity of turbines at a facility in Kalmar Sound, Sweden, flew between turbines or right next to the turbines instead of veering off in wide curves as waterfowl species were observed to do (Pettersson 2005). The Kalmar facility is located 1.9 to

7.8 mile (3 to 12.5 km) from the shore with 12 turbines spread out over two locations positioned 20 to 30 km apart. The rotor zone is 115 to 328 ft (35 to 100 m) above the water surface. The facility is located along a major migration corridor for water birds. Most birds were observed making slight alterations to their flight paths while traveling past turbines to avoid approaching individual turbines. It was estimated that the presence of the turbines resulted in a minor increase (0.2 to 0.5 percent) to the overall distance traveled by most birds during migration (Pettersson, 2005).

A post-construction study at the Zeebrugge wind farm in Belgium investigated the level of the proposed action's disturbance on nesting terns. An artificial peninsula, created to provide nesting habitat for common (*S. hirundo*), sandwich (*S. sandvicensis*), and little (*S. albifrons*) terns, was built adjacent to 25 existing small to medium-sized turbines on a breakwater. In 2004, terns nested as close as 98 ft (30 m) from the turbines, while the majority of nests were situated 328 ft (100 m) or further from the turbines (Everaert and Stienen, 2006). In 2005, terns nested as close as 164 ft (50 m) from the turbines. The greater distance between nests and turbines in 2005 was presumed to be a result of the distribution of vegetative growth on the peninsula and not due to the operation of the turbines themselves (Everaert and Stienen, 2006). While terns traveled to and from the colony past the turbines, many made no apparent changes in their flight paths. The terns that exhibited a reaction to the turbines made slight changes in their flight paths to fly between turbines (Everaert, 2004). The turbines did not present barriers to the flight paths of terns and observations suggest the presence of turbines resulted in minimal increases in energy expenditure for the terns. It was concluded that the presence of the turbines represented little disturbance to the activity of breeding terns (however, the action resulted in high numbers of collisions due to the facility's location in proximity to the colony, discussed in the following section, *Risk of Collision*).

***Risk of Collision***

The potential exists for roseate terns to collide with WTG structures, including the blades and tubular towers during the breeding, staging, and migration periods when any individual from the northeastern population could occur in the vicinity of the proposed action area. The results of available terrestrial mortality studies conducted in primarily terrestrial environments for general avian species indicate that the majority of collisions with man-made structures take place at night during periods of inclement weather (Kerlinger, 2000). There is limited mortality data available regarding the conditions of greatest risk of collision at offshore wind sites; however, Huppop et al. (2006) determined that risk of collision with man-made structures located offshore is elevated during rain and fog. However, it is possible that if terns were to use the WTG and ESP platforms, they may be at greater risk of collision even during periods of good visibility if they initiate courtship rituals from these structures.

Outside of migration, terns are mainly active during the day; except at dusk and dawn when they have been observed to depart or arrive at roosting locations (Trull et al., 1999; Hays et al., 1999), and are sometimes active after dark (Hays et al., 1999; Trull et al., 1999). Roseate terns may be at risk of collision while foraging, commuting, or conducting courtship aerial flights in the vicinity of WTGs during periods of good and limited visibility. Terns that fly within the rotor zone of the proposed turbines (75.5 to 440 ft [23 to 134 m]) during periods of low visibility may be at greatest risk of collision. There is the potential for roseate tern crossings of HSS during periods of fog or rain, during nighttime movements, and during crepuscular commutes to and from nocturnal roosts (particularly during the staging period in August and September) when visibility is decreased and the risk of collision is elevated. Nisbet (personal communication) noted that a study conducted by Winkelman in 1992 with thermal image intensifiers found that 1 of 40 (2.5 percent) nocturnally migrating birds (not terns) passing through the rotor-zone of a land-based wind farm collided with turbines. Due to the difficulties of surveying during these conditions, there is no information about roseate tern occurrence and behavior in HSS at night or during other periods of decreased visibility. Therefore, the assessment of risk of collision during these conditions in this section must rely heavily on data collected on tern and general bird behavior at existing wind turbines located onshore, near-shore, and offshore.

***Summary of Available Studies***

Post-construction studies at existing European facilities suggest offshore wind farms, when properly sited, do not impose major impacts to local tern populations. Studies conducted at the wind farms in Sweden and Denmark showed continued tern use of turbine areas after development, as well as collision avoidance behaviors when terns approached individual turbines (Petersen et al., 2006; Pettersson, 2005).

The study conducted in 2007 and 2006 at the MMA turbine, near the Cape Cod Canal in Buzzards Bay, indicated continued use of the area by roseate terns and avoidance of the rotor zone when the turbine was operating at greater than one rpm (Vlietstra, 2007). When the rpm was greater than one, terns were 4 to 5 times less abundant in the 164 ft (50 m) airspace surrounding the turbine blades in 2006. During 2006, tern passage rates were evaluated in relation to rotor velocity: when the rotor was operating, six percent of all terns (3 of 51) in the turbine airspace flew at rotor-swept altitudes, whereas 16 percent (33 of 203) flew within the rotor-swept altitudes when the rotor was shut-down (Vlietstra, 2008). For the 8 total roseate terns observed in 2006 and 2007, flight altitudes were consistently below the rotor zone, between 8 and 21 m above ground (Vlietstra, 2008). For those terns observed passing through the rotor-swept zone when the turbine was operating, there were three sitings of common terns that passed through unscathed when the rotor velocity was 3.0 rpm. It was hypothesized that the terns visually and acoustically detected the spinning blades when the rotor was operating (Vlietstra, 2007; 2008). Mortality surveys at the MMA turbine indicated no tern fatalities in 2006 or 2007. There were 5 total birds found during the mortality searches in both years combined, three of these birds (a laughing gull [*Larus atricilla*], osprey [*Pandion haliaetus*], and a great black-backed gull [*Larus marinus*]) were presumed to have collided with the turbine (Vlietstra, 2008).

Poorly sited facilities can result in high collision rates of terns. A mortality study conducted at the Zeebrugge, Belgium facility reported notably high tern collision mortality. Everaert and Stienen (2006) concluded that wind turbines should not be placed in the frequent flight paths of terns, nor should artificial nesting habitat be created adjacent to turbines as the collision mortality observed at the Zeebrugge facility was determined to have an adverse impact on a breeding population of terns. At this facility, nesting habitat was enhanced on the eastern port side of the breakwater next to a string of 25 small to medium sized turbines (10 at 200 kW, 12 at 400 kW, and 3 at 600 kW). Since operation of the facility, terns have nested as close as 98 ft (30 m) from the towers. Between 2001 and 2003, there were 20 total tern fatalities found at the site. However, in 2004 alone, the number of tern fatalities was more than double the number of fatalities found in the three previous years combined. There was a correlation between increases in the number of breeding pairs and increases in collision mortality, and it was presumed that an increased number of foraging flights since 2004 resulted in the observed increase in collision fatalities in 2004 and 2005 (Evareart and Stienen, 2006).

Collision probability at the Zeebrugge facility was believed to be influenced by flight behaviors and flight height, but observed increases in collision fatalities were mainly attributed to the increased number of crossings of the turbines after the number of breeding pairs at the tern colony increased in 2004. In relation to collision risk at HSS, the results of the Zeebrugge study indicate that an increased number of crossings could result in increased collision fatalities. More information regarding roseate tern movement patterns through HSS is required to better assess collision risk. The results of the Zeebrugge study indicate that collision probability is not simply a function of the number of crossings of the turbines or the overall time spent in the rotor-zone; in addition, specific flight behaviors may increase the probability of collision. The primary flight behavior expected of roseate terns in the proposed action area is relatively direct paths (with some influence of wind drift on the direction terns travel) to and from breeding, staging, or foraging locations.

***Factors Increasing the Risk of Collision***

*Changes in Foraging Habitat*

The additional substrate resulting from construction of the proposed action would be oriented vertically in the water column, and could result in a localized and minor increase in certain prey fish species. The increase in prey fish may ultimately attract tern species to the area to forage. A potential increase in the abundance of foraging terns may increase the risk of collision. Roseate terns are known to forage at low heights of 3.3 to 39.4 ft (1 to 12 m) (Gochfeld et al., 1998); therefore, when foraging at low altitudes terns would be expected to be at low risk of collision with the WTG blades as they would remain below the proposed rotor zone. Nisbet (2005) suggests that "Terns are at little risk of collision with turbine rotors when they are foraging, because they are then usually within 3.1 to 4.6 ft [10 to 15 m] of the sea surface. The main risk of collision is when they are commuting, when they sometimes fly higher." Terns are expected to have a high avoidance of collisions with stationary monopiles during periods of good visibility, given their known flight maneuverability around artificial structures while traveling and foraging.

*Increased Perching Habitat*

A flight behavior that could put roseate terns at a greater risk of collision with the proposed WTGs is aerial courtship displays which typically involve flights at heights of 98 to 980 ft (30 to 300 m) (Gochfeld et al., 1998). However, provided that the perch deterrent devices and monitoring for adaptive management are effective in preventing opportunistic use of the WTG and ESP structures, terns would not be expected to launch these high risk flight behaviors in the vicinity of HSS. However, Nisbet (2005) notes that the ESP platform would be difficult to bird-proof without preventing helicopters from landing on the platform as well. If the perch deterrent devices are faulty, it is possible that roseate terns may initiate courtship flights from the ESP and WTG structures which would result in an increased risk of collision. Some courtship behaviors have been observed at the edge of colonies or at resting areas far from the colonies (Gochfeld et al., 1998); and observations of courtship aerial displays have been made at foraging locations (Nisbet, pers. comm.; C. Mostello, pers. comm.; M. Amaral, pers. comm.). These displays have infrequently been seen at foraging locations but this behavior has not been studied for terns foraging offshore; these flights are not usually initiated by a bird with a fish, so they could happen at HSS (M. Amaral, pers. comm.). Observations made at Bird Island indicate that high flights are conducted throughout the season and may serve the purpose of mate selection for the following year (Gochfeld et al., 1998). The approach of vessels or helicopters associated with the proposed action's construction and maintenance or other unassociated vessels or aircraft could cause terns to quickly depart the proposed action area. Fleeing behavior could increase the risk of roseate tern collisions with the WTG structures. If the perch deterrent devices are faulty, Nisbet (2005) notes that the wires and fences used on the ESP and WTG platform in an effort to deter birds may pose a risk to birds fleeing the structures.

*Flight Height*

If making shorter, more localized flights in an effort to forage in HSS, roseate terns would be expected to occur at flight heights at or below their maximum foraging height of 39.4 ft (12 m). Nisbet (2005) suggests that "terns are at little risk of collision with turbine rotors when they are foraging, because they are then usually within 31 to 46 ft [10 to 15 m] of the sea surface. The main risk of collision is when they are commuting, they sometimes fly higher." It is expected that the majority of roseate terns would fly below the rotor zone when commuting with a headwind. However, if traveling in following winds while commuting, terns may fly at higher altitudes, potentially in the rotor zone. Roseate terns may fly higher in following winds and may occur within the rotor zone while commuting; however, terns may be at decreased risk of collision with the spinning blades if flying with following winds because of the shorter length of time spent in the rotor-zone due to a higher ground speed (Report No. 5.3.2-1); and because during the day, terns are expected to visually detect turbines. Although flights into headwinds at rotor height would be more dangerous due to a greater amount of time spent in the rotor-zone while passing. Terns are expected to fly closer to the water's surface when flying into headwinds to avoid excessive energy expenditure, and would therefore not be expected to fly in the rotor-zone during such conditions: only 1 of 110 terns flying into a headwind during the August 2006 surveys flew at the height of the rotor-zone *(see Results of Surveys and Available Information).*

*Periods of Decreased Visibility*

There is the potential for roseate tern crossings of HSS during periods of fog or rain, during night time movements, and during crepuscular commutes to and from nocturnal roosts (particularly during the staging period in August and September) when visibility is decreased and the risk of collision is elevated. Due to the difficulties of surveying during these conditions, there is no information about roseate tern occurrence and behavior in HSS at night or during other periods of decreased visibility. Therefore, the assessment of risk of collision during these conditions in this section must rely heavily on data collected on tern and general bird behavior at existing wind turbines located elsewhere onshore, near-shore, and offshore.

During the breeding and staging periods, terns arrive at roosting sites around sunset and continue to arrive after dark (Trull et al., 1999). Terns are presumed to depart staging grounds before sunrise to travel to foraging locations. While making daily movements to and from breeding habitat, some roseate terns have been observed traveling overland across Cape Cod and some may pass over waters in Nantucket Sound (RTRT, 2007). It is possible that terns may cross HSS during commuting flights to and from nocturnal roosts during post-breeding staging in August and September. Observations made in August 2002 in the southern part of the shoals study area documented terns flying after sunset toward Ferdando's Fetch. Terns will also fly at night if disturbed by predators at the colony site but as HSS is not located near breeding colonies, it is unlikely that these flights would occur over HSS. J. Hatch (as noted in Report No. 5.3.2-1) and Nisbet (unpubl. obs.) have seen and heard mixed-species flocks of terns arriving at South Beach after sunset, descending from heights of 121 to 197 ft (37 to 60 m) (or higher). Nisbet (2005) notes that project area at HSS does not lie directly between the roosting area at South Beach and the daytime resting areas as described by Trull et al., 1999. However, the parts of Martha's Vineyard from which terns would fly through the area of the proposed action on a direct course to South Beach have not been surveyed. It is unknown whether migratory flights may result in nighttime crossings over the waters of Nantucket Sound.

Roseate terns disperse to their wintering grounds during August and September and return to breeding locations from late-April to mid-May. Some terns depart for wintering grounds during the day but it is likely that terns also depart in the evening. There is little data available on roseate tern nighttime migration; however, other species of tern are known to travel extensively at night (Alerstam, 1985). Additionally, observations have been made of mixed flocks of terns departing staging grounds in Nantucket Sound around sunset (refer to Appendix G - Biological Assessment Section 5.3.1.2.3 for more detail). Although there are no known staging areas that would funnel terns over HSS, in varying wind conditions, the potential exists that roseate terns could cross HSS while departing staging grounds or when arriving at breeding areas in the spring. If migrating terns were to occur over HSS, the risk of collision would be dependent upon the flight height of the migrants and their ability to detect and avoid the WTGs.

Terns have been observed at heights well above the rotor zone when making migratory movements. There have been observations of what were assumed to be both roseate and common terns departing

South Beach in the fall around sunset, apparently heading toward their wintering grounds, and quickly gaining altitudes of hundreds of meters (Veit and Petersen, 1993). Other species of terns have been observed migrating at heights above 9,842 ft (3,000 m) when migrating over land (Alerstam, 1985). It is likely that nighttime migration movements of terns traveling direct to the Gulf of Maine, if they were to cross HSS, would occur well above the rotor zone. The flight height, however, would be dependent on weather conditions. If terns were to depart in unfavorable conditions such as strong headwinds, their flight heights would likely be lower as other tern species have been observed flying close to the water's surface during strong headwinds (Alerstam, 1985). More data is required to assess potential roseate tern migratory behavior in HSS during a variety of weather conditions.

Results of the MMA turbine visual surveys conducted from 5:30 am to 9:30 pm (0530–2100), indicate that during the "chick-rearing" period (when terns were found to be most abundant in the turbine airspace), terns were equally abundant in the wind turbine airspace during periods of poor visibility as they were during periods of unlimited visibility (Vlietstra, 2008). Passage rates were statistically similar among periods of poor (0.12 to 0.62 miles [0.2 to 1.0 km]), moderate (0.62 to 6.2 miles [1.0 to 10.0 km]), and unlimited visibility in the morning and midday hours (5:30 am to 4 pm [0530–1600]). During the evening hours 4:00 pm to 9:30 pm [1600-2100], terns were more abundant in the airspace when visibility was moderate than when visibility was poor or unlimited (Vlietstra, 2008). More terns were observed in the turbine airspace when visibility was only slightly reduced, than when conditions were poor.

Vlietstra suggests that if terns were not able to see and avoid the turbine during fog, terns would to be more abundant in the turbine airspace during periods of poor visibility. Vlietstra hypothesized that there may be a few factors that influenced these findings: 1) terns in the turbine airspace may have been undetected by observers during poor conditions; or 2) the difference in tern occurrences in the turbine airspace during varying visibility conditions may be correlated to other behavioral or weather related factors that are unidentified. No information is currently available about the correlations between rotor velocity and visibility conditions, and between flight height and fog (Vlietstra, personal communication). In the absence of these correlations, it is difficult to draw relevance from this study to assessing risk to terns crossing HSS during periods of reduced visibility. However, two of Vlietstra's findings are important to consider from this study when considering risk of collision in the proposed action area: 1) terns were equally as abundant in the turbine space during periods of poor visibility due to fog and unlimited visibility, and, 2) there were no tern fatalities found during mortality searches. However, this is a near-shore site consisting of one turbine that is notably smaller than the number of turbines proposed for HSS. Tern interaction behavior at a near-shore turbine as opposed to an offshore wind farm may vary.

***Effects of FAA Lighting***

Studies have demonstrated that steady burning FAA obstruction lighting, (Gehring and Kerlinger, 2007) and some other types of lighting, on tall structures can cause collisions by attracting or disorienting night migrating birds, especially during periods of fog, rain, or low cloud ceiling (Huppop et al., 2006). However, other studies suggest that there are not statistical correlations between mortality at turbines that are lit verses un-lit at onshore wind farms (Jain et al., 2007). The substantially higher numbers of fatalities observed at lit communication towers (at heights greater than 1,000 ft [305 m]) in the U.S. may be influenced by the greater heights of the towers, the guy wires, or the steady-burning lights mounted on many towers (Jain et al., 2007), verses the pulsing lights on wind turbines.

The birds involved in collisions with a lit platform located offshore were primarily night migrating songbirds and a few other species, including one dunlin (*Calidris alpina*) and four large gulls (Huppop et al., 2006). Terns are rarities among reported collisions at 47 mainly land-based and some coastal communication towers in the U.S. that are lit and are typically over 200 ft (61 m), with one sooty and one common tern reported from a total of 47 towers as of 2000; gulls, terns, and petrels represented 2 percent of fatalities reported at these towers (Shire et al., 2000). Although passerine species are known to be attracted to the refracted lighting at "offshore obstacles" during periods of fog or rain (Huppop et al., 2006), there is no data available that suggests terns are attracted to refracted lighting during these conditions.

It is unknown if natural sources of nighttime lighting (i.e., moonlight or starlight) may decrease the risk of tern collisions if their movements result in nighttime crossings of the proposed action area. It is also unknown if the lighting mounted on nacelles may help terns detect the presence of the WTGs (not necessarily the blades) and may facilitate avoidance of the WTG area. At the Nysted and Horns Rev wind farm in Denmark, wind turbines positioned at the outer edge of the wind farm are equipped with two medium intensity flashing red lights on the top of the nacelles. The lights operate at a frequency of 20 to 60 fpm (Petersen et al., 2006). Radar observations suggest that birds approached the turbines at closer distances at night than during the day, and that more birds entered the wind farm at night than during the day; however, observations indicated avoidance behavior of the turbines by nighttime migrants. The typical distance at which an avoidance reaction occurred was 1,640 ft (500 m) from turbines at night and 1.9 mile (3 km) during the day (Petersen et al., 2006). It may be that that migrating birds react later to the turbines at night due to decreased visibility, but are eventually able to detect the turbines due to lighting mounted on the nacelles or natural sources of night lighting. However, the effects of FAA lighting and natural sources of lighting on roseate tern flight behavior require further study. Another study conducted with vertically oriented radar suggests that migrating birds may also react to turbines by 'vertical deflection' at night instead of the horizontal avoidance primarily observed during the day (Blew et al., 2006 *as cited by* Petersen et al., 2006). Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of inclement weather (Petersen et al., 2006). Roseate tern reactions to FAA lighting on tall, offshore structures during foggy or inclement weather conditions at night have not been studied.

***Summary of Risk of Collision***

Roseate terns are at risk of collision with above-water WTG structures, particularly during commuting trips between breeding, staging, and roosting sites in Nantucket Sound during the breeding season, as well as during migration movements through Nantucket Sound. Risk of collision is elevated for terns crossing the area of the proposed action at rotor height during periods of reduced visibility including dusk and dawn, at night, and during periods of fog or storm. More information is required to determine roseate tern flight behaviors and use of the area of the proposed action during these low visibility conditions to fully assess the impacts to roseate terns associated with collision. Because there is a potential for tern crossings of the area of the proposed action during elevated periods of collision risk, and the mortality of a single roseate tern is considered a major impact, the impact to roseate terns associated with risk of collision with the proposed turbines may be major. Refer to Section 9 for a summary of mitigation and post-construction monitoring effort that have been developed to reduce impacts to roseate terns.

Refer to Appendix G - Biological Assessment Section 5.3.1.2.3 *Collision Risk Modeling* for discussion of the estimate of annual collision mortality for roseate terns, and *Population Viability Analysis* for a discussion of the estimated range of collision mortality the Northeast population of roseate terns may tolerate without an increased risk of collision.

***Additional Sources of Mortality***

There is the potential that additional mortality or injury could result from birds not actually colliding with the turbines, but getting caught in the turbulence behind rotors (Winkelman, 1994). Winkelman's 1992 study suggests that approximately 20 percent of avian mortality found at the shore-based

Oosterbierum wind farm in the Netherlands was caused by such turbulence 'strikes', however, there are no other studies that have reported observations of this phenomenon for birds (Desholm, 2006). Turbulence effects may also increase avian avoidance of turbines. Daytime visual surveys, radar, and nocturnal surveys with a thermal image intensifier suggested that birds flying into a headwind were more likely to react to turbines perhaps because they approached the rotor wake before reaching the rotor (Winkelman, 1994). The MMA turbine study suggests that birds can, in addition to visually detecting and avoiding turbines, detect the 'whooshing' sound that rotors create (Vliestra, 2007). Potential turbulence effects to birds would depend on the wind speed and direction, and the direction from which a bird approaches a turbine. However, further studies are required to determine the level of impact rotor turbulence poses to terns.

***Increased Predation***

There is a potential that WTG and ESP foundation structures may provide perching habitat for predatory peregrine falcons (*Falco peregrinus*), which could result in the mortality of roseate terns. Peregrine falcons hunt in flight or from perches while they take avian prey. They are known to rarely take tern species (Wheeler, 2003). Peregrine falcon have been known to infrequently, but regularly, take or attempt to take terns at the colonies in Buzzards Bay, particularly during the spring (MDFW, personal communication); there was a tern found predated at Bird Island after a peregrine was observed there on June 11, 2006 (Causey and Mostello, 2006).

There is a population of arctic nesting peregrine falcons that migrate south between mid- September and late-October. Banding and telemetry data indicate that peregrine "migration routes are distinctly centered along the Atlantic Coast" during fall migration (Wheeler, 2003). Peregrine falcons will also make major over-water crossings from Baffin Island or Labrador to the mid-Atlantic Coast (Wheeler, 2003).

There is some seasonal overlap between roseate terns and migrating arctic-nesting peregrine falcons within the Atlantic Coast region; particularly in the spring when predation is observed at the Buzzards Bay colonies (MDFW, personal communication). Arctic nesting peregrine falcon fall migration peaks in late-September to early-October (Wheeler, 2003) and roseate terns migrate south by mid-September. Limited information is available regarding peregrine falcon spring migration. However, telemetry data indicates that peregrine falcons reach breeding grounds by May (Wheeler, 2003), at which time roseate terns return to Nantucket Sound. Mainly the winter range of the arctic nesting peregrine falcons overlaps with the proposed action area (Wheeler, 2003) when roseate terns are not present. There is also a small population of peregrine falcons that are generally year-round residents in Massachusetts (Massachusetts had 14 known territorial pairs in 2007 [MNH & ESP, 2007]). Breeding territories occur along the Connecticut River Valley, the Lowell-Lawrence area, the Worcester area, and Boston (MNH & ESP, 2007). Most of the breeders and first-year birds are non-migratory, but they disperse toward the coast in the winter and the spring. Some first-year birds will disperse to other Northeastern states where they will eventually breed. During the spring and summer, if a member of a breeding pair in Massachusetts is killed, that individual is generally quickly replaced, indicating the presence of a number of non-breeding birds in the area (USFWS, personal communication).

Peregrine falcons are known to regularly take advantage of artificial structures for perching opportunities (Wheeler, 2003); peregrines will perch, and sometimes nest on, lighthouses, telecommunication towers, grain elevators, suspension bridges, and other tall, man-made structures (USFWS, personal communication); however, the extent to which artificial structures are used for perching at offshore locations is unknown.

It is possible that the WTG and ESP platforms will provide perching substrate for both roseate terns and predatory peregrine falcon (USFWS, personal communication). There is an adaptive management strategy incorporating anti-perching devices on the WTG and ESP (refer to Section 8 of the Biological Assessment and Section 9.0 of this FEIS). Additionally, because of the use of tubular towers instead of lattice towers which do not provide as much perching opportunity, it is anticipated that development of the proposed action will not result in substantially increased hunting opportunities for predatory species or result in substantial increases of predation of roseate terns. Therefore, the potential of increased predation is anticipated to result in negligible impacts to roseate terns.

***Vessel Activity***

Terns appear to be less sensitive to human disturbances than other species of birds, and are also thought to be attracted to some areas of human activity (Borberg et al., 2005; Drewitt and Langston, 2006; Sadoti et al., 2005a). Terns are known to habituate to some levels of human presence and disturbance. Terns are regularly observed traveling and foraging in the vicinity of vessels and other man-made structures. The major northeast roseate tern breeding colonies on Ram and Bird Islands in Buzzards Bay are located near the entrance of the Cape Cod Canal which receives frequent recreational boating and commercial shipping activity, yet terns continue to colonize these islands. Biologists frequently visit the large roseate tern colonies on the Atlantic Coast and consequently, roseate terns have become habituated to their presence and their handling of eggs, chicks, and adults (Nisbet et al., 1999). An increase in the presence of terns and gulls observed in areas around the Horns Rev offshore facility in Denmark was believed to be associated with increased boat activity for maintenance activities (Petersen et al., 2006). Therefore, roseate terns are expected to continue their traveling and foraging activities despite the presence of increased boat traffic and the few anticipated helicopter landings in HSS. Terns would be expected to return to the area after the departure of the vessels. However, fleeing behavior could increase the risk of roseate tern collisions with the WTG structures. If the perch deterrent devices are faulty, Nisbet (2005) notes that the wires and fences used on the ESP and WTG platform in an effort to deter birds may pose a risk to birds fleeing the structures.

Roseate terns are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with maintenance activities. Therefore disturbances associated with the operation of the facility are anticipated to have negligible effects on roseate terns (refer to previous section *Risk of Collision* for discussion of impacts associated with encounters with the turbines).

***Unplanned and Accidental Events***

Roseate terns may also be impacted by oil spills, monopile collapse, cable repair, and pre-construction geotechnical and geophysical investigations. The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Because terns forage at the water's surface, they are among those species of birds that are particularly vulnerable to oil spills (Jarvis, 2005). If the feathers become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport Massachusetts in 2003. Oil was reported as far as Block Island and Middletown, Rhode Island (BBNEP, 2003). At least three adult roseate terns were found dead with traces of oil. Roseate terns were discouraged from nesting on Ram Island in 2003 because it was soiled from the oil spill. Consequently, 250 pairs nested on Penikese Island that year and productivity suffered due to the late initiation of egg-laying (BBNEP, 2005a). Oil spills that occur when terns are not present could result in indirect effects to habitat availability and prey availability.

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the loss of roseate tern adults or could lead to decreased nesting success. Oil spills could directly impact roseate tern colonies, as the Ram Island colony was impacted in 2003. However, due to the distance of the proposed action from nesting colonies, oil spills associated with the proposed action are unlikely to impact nesting colonies. Additionally, an OSRP would be implemented during construction, operation, and decommissioning. In the event of a spill, clean-up measures would be used to prevent contamination of the environment and impacts to wildlife.

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Tern foraging in areas of elevated suspended sediments would be reduced. In both instances the habitat and species would recover and no impacts to roseate terns are anticipated from cable repair activities.

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for terns would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a tern dive for fish within this small plume, it could be harmed. There is a low likelihood of this occurrence and low probability of it occurring coincidentally with tern use of the immediate area. Potential impacts to roseate tern in the event of a monopile collapse would therefore be negligible

The geotechnical investigation methods such as borings would result in negligible effects on benthos and water column characteristics, and these activities would be localized and short term, such that no affects on roseate tern habitat or use of the proposed action area are anticipated, even though much of this activity will be focused on the Horseshoe Shoal area. Geophysical investigation methods, such as sidescan sonar, are even less intrusive and have less habitat altering capabilities, and would, therefore, also have no major effects on roseate terns.

**Northeastern Beach Tiger Beetle**

As described for construction activities, the only potential for impact to this species is through an accidental oil spill. Oil spills are a possibility during operation of the facility, either during maintenance activities or as a result of vessel collisions. As mentioned in the construction assessment section, such probabilities are so small as to yield a not likely to adversely affect, and this determination remains valid for the operational timeframe as well.

The determination of not likely to adversely affect is supported by the FWS BO issued on November 21, 2008, which concurred with the findings presented in the BA amendment, and which are summarized in the paragraph above.

**Red Knot**

The potential impacts to red knot during proposed action operation may include impacts associated with disturbance from vessel activity during any necessary cable repair, impacts associated with oil spills or WTG structure or ESP fluid spills, and the risk of collision of migrant red knots with WTG structures.

### *Vessel Traffic*

There would be an increase in vessel activity within the Horseshoe Shoal area associated with maintenance of the WTGs during the operational period. During operation, maintenance vessels would mainly operate out of Hyannis or similar Cape Cod ports. These ports have adequate facilities for berthing and loading of the maintenance vessels. These ports occur in developed areas and currently experience similar uses. There are no known important staging areas in the vicinity of these ports; therefore, the increase in vessel activity in these areas is anticipated to result in negligible impacts to red knot.

There may be an increase in vessel activity associated with offshore cable repair during the operation phase. However, the cable is designed under normal conditions to last the life of the project. The closest distance of the offshore transmission cable system to potential staging habitat on the seaward side of Great Island is 0.8 miles (1.3 km). Near shore construction activities in Lewis Bay would be temporary and would occur outside of the 1000 m vessel disturbance distance for red knot. Therefore, vessel disturbances associated with cable repairs are anticipated to result in negligible impacts to red knot

### *Oil Spills*

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil spills may result in the release of contaminants from vessels or from the WTG or ESP foundations themselves. Depending on the location and the size of a spill, red knots may be impacted. If the feathers of birds become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Shorebird habitat was impacted by the oil spill, particularly at Barney's Joy, Dartmouth, and shorebird mortality was a resulting impact.

Monopile collapse, vessel collisions, or storm damage to the ESP or WTG structures could result in oil or other fluid contamination. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons (158,987 liters) at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons (810 liters) at any given time (27,820 gallons [105,310 liters] for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

The potential impacts of oil spills associated with the operation of the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the mortality of red knot if staging areas were to be impacted. Oil spills that occur outside of dispersal, staging periods, or wintering periods could result in no impacts to red knot. Due to the distance between the WTG area and the closest known red knot migratory and wintering habitat on Monomoy, the potential for impacts are reduced, and when the probability is considered, oil spills should be considered to represent a minor impact.

*Risk of Collision*

There is the potential for red knot collisions with the proposed WTGs. The risk of collision is dependent on the frequency of occurrence of red knots within the site of the proposed action, visibility during potential red knot encounters with WTGs, and the flight behaviors of red knots within the area of the proposed action.

Red knots may occur with the area of the proposed action during migration, however, no red knots were observed in HSS during aerial and boat surveys conducted during 2002 to 2006. One individual was observed during one of the applicant's boat surveys near Cape Poge off of Martha's Vineyard on September 13, 2002. The individual was in a mixed flock of sandpipers and was observed flying low over the water.

Red knots undertake one of the longest known migrations and may travel thousands of kilometers without stopping (Harrington, 2001). Departure for migration for most shorebirds, including red knots, tends to occur on sunny days in the few hours before twilight (Harrington, 2001). Red knots tend to occur in larger flocks than most other shorebirds with flocks sizes at over one hundred individuals; the average size of red knot flocks consisted of roughly 50 individuals at one study location (Harrington, 2001). Observations suggest red knots fly in v-formations, and mixed flocks eventually segregate according to species after departure from beaches (Harrington, 2001). Flocks observed departing for migration, gained altitudes at relatively high rate of 31 mph (0.91 m/s) compared to 7 other species observed (Harrington, 2001). Limited migration behavior information suggests that red knots mainly migrate during periods of good visibility and that they may travel at relatively high altitudes. These behaviors may put red knot at a low risk of collision with the proposed turbines; however, more site-specific information is required to assess their risk.

Red knot are known to occur regularly during migration on Monomoy Island (USFWS, 2006), especially during the late summer and early fall. Migration paths and flight altitudes used to access Monomoy are not known. The observation of a single individual near Cape Poge off of Martha's Vineyard may indicate that red knots also utilize beach and inter-tidal areas associated with the islands of Nantucket Sound, or that some individuals may pass Martha's Vineyard while accessing staging habitat. No other individuals were observed in the study areas and no individuals were observed within HSS during the 2002 to 2006 boat and aerial surveys. However, aerial and boat surveys were conducted during the day, and therefore it is not known whether red knot may cross HSS during nighttime migration movements. Additionally, there are limitations to visual observations of shorebirds flying near the surface of the water from aerial surveys, as well as visual observations of high flying shorebirds from the surface of the water during boat surveys. More information is needed to access red knot occurrence and flight behavior in HSS during the day and at night, during a variety of weather conditions. However, the results of available surveys indicate a low chance of occurrence of red knot in the area of the proposed action. The risk of collision is low and therefore, collision mortality associated with the proposed action is anticipated to result in negligible impacts to red knot.

**New England Cottontail**

Small populations of New England cottontails were observed in Barnstable County during a 2000-2003 survey (MDFW, 2003). The upland portion of the underground cable would be located within streets and an existing previously disturbed utility ROW, which would be allowed to revegetate after construction. As such, operation of the underground cable would have negligible impacts on the New England Cottontails. Operation of the WTGs would not have an impact on New England Cottontails as the WTGs would be located far offshore.

**Conclusion**

The operation of the proposed action is expected to have insignificant or negligible impacts on T&E species of sea turtles, cetaceans, and the red knot (not yet listed as a T&E species but likely). With respect to the piping plover, the proposed action may have a moderate effect due to the potential for any collisions. Although the level of collision mortality associated with the proposed action is anticipated to be low, there is uncertainty surrounding piping plover use of the proposed action area. With respect to the roseate tern, available data suggest a low level of risk of collision with WTG structures. However, there is uncertainty surrounding the available data. The loss of breeding individuals would be detrimental to the regional population; therefore, the proposed action may have a moderate effect on roseate terns due to the estimated collision risk. Operation of the underground cable would have negligible impacts on the New England Cottontail as the cable would be installed in streets and an existing ROW.

The NOAA Fisheries issued its BO (see Appendix J) on November 13, 2008 which concluded that the proposed action would not jeopardize the continued existence of any threatened or endangered species. In particular, the NOAA Fisheries's BO analyzed the proposed action activities and found that the hawksbill turtle and the sperm, blue and sei whales do not occur in the action area and needed no further analysis, yielding a determination that the proposed action will not affect these species. For the right, humpback and fin whales, NOAA Fisheries concluded that since "all effects to whales from the proposed project are likely to be insignificant or discountable, this action is not likely to adversely affect listed whales in the action area," and, therefore, is not likely to jeopardize the continued existence of these whale species. NOAA Fisheries concluded that the proposed action may adversely affect but is not likely to jeopardize the continued existence of the loggerhead, Kemp's ridley, leatherback or green sea turtles. Lastly, because no critical habitat is designated in the action area, none will be affected by the proposed action. The Reasonable and Prudent Measures contained within the NOAA Fisheries BO are outlined in Section 9.0.

The FWS' BO analyzed the proposed action operational activities and found that for the piping plover and roseate tern, short term habitat loss or displacement may occur during operation. A second potential impact involves the potential for an oil spill during operation associated with a vessel accident, or leaks and spills during activities such as changing out the various lubricant and coolant fluids on the WTGs or ESP as part of regular maintenance. The determination was made that the proposed action is not likely to adversely affect the northeastern beach tiger beetle. Lastly, because no piping plover or roseate tern critical habitat is designated in the action area, none will be affected by the proposed action.

The FWS BO analyzed the proposed action operational activities and found that some take of roseate tern and piping plover may occur. For the roseate tern the FWS estimates that four to five roseate terns per year (80 to 100 terns over the 20-year life of the project) are likely to be taken (injured or killed) as a result of collisions with the WTGs on Horseshoe Shoal. If any of the four or five individuals are successful adult breeders with dependent young of the year, the survival rate of their young will be reduced, adding to the level of take.

For the piping plover, the FWS anticipates that a maximum of 10 piping plovers will be taken over the life of the Cape Wind Energy Project, based on their upper bound estimate of one piping plover collision every two years with the WTGs in the Horseshoe Shoal project area. As for roseate terns, the FWS based this estimate on an independent review of the various collision modeling discussed previously and includes their full consideration of the best available scientific information and understanding of the species. Because the formulation of mortality estimates is very complex, new empirical information demonstrating one or more of the following circumstances will constitute evidence that estimated take of piping plovers has been exceeded:

1. Annual flights across the project area exceed the total number of pairs breeding in and north of the action area. This is equivalent to approximately 18 percent of migration flights by adults and young of the year (pairs x 5.5).
2. More than 20 percent of flights occur at rotor height.
3. Avoidance rates <0.95.

The FWS determined that this level of take is not likely to jeopardize the continued existence of the piping plover and roseate tern. The FWS estimated that implementation of the Bird Island restoration project will offset any potential roseate tern mortality that may occur from the proposed action.

However, pursuant to Section 7(b)(4) of the Endangered Species Act, the FWS identified five reasonable and prudent measures that are necessary and appropriate to minimize incidental take of roseate terns and piping plovers, and these are presented in Section 9, while the terms and conditions required for implementation of their reasonable and prudent measures are presented in their BO. In a similar fashion, NOAA Fisheries identified four reasonable and prudent measures that are necessary and appropriate to minimize incidental take of the four sea turtle species, and these are presented in Section 9, while the terms and conditions required for implementation of their reasonable and prudent measures are presented in their BO.

### 5.3.3 Socioeconomic Resources and Land Use

Socioeconomic data provided to describe socioeconomic impacts in this section came from the United States census unless otherwise noted (http://factfinder.census.gov). The most recent available U.S. Census community data for Barnstable County, Massachusetts and Washington County, Rhode Island came from 2005 estimates, and the most recent available community data for Nantucket County, Dukes County, and Bristol County, Massachusetts came from the 2000 census (U.S. Census, 2005 and U.S. Census, 2000).

There would be few and minor adverse impacts on socioeconomics from the construction and operation of the proposed action. In addition, the proposed action would create jobs and require the purchase of goods and services which could benefit the local and regional economies. The applicant would implement a variety of mitigation measures to address impacts on socioeconomics, which are discussed in Section 9.0.

#### *5.3.3.1 Urban and Suburban Infrastructure*

##### 5.3.3.1.1 Construction/Decommissioning Impacts

**Housing**

The increase in number of workers to fill the construction requirements of the proposed action would be modest: 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (79 and 237 of which would be from Massachusetts and Rhode Island, respectively) and 75 for construction and installation activities (56 and 19 of which would be from Massachusetts and Rhode Island, respectively). Fewer workers would be required to decommission the proposed action as manufacturing activities would not be required, while some dis-assembly jobs would occur. It is unlikely that this level of employment would require significant migration of workers from outside of the ROI. However, as shown in the existing conditions discussion, the Barnstable County, Massachusetts communities of Barnstable and Yarmouth had over 10,000 vacant housing units in the year 2000. Even considering that 89 percent of those vacant units are considered to be seasonal or recreational in nature, there would still be approximately 1,200 housing units available in Barnstable/Yarmouth to accommodate the new residents. As a result, the proposed action would have a negligible impact on housing in the area. In addition, the relatively small number of workers required relative to the population of Barnstable County indicates that workers coming to live in the area during construction and or operation would have a negligible impact on public services (i.e., school system enrollment, water use, sewer demands, emergency services, etc.). The manufacture and assembly operations slated for Quonset, Rhode Island would also have negligible impact on housing and public services given the relatively small number of employees relative to the number of vacant homes in Washington County Massachusetts.

**Construction and Manufacturing Industries**

The proposed action would have minor impacts on Barnstable and Washington counties through the resulting temporary increase in construction employment, and associated hirings and purchases that would benefit the construction and manufacturing industries. Refer to Section 5.3.3.2 for further information on economic impacts of the proposed action.

**Service Industries**

The proposed action would have a minor impact on Barnstable and Washington counties through the temporary increase in demand for service industries during construction (i.e., restaurants, hotels/motel use, hardware, and etc.). Refer to Section 5.3.3.2 for further information on the economic impacts associated with the proposed action.

**Waste Disposal and Transit Facilities**

The only impact on the Barnstable and Washington county waste disposal and transit facilities would consist of normal work day waste produced by workers who load and unload from boats in Falmouth, and small anticipated small quantities of wasted associated with manufacture and assembly in Quonset. This waste disposal would have negligible impact on the area.

**Military Activity and Energy Industry**

The construction and decommissioning activities associated with the proposed action are not anticipated to have effects on the military activity in the area or the energy industry during its construction/decommissioning phase. Refer to discussion of these issues with respect to operational impacts at 5.3.3.7.

**Conclusions**

The proposed action is expected to have negligible to minor impacts (both positive and negative) during construction/decommissioning on urban and suburban infrastructure (i.e., impacts on housing, construction and manufacturing industries, service industries, waste disposal, and military activity). This is because the construction workforce required is relatively small relative to the work force in the area, and there is ample availability of necessary housing stock and other infrastructure to accommodate the construction activity.

#### 5.3.3.1.2 Operational Impacts

**Housing, Construction and Manufacturing Industries, Service Industries, Waste Disposal**

Approximately 50 workers are required to operate and perform routine maintenance on the facility. These workers would access the site via work boats from Falmouth with a maintenance supply vessel coming from New Bedford, Massachusetts. As the level of employment for operations and maintenance is very small, there will be no significant in-migration of workers from outside of the ROI, and impacts on housing, municipal services and infrastructure in the area would be negligible. The proposed action, once in operation would also have a negligible impact on construction and manufacturing industries and service industries due to the small number of workers required and negligible amount of supplies needed to be purchased to run the facility. Once in operation, the facility would generate a negligible amount of solid waste and thus there would be negligible impact with respect to waste disposal requirements.

**Military Activity**

Concerns have been raised as to how the proposed action would impact the PAVE PAWS early warning radar site. However, in a memo dated March 21, 2004, the U.S. Air Force stated, "Our experts have reviewed the proposed locations for the Wind Power Plant near Cape Cod AFS and have determined it poses no threat to the operation of the PAVE PAWS radar at Cape Cod AFS. At the nearest proposed location, the main radar beam would clear the towers by more than 4,500 ft (1,372 m)" (Refer to Air Force Letter and PAVE PAWS Report in Appendix B).

**Energy Industries**

***Electrical Generating Capacity, Base and Surge Load Servicing, Transmission and Relay System, and Wholesale Energy Market***

The proposed action represents a new source of generating capacity, which would provide electricity to the region and contribute to the Commonwealth of Massachusetts's alternative energy portfolio. The electricity from the proposed action would most likely be consumed in the area of the facility (i.e., Cape Cod and the Islands). The proposed action's expected production of 182 MW of electricity in average wind conditions would meet three quarters of the 230 MW average demand of Cape Cod and the Islands, and thus have a substantial positive impact on electrical generating capacity. Negligible impacts are anticipated to base and surge load servicing, as the ISO-NE manages the electrical system to create built in redundancy to address planned and unplanned outages. With respect to transmission cable system impacts, the proposed action has undergone a system impact study by NSTAR and with NSTAR's recommended system upgrades, the proposed action was found to not have an adverse impact on the NEPOOL transmission system and "would improve the Cape area transmission performance particularly when the power plant is producing power" (Tourian, 2005a and Tourian, 2005b).

In addition to managing the electrical system, ISO-NE also is responsible for regulating the electricity market. Electricity prices are determined through the ISO-NE's wholesale energy market. The wholesale energy market functions like an auction. Electric utility companies and competitive suppliers forecast customers' electricity consumption, and bid to buy wholesale power at a specified price per megawatt-hour (MWh). Similarly, power plants offer into the auction to produce a certain amount of electricity at a specified price per MWh. The ISO-NE takes the lowest priced energy bid by suppliers until the point where total demand equals supply. The proposed action will participate in this wholesale energy market and ISO-NE will continue to take the lowest priced energy supplied to fulfill demand. Therefore, the proposed action will not increase energy prices in New England and could help to lower energy prices, should it supply energy at lower prices per megawatt hour.

**Conclusion**

The proposed action is expected to have a negligible impact during operations on urban and suburban infrastructure (i.e., impacts on housing, construction and manufacturing industries, service industries, waste disposal, and military activity). This is because once the proposed action is in operation it would only require a very small workforce and minor services from the local area, and generate a negligible amount of solid waste. The socioeconomic impact on the energy industry during the operational period would be moderate as the proposed action would result in a substantial contribution to the Commonwealth of Massachusetts' alternative energy portfolio standards.

### 5.3.3.2 Population and Economics

#### 5.3.3.2.1 Construction/Decommissioning Impacts

**Impacts on Demographics**

Construction would require a small number of workers relative to the population of the area, most of whom would commute to the area (an annual average of 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (likely in Quonset Rhode Island), and 75 for construction and installation activities in Barnstable, Massachusetts. As such the proposed action is expected to have a negligible impact on population, as well as other demographic factors including age, race and ethnic composition, and education.

**Impacts on Economics**

The direct economic impacts in the Region of Impact (ROI) and Massachusetts during manufacture and assembly and construction and installation would consist of the hiring of manufacture, assembly, and construction and installation workers and the purchase of non-labor goods and services. Most of the specialized components of the WTGs, such as the nacelles (i.e., the portion of the WTGs that contain the drive train and the electromotive generating systems), and the rotors would be purchased outside the ROI and very likely outside of Massachusetts (Report No**.** 5.3.3-1). Other non-labor goods and services would be bought in Massachusetts or Rhode Island such as concrete, steel, and barge services. The temporary increase in economic activity within the ROI and Massachusetts during the manufacture and assembly and construction and installation phase would be the sum of the: (1) direct economic impacts – hiring of manufacture and assembly and construction and installation workers and purchases of non-labor goods and services; (2) indirect effects – the additional demands for goods and services, such as replacing inventory, from the industries that sell goods and services directly to the project; and (3) induced effects – the increases in employment, income, etc. generated by the expenditure of disposable income of the newly hired manufacture and assembly and construction and installation workers. The size of the temporary increase in economic activity in the ROI and Massachusetts during manufacture and assembly and construction and installation and operation would depend on the proportion of direct expenditures that take place within these regions. Once the proposed action begins operating, the direct, indirect and induced economic effects would be permanent changes to the state and ROI economies.

**Impacts on Employment**

Based on the estimate of total person-months of labor required for manufacture, assembly, construction, and installation phases, it is estimated that a total of 880 person-years of labor would be required during the manufacture, assembly, construction, and installation phase, 711 for manufacture and assembly operations and 169 for construction and installation activities. Assuming a 27-month manufacture and assembly and construction and installation phase, this translates into an annual average of 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (79 and 237 of which would be from Massachusetts and Rhode Island, respectively) and 75 for construction and installation activities (56 and 19 of which would be from Massachusetts and Rhode Island, respectively). However, in actuality the manufacture and assembly and construction and installation activities would not be evenly distributed across the manufacture and assembly and construction and installation phases, but would instead peak during year 2 when the maximum temporary employment at the two locations at one time would be about 600 workers. Given the size of the regional manufacture and assembly and construction and installation labor market, and proximity of manufacture and assembly and construction and installation phase operations to both the Boston and Providence Metropolitan Statistical Areas (MSA), it is estimated that 75 percent of the construction and installation workers would be from Massachusetts, while 25 percent of the manufacture and assembly workers would be from Massachusetts. The latter proportion could rise if some or all of the manufacture and assembly operations are conducted in Fall River, Massachusetts, or possibly southeastern Massachusetts.

In addition to the employment benefits described above, the use of the IMPLAN input/output (I/O) model predicts secondary induced employment benefits resulting in an additional 206 to 622 jobs in Massachusetts and an additional 388 to 1,150 jobs in Rhode Island.

### Impacts on Income and Wealth

Impacts on income and wealth would come from new wages associated with construction and operation of the proposed action, as well as purchases of equipment and services locally (i.e., non-labor goods and services). It is estimated that total payments of wages and salaries to Massachusetts' residents hired during the manufacture and assembly and construction and installation phase would be about $17,158,000. In addition, total payments of wages and salaries to Rhode Island residents hired during the manufacture and assembly and construction and installation phase would be about $32,445,000 over the 27-month period.

In order to estimate the temporary increase in economic activity during the manufacture and assembly and construction and installation phase, the IMPLAN input/output (I/O) model was used for Massachusetts. A discussion of the model is provided in Report No. 5.3.3-1. Approximately 20 percent of the Project's total capital cost of $700 million would be needed for labor, while 80 percent would be required for non-labor goods and services, including the WTG components; electric equipment including transmission lines; environmental studies and licensing costs; materials; legal service; construction materials, such as steel; and transportation services. The 80 percent share for non-labor costs means that the temporary increase in economic activity in the ROI and Massachusetts, and even in New England, during the manufacture and assembly and construction and installation-phases would depend primarily on the value of non-labor items purchased within these regions. Based on the location of likely suppliers for the WTG components, it is estimated that between $150 million and $250 million in purchases on non-labor goods and services would occur in Massachusetts during the manufacture and assembly and construction and installation phases. Total output in Massachusetts would increase by between $85.0 million and $137.4 million annually, while the annual increase in value added would range between $43.9 million and $71.0 million (Report No. 5.3.3-1). Total output in Rhode Island would increase by between $180.6 million and $292.0 million annually, while the annual increase in value added would range between $93.3 million and $151.0 million. In addition, between $360 million and $410 million in purchases on non-labor goods and services would occur in Rhode Island during the manufacture, assembly, construction, and installation phases.

Other Massachusetts property income, comprised of rent, dividends and interest, and corporate profits, would rise by between $9.2 million and $14.8 million annually, producing an annual increase in corporate income taxes of between $434,900 and $702,200 if half of the increase were taxable corporate net income. The total increase in corporate income tax revenues during the manufacture and assembly and construction and installation phases could range between $1.304 million and $2.106 million.

Other Rhode Island property income, comprised of rent, dividends and interest, and corporate profits, would rise by between $19.6 million and $31.5 million annually, producing an annual increase in corporate income taxes of between $924,000 and $1.5 million, if half of the increase were taxable corporate net income. The total increase in corporate income tax revenues during the manufacture and assembly and construction and installation phases could range between $2.8 million and $4.5 million.

**Impacts on Business Activity by Industrial Sector**

The main impacts of the proposed action would be on the construction sector as a result of construction related job hires and purchase or lease of offshore construction vessels, equipment, and related supplies, as described above. Accordingly, the proposed action is expected to have a minor to moderate positive impact on the construction industry in the area.

**Conclusion**

The proposed action is expected to have a minor impact on population and economics during its construction/decommissioning. The proposed action would generate construction jobs (391 full time, temporary jobs) and generate revenues resulting from construction jobs (approximately $50 million to be spent on construction wages) as well as contribute to the economy via the purchase of materials and supplies, and secondary induced economic effects from construction.

#### 5.3.3.2.2 Operational Impacts

**Impacts on Demographics and Employment**

Approximately 50 workers would be required to maintain the facility during operation, with approximately $2.64 million spent on salaries. The use of multipliers indicates that as many as another approximately 104 additional indirect jobs may result from the proposed action's operation (Report No. 5.3.3-1). Impacts from operation on demographics and employment would be negligible given the small number of operational workers relative to the area workforce and size of the economy.

**Impacts on Income and Wealth**

Once the facility begins operation, an estimate of the annual operation and maintenance (O&M) purchases is approximately $16 million to maintain the facility. The annual purchase of O&M services would generate additional permanent increases in economic activity in the ROIs. The combination of the direct, indirect and induced effects as described above would generate an annual increase in Massachusetts' personal income tax revenues of $346,500, while the rise in corporate income tax revenues would be approximately $113,900.

It is estimated that the on-land improvements of the transmission line and related facilities located in Barnstable and Yarmouth would have an assessed value of $26.25 million, and generate annual property tax revenues of $62,500 in Barnstable and $217,200 in Yarmouth. Approximately 25 percent of the onshore transmission facilities would be located in Barnstable and 75 percent would be located in Yarmouth.

The resultant employment and tax revenues would have a minor to moderate positive impact on the tax revenues for the Towns of Barnstable and Yarmouth, but negligible impact when measured against the larger economy of Massachusetts. The resultant employment and tax revenues associated with the maintenance operation out of New Bedford would have a negligible impact when measured against the local economy.

**Impacts on Property Values**

Currently available information does not support any firm conclusion with respect to the wind facility's effect on property values. A potential purchaser of a piece of property would make an offer to purchase based on his or her own values and sense of aesthetics, which may or may not be affected positively or negatively by the proposed action. A U.S. Government funded study published in 2003 entitled "The Effect of Wind Development on Local Property Values" examined 25,000 real estate transactions within 5 miles (8.0 km) of ten of the larger wind farms built in the United States between

1998 and 2001. The study found no adverse effect of views of wind turbines on nearby real estate values. Similarly, in 2006 a study entitled "Impacts of Windmill Visibility on Property Values in Madison County, New York" found no negative impact on real estate values from a wind farm there. Thus, there is evidence that some wind projects may not affect property values, though impacts are likely to vary on a project specific basis, and based on the person or persons own interpretation of whether they like or dislike the wind farm.

**Impacts on Business Activity by Industrial Sector**

Impacts on the ROI during operations of the proposed action would be limited to employment of a small crew for maintenance of the proposed action. This small amount of new employees would have a negligible impact on overall business activity and the local economy.

**Public Perception**

Many comments were received both in favor and against the proposed action. A recent contingent evaluation study (Seltzer, 2006) concluded that in general people were willing to pay $164.41 per year for a policy that would allow Nantucket Sound to be used for the proposed action. The study attempted to measure peoples attitudes toward the development and included the presentation of visual simulations to help show what the proposed action would look like. Thus, the study attempted to incorporate peoples' attitudes to aesthetic impacts as well as other factors. Yet, contingent valuation studies can be prone to errors depending on how they are carried out, and one review of the study concluded that it was not reliable because the methodology did not follow professional standards for contingent valuation studies (Ward and Niemi, 2007).

**Health Impacts**

The proposed action would have negligible impacts on public health as its operation would comply with environmental standards to protect public health and the facility would not generate air or water pollution that could affect public health.

**Tourism and Recreation**

Comments were received on the MMS public notice and subsequent DEIS that the proposed action would have a negative impact on tourism and recreation due to visual impacts, and other comments were received that the proposed action would have a positive impact on tourism and recreation due to the desire of persons to visit the WTGs via boat tours and the potential for additional recreational fishing opportunities as a result of the added hard bottom structure associated with the monopiles. It is difficult to predict the economic impact of the proposed action on tourism and recreation. However, as discussed in the visual section at 5.3.3.4.2, the visual impacts of the proposed action are unlikely to affect the viability of the recreational areas upon which tourism is strongly based (i.e., the general public is not expected to stop using the recreational areas around Nantucket Sound, Cape Cod and the Islands for summer enjoyment including activities like sitting on the beach, viewing the expanse of Nantucket Sound, swimming, fishing, sailing, and other recreational activities). In general, direct impacts to recreation from the WTGs to recreation such as boating and fishing are minor and discussed further in Section 5.3.3.6.

**Conclusion**

The proposed action is expected to have a minor impact on population and economics during its operation through its operation and maintenance expenditures, tax payments, and the small increase in jobs related to operation. The applicant has provided further economic benefits including payments to the Town of Yarmouth of $350,000 annually or $7,000,000 over twenty years of operation for the on land portion of the interconnection line. Discussion of any mitigation measures proposed by the applicant or being required by MMS is provided in Section 9.0.

#### 5.3.3.3 Environmental Justice

A socioeconomic analysis was conducted and showed that the counties within the ROI (Barnstable County, Nantucket County, Dukes County, Washington County, and Bristol County) had a lower percent minorities than the rest of the State, and a lower percentage of people living under the poverty level than the rest of the state and thus the ROI in a broad sense is not within an environmental justice population (refer to Section 4.3.3.3.1).

Although the statistics for Barnstable County as a whole indicate that the area is not an environmental justice area of concern, the Massachusetts Environmental Justice GIS Map shows that there is a smaller census block group in and around Hyannis, Massachusetts that is an Environmental Justice Population (refer to Figure 4.3.3-1). The on-land cable portion of the proposed action is located outside of this area, but the existing substation where the cable connects is located within this area. The location of the existing substation is outside the population center of Hyannis and work at the substation is expected to be minor with negligible environmental impact. As discussed in Section 4.3.3, Wampanoag tribes are located in the ROI in the Town of Aquinnah (Gay Head) and in the village of Mashpee, Massachusetts and constitute an environmental justice population. Due to the distances of these two Indian tribal lands from the offshore proposed action site, (Gay Head Wampanoag Tribal Land is 24 miles [38.6 km] away and Mashpee Wampanoag Tribal Land is more than 10 miles [16.1 km] away) direct environmental impacts on these areas is limited. During government to government consultations between MMS and the tribes, there was concern expressed that the proposed action would interfere with the tribes' subsistence fishing. However, the proposed action would not preclude fishing from the area around the proposed action and the spacing of the turbines would not have a significant affect on fish populations or trawling and other types of fishing activities at the site of the proposed action. Visual impacts on these tribes is discussed in Section 5.3.3.5.2.

##### 5.3.3.3.1 Construction/Decommissioning Impacts

The onshore cable portion of the proposed action would be constructed in streets and in an existing ROW, and thus would result in negligible to minor environmental impacts. Only the area of the cable interconnection with an existing substation is within a State GIS designated environmental justice population area, and the work at this location would be minor and at an existing substation. Construction work is not located near Wampanoag tribal lands and would not affect these areas, though economic benefits including construction jobs, and economic revenues (refer to Section 5.3.3.2.1) could have a minor positive impact on environmental justice populations including the Wampanoag's.

Construction/decommissioning impacts are not expected to result in a disproportionately high adverse environmental and/or health impact on low income or minority populations in the ROI.

##### 5.3.3.3.2 Operational Impacts

As discussed above, the ROI in a broad sense is not within an environmental justice population. Therefore, operational impacts are not expected to result in a disproportionately high adverse environmental and/or health impact on low income or minority populations in the ROI. See Section 5.3.3.5.2 for further discussion of impacts to Native American tribes.

### *5.3.3.4 Visual Resources*

#### 5.3.3.4.1 Construction/Decommissioning Impacts

Visual impacts during construction and decommissioning would be limited to vessels working out in Nantucket Sound and traveling back and forth between Barnstable (for worker staging/supplies) and Quonset, Rhode Island (for manufacturing/assembly). Equipment for installation and decommissioning of the monopiles would require the use of jack-up barges and cranes. The installation of the monopiles is expected to take 8 months and installation of the WTGs is expected to take approximately 9 months. A crane and barge would also be required for near shore dredging work associated with construction of the exit hole associated with the horizontal directional drill operation for the landfall of the offshore transmission cable system. Utility line construction equipment would also be required on land to install the onshore transmission cable system. The onshore portion of the work is expected to take approximately 10 months. Decommissioning is expected to require similar equipment and time requirements. The larger construction/decommissioning vessels would be a visible feature within the area viewshed, more so from boats in proximity to Horseshoe Shoals than from land. And while most construction is expected to occur during daylight hours, these vessels would have nighttime lights in accordance with USCG regulations. In addition, during dawn and dusk periods, particularly on cloudy days, work lights may be required for worker safety as well as to improve visibility on construction vessels. Work lights are generally downward directed lights and would not typically be oriented horizontally where their visibility on shore would be increased.

**Conclusion**

Visual Impacts associated with construction/decommissioning would be limited to construction equipment and partially built structures depending on phase of construction. Such impacts in general would be minor as construction equipment would only be in use temporarily during the construction and decommissioning periods.

#### 5.3.3.4.2 Operational Impacts

**Major Visual Components of the Proposed Action**

The proposed action is a 454 MW offshore wind-powered electric generating facility, with associated offshore and onshore transmission cable system. As currently proposed, the proposed action includes 130 3.6 MW offshore wind turbines, each mounted on 257 ft (78.3 m) tall tubular steel monopile towers. The 3-bladed rotors have a diameter of approximately 364 ft (111 m) and would reach a maximum height of approximately 440 ft (134.1 m) above sea level. Each tower has a service platform located approximately 30 ft (9.1 m) above the water surface. The turbines are arranged in a grid pattern with an approximate separation distance of 0.3 to 0.5 miles (0.6 to 0.9 km).

The 50 perimeter WTGs and the eight WTGs located directly adjacent to the ESP would be lit at night. Every corner would be marked with a medium intensity red light (similar in intensity to FAA L-864) at night with no more than 1.7 miles (2.8 km) between medium intensity lights. The remaining perimeter WTG would be marked with low intensity light fixtures (similar in intensity to FAA L-810), visible from approximately 1.15 miles (1.9 km). The eight interior WTGs adjacent to the ESP would have the low intensity lights. All other interior WTGs would not be lit by red lights at night. The red lights on the perimeter WTGs would be synchronized to flash in unison rather than randomly as previously proposed. The red lighting would flash on for one second, with no lighting for two seconds, for a total of 20 FPM. This lighting design complies with the new FAA guidelines. The FAA lights would be visible from land.

Two USCG amber navigation warning lights would be also installed on the access platforms of each tower approximately 32 ft (9.8 m) above the water's surface. The USCG access platform lights would not be visible from land. If, over concerns about navigation safety within the wind turbine array, the USCG requires day beacons as part of the mitigation for radar impacts, then certain WTGs would contain lights that operate during daylight hours. These day beacons would most likely be used to demarcate designated travel lanes through the wind turbine array.

Other visible components of the proposed action include a 20 x 26 ft service platform on top of the nacelle, which is topped with an FAA aviation warning light.

The ESP includes an enclosed structure, 49 ft (14.9 m) tall, by 185 ft (56.4 m) long, by 82 ft (25 m) wide, which houses transformers and electrical switching equipment. The enclosed structure rests on a platform that is 200 ft by 100 ft (61 m by 30.5 m). The platform is sided with metal panels and supported by cross-braced tubular steel legs, approximately 40 ft (12.2 m) above the water surface at MLLW. No FAA lights are required on the ESP; USCG lighting would be installed, as described above. Helicopter warning lights would be remotely activated on the helipad as needed. All built components of the facility are proposed to be painted an off white color.

The turbine array would be located 13.8 miles (22.2 km) from Nantucket, 9 miles (14.5 km) from Edgartown, 9.3 miles (15.0 km) from Oak Bluffs, 5.6 miles (9.0 km) from Cotuit, 6.5 miles (10.5 km) from Craigsville Beach, and 5.2 miles (8.4 km) from Point Gammon.

**Visual Assesment Methodology**

The visual simulation views were chosen to represent worst case views from selected historic structures and other recreational areas assessed. They were developed using state of the art software that allows for accurate placement and sizing within the photograph. Full details on how the simulations were prepared are provided in Report No. 5.3.3-2. With respect to extrapolation of impacts to other areas not simulated, locations near these representative viewpoints would have similar views of the proposed action, locations seaward or closer than these viewpoints would have somewhat more visual impacts depending on their distance to the WTG's, and sites inland of these areas would have less visual impacts due to blocked views from trees and or structures, greater atmospheric effects, and/or smaller visible structure size. Though variable depending on tree cover and houses in the area, generally, locations more than 300 ft (91.4 m) inland would not have views of the proposed action.

**General Overview of Impacts**

The proposed action is located more than 4 miles (6.4 km) from land and thus would appear in the "background" viewing area as defined by the U.S. Forest Service. In this area, objects appear smaller than in the foreground (0 to 0.5 miles [0 to 0.8 km]) or the midground (0.5 to 4.0 miles [0.8 to 6.4 km]). The U.S. Forst Service states that in the background area "texture has disappeared and color has flattened" due to the distance away from the object. The photo simulations show that the general landscape features or landform in the vicinity of the proposed action is the flatness associated with the expanse of the ocean. The WTG's represent a new vertical element in this flat landscape, though the simulations show they appear small compared to the vastness of the ocean and sky in the midground and background.

With respect to the geographic extent of the visual impacts, the simulations show the WTGs would be visible from the surrounding shorelines (Falmouth to the west, Barnstable to the north, Martha's Vineyard to the west and south, Nantucket to the South, and Monomoy to the east. Refer to photosimulations which also include distances to the WTGs at Figure 5.3.3-1, 5.3.3-2, and 5.3.3-3.

### Visual Impacts to Historic Structures and Districts- Assessment of Effects

The ACHP regulations at 36 CFR 800.5(a) require the MMS to apply the criteria of adverse effect to historic properties within the APE, which are discussed in Section 4.3.4 and summarized in Table 5.3.3-1. The visual simulation views also are noted in Section 4.3.4 and in Table 4.3.4-1. Three categories of effect are considered for each property identified: adverse effect, no adverse effect, and no effect.

According to 36 CFR Part 800.5(a)(1), "an adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association." Accordingly, for an effect to be considered adverse, it must alter a qualifying characteristic of the property, or "diminish the integrity of the property's significant historic features" (36 CFR Part 800.5(a)(2)(v)). A finding of no adverse effect has been made when the view of the WTGs is very limited, and a finding of no effect is made when a view of the undertaking from historic properties within the undertaking's APE is not present.

An underlying assumption used in the assessment of adverse visual effects for the proposed project is that, for the Nantucket Sound area, the ocean is an important component of the setting for all of the historic properties within the APE, since many of them were designed as seasonal resort communities to take advantage of the coastal setting, or light houses, designed to warn watercraft of hazards. Therefore, any open view of the proposed project from a historic property is considered to be an adverse visual effect. Table 5.3.3-1 summarizes the assessment of effects considerations for the historic properties located within the proposed action's APE.

As a result of comments and recommendations received from consulting parties during the ongoing Section 106 consultation process, MMS has reconsidered the analysis and conclusions published in the DEIS, and has revised its determinations of adverse visual effects to historic properties. While the methodology employed during preparation of the DEIS is an equally valid approach as that used by the applicant, the outcomes were different because of some different features of the methodologies. MMS now concludes that adverse effects from construction and operation of the proposed action will occur to 16 historic properties evaluated in the DEIS, as was concluded by the applicant and presented in the FEIR document. MMS also has evaluated 22 additional properties for potential eligibility to the NRHP that were brought to the attention of MMS after release of the DEIS and assessed effects the project would have on those properties that meet NRHP eligibility criteria. Eighteen of the 22 properties evaluated after publication of the DEIS are recommended eligible or were identified by MHC as eligible for inclusion in the NRHP, and it was determined that the project will have an adverse visual effect on 12 of those properties, for a total of 28 historic properties that will be adversely affected by the project. There will be no adverse effect on one and no effect on five of these 18 properties (see Table 5.3.3-1).

### Conclusions on Visual Impacts to Historic Structures and Districts during Operation

Based on an analysis of visual effects undertaken in the visual impact assessment, which included both daytime and nighttime visual simulations, MMS concludes that the proposed action would have an adverse effect on two National Historic Landmark (NHL) properties (the Kennedy Compound and the Nantucket Historic District), four historic districts listed on the NRHP (Cotuit Historic District, Wianno Historic District, Hyannis Port Historic District, and Edgartown Village Historic District), 10 individual historic properties listed on the NRHP (Nobska Point Light Station, Col. Charles Codman Estate, Wianno Club, Monomoy Point Lighthouse, West Chop Light Station, East Chop Lighthouse, Tucker Cottage, Edgartown Harbor Lighthouse, Cape Poge Lighthouse, and Nantucket/Great Point Lighthouse), 10 historic districts determined or recommended eligible for the NRHP (Falmouth Heights Historic District, Ocean Grove Historic District, West Chop Historic District, Maravista Historic District, Menauhant Historic District, Church Street Historic District, Park Avenue Historic District, Champlain Road Historic

District, Cottage City Historic District, and Vineyard Highlands Historic District), and two individual properties recommended eligible for the NRHP (Hithe Cote and Stage Harbor Light). The visual alteration that the WTGs would entail to the setting of these properties, particularly the relatively close, unobstructed views to the WTGs from nearly any vantage point within the properties, would diminish the integrity of these properties' significant historic features.

The proposed action would have no effect on two NHL properties (the Martha's Vineyard Campground Historic District/Wesleyan Grove NHL and Flying Horses Carousel NHL), one NRHP district (William Street Historic District), three individual NRHP properties (the Ritter House, the Arcade, and the Oak Bluffs Christian Union Chapel), one district recommended eligible for the NRHP (Massachusetts Avenue Historic District), and four individual properties determined or recommended eligible for the NRHP (Seaman's Reading Room, Three-quarter Cape house at 205 South Street, Capt. Joshua Nickerson House, and Jonathan Higgins House). These properties are generally within the visual APE defined as 300 ft (91.4 m) from the shoreline, but are screened from water views by intervening structures, vegetation and/or topography.

A finding of no adverse effect was issued for the Stage Harbor Road Historic District, due to a very limited view to the project.

At present, the MMS is continuing the Section 106 process, and will continue consultation per 36 CFR 800 to evaluate strategies to mitigate adverse effects and to consider appropriate mitigation measures to minimize impacts.

**Visual Impacts to Tribal Areas of Traditional Cultural and Religious Importance**

The potential visual impact of the proposed action on the Wampanoag Tribe of Gay Head/Aquinnah was raised as a concern during government to government consultations about the proposed action between the MMS and the Tribal Historic Preservation Office. Their ceremonies, and spiritual and religious practices, are dependent upon maintaining the ability to view the first light, the eastern horizon vista and viewshed.

To address the concern of visual impacts from Gay Head/Aquinnah, three line-of-sight profiles were created along transects originating at the approximate highest ground elevation in Gay Head/Aquinnah and extending northeasterly to the maximum height of the nearest proposed WTG along the profile. The three profiles were oriented to represent potential views of the landscape that a person standing at the Gay Head location would see when facing toward the left, middle and right (south side) of the WTG array. The locations of the three profiles (or transects) are shown on Figure 5.3.3-4. Profiles A, B and C are presented in Figures 5.3.3-5 through 5.3.3-7.

The transect lines on each figure are color coded to indicate areas along each profile that would be visible (green) to the person at Gay Head, based only upon screening afforded by the specific Martha's Vineyard topography along that profile. This type of line-of-sight profile does not take into account the additional screening effects of vegetation or intervening structures, if present. Areas not visible to the viewer, again based upon topography only, are indicated in red. As shown in the figures, the profiles indicate that no portions of the offshore turbines in the array would be visible to the viewers at Gay Head/Aquinnah.

In their letter of comment on the DEIS, George "Chuckie" Green, Jr., Tribal Historic Preservation Officer for the Mashpee Wampanoag Tribe, states, "The Mashpee are members of the Great Wampanoag Nation (the People of the First Light). Our name defines who we are ...." The letter goes on to state that the Mashpee have a significant cultural and religious need to have a clear unobstructed view of the southeast horizon. The land associated with the Wampanoag tribe of Mashpee is well inland from the coast line, and given the wooded vegetation, and fairly level topography, there would not be a view from this location. However, in a subsequent Section 106 Consultation meeting with the Mashpee and Gay Head/Aquinnah Wampanoag Tribes, the MMS was made aware of a sacred site off of tribal land from which there would be a view of the proposed project. Visual simulations from this viewpoint show that the wind turbines would be visible along the eastern horizon from the site. According to the Mashpee, religious ceremonies are often held at this location, and to the Mashpee, the altered view of the eastern horizon that would result from construction of the proposed project would be a major impact.

When the Indian tribes use areas beyond their tribal lands such as along the eastern/northeastern shoreline of Martha's Vineyard, or the southern Cape Cod Shoreline near Mashpee, or the waters of Nantucket Sound themselves, they would be able to see the Project, and would encounter visual impacts as discussed in Section 5.3.3.4.

**Visual Resource Impacts to Recreational Areas (Non Historical)**

The visual impacts from development of the proposed action on onshore recreational resources would be essentially the same as those described for onshore historic sites. Refer to simulation photographs in Figures 5.3.3-1 and 5.3.3-2. The same daytime and nighttime visual simulations are used to assess the degree of these impacts.

Nantucket Sound beaches along the southern shore of Cape Cod in the Towns of Falmouth, Mashpee, Barnstable, Yarmouth, Dennis, Harwich, and Chatham would have open views of the visible structures. The visual simulations indicate the greatest proposed action visibility would be between Cotuit (VP 5 at 6.4 miles [10.3 km] distance) and Hyannis Port (VP 8 at 6.2 miles [10 km] distant), including Craigville (VP 7 at 7.0 miles [11.3 km] distant). Applying these distances to areas not simulated west of Cotuit and east of Hyannis Port, visual impacts on Cape Cod are expected to be greatest from Great Neck in Mashpee to the mouth of Bass River at the Yarmouth-Dennis town line.

Open views would be available from other recreational resources along the south side of Cape Cod, including the Shining Sea Bike Path in Falmouth, the New Seabury Golf Club's Ocean Course, the Hyannis Port Golf Club, and shorefront conservation areas (see Table 4.3.4-2 and Figure 5.3.3-1).

Falmouth beachgoers would experience views between those simulated at Nobska (VP 1) and Cotuit (VP 5), depending on their respective distances to the wind turbine array. VP 5 approximates views at Mashpee beaches, including New Seabury and Popponesset, east through Oyster Harbors. Users of the small Town Beach at the eastern end of Sea View Avenue would experience similar views to VP 6. No views toward the water and the proposed action were found in the Village of Osterville. The Craigville simulation (VP 7) approximates proposed action visibility from the Craigville beaches, Long Beach in Centerville, and West Hyannis Port. Because this viewpoint was taken on a bluff at approximate elevation 35 ft (10.7 m) above sea level, the simulation provides somewhat more visibility of the built proposed action than would be experienced at sea level on the beaches.

Views from VP 8 are similar to what would be experienced at Kalmus Park Beach, the large public beach in Hyannis, smaller area public beaches, and the outer areas of Hyannis Harbor. Views from points to the east out to Chatham (VP 26) would be similar, although the structures would be increasingly smaller and less noticeable in the field of view as one proceeds east along the south shore of the Cape and away from the wind turbine array.

On Martha's Vineyard, open views of the proposed action would be available along the beaches and in the immediate vicinity from East Chop at Oak Bluffs south to the Edgartown Lighthouse. VP 21 is similar to what would be experienced under similar conditions at east-facing beaches between Oak Bluffs and Edgartown, as well as portions of Felix Neck Wildlife Sanctuary in Edgartown. Open views would be available from the beaches at Cape Poge on Chappaquiddick Island (VP 19).

On Nantucket, open but distant views of the proposed action would be available from beaches along the entire north shore of Nantucket Island east to Great Point.

Visibility of the proposed action would be affected during the high use season by the degree of haze and fog that develops over the water. According to the U.S. Coast Pilot 2 (NOAA, 2004) for Nantucket Sound "the characteristic advection fog, formed by warm air over cool water, is most frequent from April through August. At this time visibilities drop below 2 miles (3.2 km) 10 to 18 percent of the time. In addition the Coast Pilot provides a climatological table for Nantucket Island which shows that the number of days with fog averages 200 days annually. Thus, there would be a substantial portion of time (at least 10 to 18 percent in the summer months) where the proposed action would not be visible from shorelines.

In addition to the photographic simulations referenced above, daytime photographic renderings from each of the six viewpoints most distant from the proposed action were assessed using two generic waterfront photographs, to try to heighten the contrast and visibility of the WTGs against the sky. These are termed renderings (and each viewpoint is labeled with "B") to differentiate them from the site-specific photographs used to generate the simulations. The six viewpoints are listed below; photo-renderings are shown from each viewpoint respectively in Figure 5.3.3-3, sheets 1 through 6:

- **Viewpoint 1B:** Nobska Lighthouse, Woods Hole in Falmouth, Cape Cod;
- **Viewpoint 26B:** Monomoy Lighthouse, Monomoy Island, Chatham, Cape Cod;
- **Viewpoint 20B:** Lighthouse Beach in Edgartown, Martha's Vineyard;
- **Viewpoint 22B:** Nantucket Cliffs, Nantucket;
- **Viewpoint 23B:** Great Point, Nantucket; and
- **Viewpoint 24B:** Tuckernuck Island, Nantucket.

To develop each rendering, one of the two generic waterfront photographs were selected for each viewpoint, based upon the specific orientation of views toward the proposed action at that viewpoint, and the applicable sun angle that would heighten the visibility of the WTGs to the greatest degree. Both generic photographs were shot into the midday sun, resulting in a light-colored washed-out sky above the horizon. Under these conditions, depending on the orientation of each specific viewpoint toward the wind turbine array, WTGs on the horizon would either be cast into shadow or be strongly front-lit. These lighting conditions heighten the contrast of the WTGs against the sky. The WTGs are front-lit in views from north-facing viewpoints at Nantucket Cliffs and Tuckernuck Island because the sun angles at these locations would rarely back-light the WTGs. The WTGs are shown as back-lit in the remaining far-field viewpoints.

The distances range from almost 9 miles (14.5 km) in Edgartown to approximately 14 miles (22.5 km) at Nobska Lighthouse, Nantucket Cliffs, and Monomoy Lighthouse. Because the WTGs are relatively slim light-colored structures, they are difficult to see at these distances.

Visual impacts at very long distances (15 and 18.8 miles [24.1 and 30.3 km]) were also assessed. These represent distant views of the proposed action that would be experienced by viewers at some shoreline recreational resources, such as beaches and dock areas. For a listing of specific resources at these distances see Table 4.3.4-2 and Figure 4.3.4-3. Both of these photo-renderings represent potential daytime views of the proposed action under clear sky conditions from distant shoreline recreational areas. A visual Simulations has been prepared that shows the proposed action at a distance of 15 miles (24 km), and represents daytime views that would be experienced from south-facing Cape Cod beaches in Dennis Port and Harwich Port, near the border between the two towns (see Sheet 1 of Figure 5.3.3-8). An additional simulation has been prepared that shows the proposed action at a distance of 18.8 miles (30.3 km), representing daytime views that would be experienced from south-facing beaches in the vicinity of East Harwich and Chatham, and west-facing beaches on the northern portions of Monomoy Island (see Sheet 2 of Figure 5.3.3-8). The long viewing distances results in the facility structures looking very small, as a result of perspective, atmospheric clarity, and the curvature of the earth's surface.

**Visual Impacts from Boats in Close Proximity**

The turbines would obviously appear much larger while viewed close up by boaters traveling or recreating near the site. As such, the turbines would be much larger relative to surrounding features and would be more visible under hazy or foggy weather conditions at these distances. Figures 5.3.3-9 and 5.3.3-10 shows similar sized features from the Nysted Project in the Baltic Sea off of Denmark. Nysted consists of 72 turbines (2.2 MW Siemens), which are 226 ft high (69 m) to hub with 270 ft (82.4 m) rotors and 361 ft (110.2 m) overall height versus the proposed action which has an overall height of 440 ft (134.1 m). The Nysted turbines are spaced in a grid 2,789 ft by 1,575 ft (850 m by 480 m [or 10.4 rotor diameters by 5.8 rotor diameters]). The proposed action has a spacing of 3,281 ft by 2,064 ft (1,000 m by 629 m). Though these are not the same dimensions as the proposed action, the photographs approximate the type of visual impact a viewer is likely to see up close to the wind turbine array.

**Conclusions on Visual Impacts to Recreational Areas During Operation**

The proposed action represents a large manmade feature in the natural landscape of Nantucket Sound that would be viewed by many people in numerous shoreline areas used for recreation that surround Nantucket Sound. Conclusions as to the significance of visual impact on the people using recreational areas are difficult, as the interpretation of visual impacts is subjective. Many comment letters were received expressing opinions that the proposed action would cause an unacceptable visual impact, and many other comment letters were received expressing views that the proposed action would be beautiful to look at.[25] Visual impacts are important from Cape Cod locations as the proposed action would change the views out to Nantucket Sound from a mostly natural ocean setting, to a setting with manmade features present across a substantial portion of the horizon. Thus, the proposed action would have moderate visual impacts to recreational resources, with major visual impact limited to boaters that are transiting near or within Horseshoe Shoals since they would be located close to the structures. However, the visual impacts are unlikely to affect the viability of the recreational areas (i.e., the general public is not expected to stop using the recreational areas around Nantucket Sound for summer enjoyment including sitting on the beach, viewing the expanse of Nantucket Sound, swimming, fishing, sailing, and other recreational activities). In addition, minimization of visual impacts has occurred through minimization of nighttime lighting, color choice, and facility layout (refer to Section 9.0 for further information on visual impact mitigation).

[25] A recent contingent evaluation study (Seltzer, 2006) assessed among other things, people's opinions of what the Project would look like. This was performed by showing individuals photo simulations of the Project, and then asking their opinion as to how they think it would look. Overall, the largest group of responders had a neutral opinion toward visual impacts, though a much larger percentage of responders from Cape Cod thought the project would be ugly compared to those questioned who lived in other areas of Massachusetts. Yet, contingent valuation studies can be prone to errors depending on how they are carried out, and one review of the study concluded that this study was not reliable, because the methodology did not follow professional standards for contingent valuation studies (Ward and Niemi, 2007).

### *5.3.3.5 Cultural Resources*

#### 5.3.3.5.1 Construction/Decommissioning Impacts

**Impacts on Onshore Cultural Resources**

***Historic***

*Historic Archaeological Resources*

Based on the results of the terrestrial archaeological intensive survey, no significant historic archaeological resources have been identified within the proposed action's APE for ground disturbance along the onshore transmission cable system route. Therefore, the proposed action is expected to have a negligible impact on onshore historic archaeological sites during construction/decommissioning.

*Above-Ground Historic Resources*

No known or designated historic structures or districts have been identified within the Project's APE for ground disturbance on land, which consists of paved roadway and cleared NSTAR ROW. There would be no physical impacts to onshore historic structures and districts due to construction/decommissioning. Therefore, impacts are negligible along this portion of the site of the proposed action for historic properties.

Visual impacts to historic properties associated with construction/decommissioning are minor as they are temporary and limited to construction equipment and partially built turbine structures depending on the phase of construction.

***Prehistoric***

Based on the results of the terrestrial archaeological intensive survey, no significant prehistoric archaeological resources have been identified within the proposed action's APE for ground disturbance along the onshore transmission cable system route. Thus, construction/decommissioning impacts to prehistoric resources would be negligible.

**Impacts on Offshore Archaeological Resources**

***Historic***

Three targets with moderate probability of representing historic shipwrecks were identified in the vicinity of Horseshoe Shoal. The MMS would require that these three potential shipwreck locations be avoided by all bottom-disturbing activities during all proposed action construction, maintenance and decommissioning activities; therefore, construction/decommissioning impacts are expected to be negligible. If avoidance is not possible, then MMS would require groundtruthing of targets in consultation with MHC and MBUAR. The MBUAR and MHC concurred with these recommendations (see letters dated May 11, 2004 and May 19, 2004, respectively).

***Prehistoric***

The archaeological analysis of the subbottom profiler and vibracore data collected within the area of the proposed action identified organic material interpreted as paleosols (ancient land surfaces) in limited areas within the easternmost portion of the WTG array. The wind turbine array has been modified to avoid the areas where intact paleosols have been identified. No other areas having a high probability for prehistoric site occurrence were identified from marine remote sensing data collected within the site of the proposed action; therefore, impacts from construction/decommissioning are expected to be negligible.

***Tribal Areas of Traditional Cultural and Religious Importance***

The Wampanoag consider the entirety of Nantucket Sound to be ancestral lands, based on their oral traditions which hold that the Wampanoag people have inhabited the land from the western shore of Narragansett Bay to the Neponset estuaries since time immemorial, even the land now called Horseshoe Shoals. The marine remote sensing survey data and vibracores that were collected to locate preserved prehistoric archaeological sites (discussed in the previous section) identified some limited areas within the easternmost portion of the WTG array where ancient land surfaces were still preserved. In areas where the ancient land surface has survived marine transgression relatively intact, there is also the possibility that prehistoric cultural material remains (i.e., sites of ancestral tribal activities) could also be preserved in those areas. Analysis of the vibracores collected at these locations contained no evidence of material cultural remains. However, to minimize any possibility of impacting ancestral sites that might be present within these limited areas of preserved ancient land surface, the wind turbine array was modified to avoid these areas. The MMS also will include a "Chance Finds Clause" as a part of the lease document which requires the lessee to halt operations and notify the MMS if any unanticipated archaeological discovery is made during Lease activities. This clause is included in all MMS lease and permit documents.

In his letter of comment on the DEIS, George "Chuckie" Green, Jr., Tribal Historic Preservation Officer for the Mashpee Wampanoag, commented, "... if remains were found in 20–60 feet of water, who would know? Between the depth and turbulence, who would see? Furthermore, who would care?" The "Chance Finds Clause" is useful in providing a legal basis for prosecution if a lessee or permittee knowingly disturbs an archaeological site and does not report it; however, in practicality it is entirely possible that unanticipated archaeological sites (e.g., tribal ancestral sites) could be inadvertently disturbed during lease activities and it would neither be recognized nor reported. It is for this reason that the MMS takes a very conservative approach by requiring avoidance or further investigation of all areas that are determined to have any potential for archaeological resources when permitting OCS activities.

**Conclusion**

Based on cultural resource surveys conducted to date and through continued coordination with MBUAR and MHC and compliance with any other future requests for further analysis and or mitigation, the construction/decommissioning impacts are expected to be minor. MMS will require that all archaeologically sensitive areas identified during the surveys either be avoided or that additional investigations be conducted before the approval of any construction or decommissioning activities on the lease. If any archaeological resources are encountered during construction/decommissioning, MMS will require that operations be halted immediately within the area of the discovery and the discovery reported to the MMS Regional Director.

#### 5.3.3.5.2 Operational Impacts

The Advisory Council on Historic Preservation regulations at 36 CFR 800.5(a) require the MMS to apply the criteria of adverse effect to historic properties within the area of potential effects, which are discussed in Section 4.3.4 and summarized in Table 5.3.3-1. Three categories of effect are considered for each property identified: adverse effect, no adverse effect, and no effect. Table 5.3.3-1 shows that out of 41 properties assessed, 29 were identified as having an adverse effect, one no adverse effect, and 11 as having no effect. See Section 5.3.3.4.2 for definitions of these categories.

Operational impacts on cultural resources will be limited to the visual effects of the wind turbine array on onshore Above-Ground Historic Resources and on Tribal Areas of Traditional Cultural and Religious Importance. The ocean is an important component of the setting for all of the historic properties within the APE, since many of them were designed as seasonal resort communities to take advantage of the coastal setting, or light houses, designed to warn watercraft of hazards. In cases where the setting of the property is impacted in such a way as to diminish the integrity of the property's significant historic features, the proposed action is considered to have an adverse effect on the historic property. Table 5.3.3-1 summarizes the assessment of effects considerations for the historic properties located within the proposed action's APE.

**Conclusions on Visual Impacts to Historic Structures during Operation**

See conclusions to Section 5.3.3.4.2 for this assessment. In conclusion, the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures would constitute an alteration of the character, setting and viewshed of some historic properties.

**Conclusions on Visual Impacts to Tribal Areas of Traditional Cultural and Religious Importance during Operation**

For a full description of visual impacts to Tribal areas of traditional cultural and religious importance, see Section 5.3.3.4.2. Analysis of visual transects run from Gay Head/Aquinnah to the proposed project location indicates that no portions of the offshore turbines in the array would be visible to the viewers at Gay Head/Aquinnah. The MMS was made aware of a sacred site of the Mashpee Wampanoag, off tribal land, from which there would be a view of the proposed project. Visual simulations from this viewpoint show that the wind turbines would be visible along the eastern horizon from the site. According to the Mashpee, the altered view of the eastern horizon that would result from construction of the proposed project would be a major impact.

When the Indian tribes use areas beyond their tribal lands such as along the eastern/northeastern shoreline of Martha's Vineyard, or the southern Cape Cod Shoreline near Mashpee, or the waters of Nantucket Sound themselves, they would be able to see the Project, and would encounter visual impacts as discussed in Section 5.3.3.4.

### *5.3.3.6 Recreation and Tourism*

This section addresses impacts to recreational activities other than visual impacts. Refer to Section 5.3.3.4 for a discussion of visual impacts to recreational areas.

#### 5.3.3.6.1 Construction /Decommissioning Impacts

**Impacts on Tourism**

The proposed action is located far offshore and its construction and associated post lease G&G field investigation are not expected to affect tourism, the use of recreational parks, and use of the ocean for recreational activities (Refer to Section 4.3.6 for a presentation of recreational activities of the area). The construction of the onshore cable system would take place during the off season to minimize disruption of the tourist season. Accordingly, impacts to tourism are expected to be negligible during construction. Decommissioning impacts are also expected to be similar to construction impacts; therefore they would also be negligible.

**Impacts on Shoreline Activities and Birdwatching**

During construction and decommissioning, the noise and activity associated with installation of the onshore cable may temporarily disturb birds that inhabit the area, though this work would occur during the winter months when many migrating birds have vacated the area. In addition, given the altered and developed nature of the shoreline cable crossing location, it is unlikely that this is a high use area for birdwatching or beach recreation. Thus, construction and decommissioning impacts on birdwatching and shoreline use would be negligible.

**Impacts on Recreational Boating**

Details of the marine-based construction and post lease G&G field investigation would be closely coordinated with the USCG and local Harbor Pilots. During construction and decommissioning, it is likely that temporary vessel access restrictions in the immediate vicinity of construction operations may be required to protect public safety. These restrictions, however, would be limited to small sections of the area of the proposed action as the cable embedment process is completed or around WTG or ESP installation. Notice to Mariners would be posted and called on a daily basis or at intervals required by the USCG. The construction vessels would display the appropriate day shapes and/or lighting, and would monitor VHF Ch. 13 and Ch. 16 during operations. Thus, impacts on recreational boating during construction, the post lease G&G field investigations, and decommissioning would be minor.

**Impacts to Recreational Fishing**

During construction and decommissioning, it is likely that temporary vessel access restrictions in the immediate vicinity of construction operations may be required to protect public safety. These restrictions, however, would be limited to small sections of the area of the proposed action as the cable embedment process is completed or around WTG or ESP installation. Notice to Mariners would be posted and called on a daily basis or at intervals required by the USCG. The construction vessels would display the appropriate day shapes and/or lighting, and would monitor VHF Ch. 13 and Ch. 16 during operations.

In general, the proposed action would have a minor and localized impact on fishing during construction and decommissioning, as a result of temporary avoidance of disturbed habitat by fish species during these activities. Accordingly, impacts to recreational fishing during operation are expected to be minor.

**Conclusion**

The proposed action is expected to have a minor impact on recreation during construction/decommissioning. This is primarily because most of the construction and decommissioning activities would be located far from shore and are not expected to significantly impact avian or fish populations (see Section 5.3.2.4 for Avian Impacts and Section 5.3.2.7 for Fishery Impacts) or access to these areas by fisherman, birdwatchers, and tourists.

#### 5.3.3.6.2 Operational Impacts

**Impacts on Tourism**

The proposed action is located far offshore and is not expected to affect tourism and use of recreational parks and use of the ocean for recreational activities. Therefore, there would be negligible impacts to tourism during proposed action operation. Refer to Section 4.3.4 for discussion of how visual impacts could affect use of the area. In fact, there are undocumented reports of increased tourism after some European wind energy projects were constructed.

**Impacts on Birdwatching**

Since the proposed action would be a minimum of 4.8 miles (7.7 km) from shore and the cable portion of the proposed action onshore would be underground, there would be negligible impacts on recreational birding which primarily occurs along the shorelines of Cape Cod and the Islands.

**Impacts on Recreational Boating**

The proposed action would impact the Figawi sail boat race that occurs between Hyannis and Nantucket and back every year on Memorial Day. This impact would be moderate, but can be overcome by selecting a race course that does not pass through the site of the proposed action - the overlay of historic race courses shows the race can still be run without crossing the area of the proposed action (refer to Figure 4.4.3-2).

In addition, sail boaters, and to a lesser extent motor boaters, would be faced with a moderate navigational impact as the proposed action would in general make offshore cruising more difficult as the operator would have to take more care to avoid the structures. All structures would be marked on updated navigation charts, as the applicant will provide as-built coordinate information to the necessary agencies. Navigation in the area would be more difficult during fog conditions and/or at nighttime. Discussions with boaters revealed that many recreational boaters avoid the shallower portions of Horseshoe Shoal, particularly under wavier conditions when the shoals make the seas more choppy. Refer to Section 5.3.4.3 for a complete discussion of recreational boating impacts and to Section 9.3.4 for navigational impact mitigation. In some instances boaters may benefit from the WTGs since they represent aids to navigation and could be used for assistance in navigating through the wind turbine array. Overall, operational impacts on recreational boating would be minor.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts to recreational boating or sailing by restricting use of those small portions of the array that may be devoted to traffic management.

**Impacts on Recreational Fishing**

The recreational anglers surveyed by NOAA Fisheries through the MRFSS program from the three counties surrounding Nantucket Sound reported hook and line as the gear type used most frequently, and recreational anglers reported fishing from a private/rental boat as the most common mode of recreational fishing. A survey of commercial and recreational activities (Report No. 4.2.5-6) indicates that 25 percent of the recreational fishermen surveyed reported fishing on Horseshoe Shoal some portion of the time. (Given the small numbers of respondents, this survey is illustrative, but not statistically conclusive.) Recreational fishing on Horseshoe Shoal proper by small private/rental boats may be limited naturally by the strong tidal currents and rips and the wave fields that set up on windy days. Although the current patterns are likely to be affected in the vicinity of the WTGs and the riprap at the base of the piles, due to the distant spacing of the WTGs, it is not expected that the natural hazards will be qualitatively altered from those occurring without the WTGs.

Because the WTGs within the array would be spaced 0.39 by 0.63 (629 by 1,000 m) apart, the physical presence of these structures should not interfere with recreational fishing activity, including maneuvering of recreational vessels (see Section 5.3.2.7 for more detail) or using recreational fishing gear. The presence of the WTG monopile foundations may enhance recreational fishing for certain species, such as Atlantic cod, black sea bass, cunner, tautog, and scup (see Section 5.1.5.11); such phenomena have been documented at oil rigs in the Gulf of Mexico.

The proposed action should not affect other modes of recreational fishing, such as fishing from shore since the shoreline would be drilled under and shoreline areas would remain undisturbed.

The NOAA Fisheries charter and party boat CPB/VTR data indicates that the portion of fishing reported to occur within the area of the proposed action on Horseshoe Shoal accounts for only a small portion of the total federally reportable charter and party boats over an eleven year period. Although it appears that charter/party boat companies do not visit Horseshoe Shoal frequently, the operation of the proposed action should not interfere with any recreational fishing conducted from charter or party boats in the area of the proposed action, and once constructed, may, in fact, enhance recreational fishing for certain species discussed above.

In summary, the proposed action is not expected to interfere with recreational fishing during operation, as it would not prohibit access or use of existing recreational fishing areas and may in fact enhance fishing as a result of the WTG foundations. Accordingly, impacts to recreational fishing during operation are expected to be minor.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts to recreational fishing by restricting use of those small portions of the array that may be devoted to traffic management.

**Impacts from Unplanned and Accidental Events**

Should a cable failure occur, a Cable Repair Plan would be implemented (see Section 2.4.6 for a description of this plan). Impacts from cable repairs would include localized turbidity around the work area, localized and temporary bottom disturbance from anchoring the work vessels, noise impacts associated with the repair work, and emissions from the work vessels. Overall impacts from cable repair on recreation and tourism would be negligible.

Should an oil spill occur, impacts on recreation and tourism would depend on the location, magnitude, and sea conditions at the time of the spill. The applicant would be required to operate the facilities with an approved OSRP that would be designed to maximize the containment and clean-up of spilled substances. However, should an oil spill reach shoreline areas, there would be a temporary reduction in beach recreation and tourism because of the unpleasant conditions that would be present on the beaches.

**Conclusion**

The proposed action would have a minor impact on recreation during operation as it is not expected to significantly impact avian or fish populations (see Section 5.3.2.4 for Avian Impacts and Section 5.3.2.7 for Fishery Impacts) or access to these areas by fisherman, birdwatchers and tourists. Measures would be implemented to help aid in safe use of the area by recreational boaters such as informing boaters of the proposed action activities in Notice to Mariners and providing the necessary as-built coordinates to allow plotting of the facilities on NOAA nautical charts.

With respect to visual impacts on recreational areas, the proposed action represents a large manmade feature in the natural landscape of Nantucket Sound that would be viewed by many people in numerous shoreline areas used for recreation that surround Nantucket Sound. Conclusions as to the significance of visual impact on the people using recreational areas are provided in Section 5.3.3.4.

### 5.3.3.7 Competing Uses in the Vicinity of the Proposed Action

#### 5.3.3.7.1 Construction/Decommissioning Impacts

**Other Pipelines and Cables**

Although a portion of the proposed offshore transmission cable system would cross over one of the existing submarine cable systems already servicing Nantucket Island from Barnstable (Lewis Bay), the effects of this crossing are expected to be negligible since the crossing is over the top of the existing cable and would likely use some form of manufactured "bridging" that would involve a very narrow linear crossing area where the cables would intersect. This is a routine installation technique that results in temporary and localized effects on the seabed and prevents damage to the other utility line. There are also cables that run from Falmouth out to Martha's Vineyard, though these are well away from the proposed action location and would not be affected. There are no known bottom-founded structures in the vicinity of the site (other than structures associated with coastal marinas, which are located far from the proposed action area), and there are no pipelines in close vicinity to the proposed action area. The onshore portion of the transmission cable system can be constructed with due care to avoid affecting any existing utilities that may be present in the streets, road shoulders, or the NSTAR ROW.

**Navigation Features**

Maintenance dredging of nearby channels, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent uses of the waterway. However, such concurrent uses would only be temporary, and the area affected at any one time during construction of the proposed action is relatively small and would not have a negative impact on navigation. The applicant and the party undertaking the dredging would have to schedule activities and vessel locations so as not to interfere with each others operations.

**Sand Mining and Mineral Extraction**

There are no sand mining projects proposed within the area of the proposed action or during the scheduled timeframe of the proposed action construction activities. There would not be any space use conflicts between the proposed action installation and sand mining projects. Furthermore, because there is currently a moratorium on oil and gas leasing along the Atlantic coast, these types of projects are unlikely in the timeframe before or during the installation of the proposed action. Therefore, no space conflicts would occur.

**Commercial Fishing and Boating**

The proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities for protection of public safety. The applicant estimates that only a few WTG locations would be worked on at any one time. However, cable jetting operations require that fixed gear not be placed in any cable segment schedule for jetting, since the gear could be damaged or lost. Since this would occur in ever changing locations, only small portions of the available fishing area would be restricted at any one time during cable jetting. The remaining areas of the proposed action would be open to unrestricted navigational access. Information updates including daily broadcasts on marine channel 16 would be provided during construction activities.

**Recreational Fishing and Boating**

The proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities (estimated to be one to two WTG locations at any one time and along the cable jetting vessel) for protection of public safety. The remaining areas of the proposed action would be open to unrestricted navigational access. Information updates including daily broadcasts on marine channel 16 would be provided during construction activities.

**Military Training**

Some of the tenants at the MMR/Otis ANG conduct military training in the vicinity of the proposed action area. They have confirmed that the proposed action would not impact such training (see letter received from the Base, in Appendix B).

**Other OCS Alternative Energy**

Currently there is only one tidal energy project proposed in the general area of the proposed action. This is proposed by Cape and Islands Tidal Energy Company and is located in Vineyard Sound. As the tidal energy project is more than 10 miles (16.1 km) away from the proposed action area, it would not result in a competing use of the area. The wind project in Buzzard's Bay proposed by Patriot Renewables, LLC would compete economically with the proposed action, but it is sited more than 17 miles (27.4 km) from the site of the proposed action and would not represent a competing use to the affected area of Nantucket Sound.

**Onshore Activities**

The construction and decommissioning of the proposed action would only cause temporary use conflicts due to the construction equipment during the installation of the transmission cable system through existing roadways. This conflict would be minor and temporary and would be minimized through implementation of a Traffic Management Plan.

**Removal of Monopiles-Decommissioning**

See Section 2.5 for a detailed description of the decommissioning process. Impacts from decommissioning would be similar to those during construction, but the end result would be the removal of navigation obstructions and return of the site of the proposed action to near pre-project conditions. All impacts from decommissioning to competing uses would be temporary and localized and would be negligible.

**Conclusion**

Overall competing use impacts of the proposed action construction and decommissioning on other existing and proposed uses would generally be minor because of the limited activity that currently takes place or is proposed at the site of the proposed action, the limited ways in which the proposed action would impact those activities, and the proposed mitigation measures.

#### 5.3.3.7.2 Operational Impacts

**Other Pipelines and Cables**

There are currently no proposed pipeline or cable installation projects proposed within the area of the proposed action in the near future. The existing cables are not within Horseshoe Shoal, therefore there are no known space use conflicts. Should future projects be proposed that would involve placing cables or pipelines within the area of the proposed action, coordination with applicant would be required, but they would not necessarily be prevented from occurring.

**Navigation Features**

Most commercial traffic, such as cruise ships, tanker or cargo ships and ferries which have deep drafts (13 to 40 ft [4 to 12.1 m]), are restricted by their draft and for safety reasons to the navigation channels marked by the USCG. Accordingly, cruise and tanker or cargo ships do not navigate out of the Main Channel and would not be expected to come close to the WTGs. Ferries between Cape Cod and the islands do navigate out of marked channels, but do not typically cross the shallower western portion of the Horseshoe Shoal area, and even when tacking, typically operate further to the east than the eastern edge of the wind park. It is also highly unlikely that any dredging projects would be allowed within the area of the proposed action, but if any were proposed, the presence of the WTGs would require restrictions. The area between the Main Channel and the Cape Cod shoreline, including Horseshoe Shoal, is designated as an anchorage ground, known as "Anchorage I." Floats or buoys for marking anchors or moorings in place are allowed in this area. Minor restrictions on anchoring would be caused by the monopile structures and the ESP. Overall, competing use impacts on navigational features would be negligible with respect to the Project's operation.

**Sand Mining and Mineral Extraction**

The monopiles and offshore cables of the proposed action would make future plans of sand mining within Horseshoe Shoal and along cable routes difficult, though there are many other locations to choose from that would be available for sand mining. In the event that the moratorium on oil and gas leasing in the Atlantic is lifted, future leasing within Horseshoe Shoal would be restricted by operation of the proposed action.

**Commercial Fishing and Boating**

Space use conflicts would occur between commercial fishing and the proposed action due to the establishment of the WTGs and ESP. Small areas would be precluded from commercial fisheries while these structures are in place during operation. (Space requirements are discussed in Section 2.2.) However, the 0.39 miles by 0.63 miles (0.63 by 1.0 km) spacing between the WTGs is far wider than the widths of existing channels in the Nantucket Sound area routinely used by commercial vessels (as shown in Table 4.2 of Report No. 4.4.3-1). Specifically, the existing channel widths in the Nantucket Sound area range from 240 ft (73.1 m) in Hyannis Harbor to 700 ft (213 m) in the Cleveland Ledge Channel. In comparison, the WTG spacing distance is 2,066 ft by 3,281 ft (630 m by 1000 m). Mariners are currently able to navigate commercial and recreational vessels safely through these commonly accepted narrow corridors. Therefore, the minimum spacing of 2,066 ft (630 m) would not present conditions more restrictive to navigation than presently exist in these channels.

Fishing vessels would still be able to trawl within the wind turbine array. (Refer to the discussion about fish trawling activities, particularly with respect to squid trawling, in Section 5.3.2-7.) However, their operators would have to take the presence of the WTGs into account as they steer their courses. The WTGs on the east side of the array have been relocated to the northwest corner of the array in response to comments received from commercial fishermen who use mobile gear stating that the deep water to the east of Horseshoe Shoal is where they work most (Report No. 4.4.3-1).

The 115 kV offshore transmission cable system is also buried at sufficient depth and would be monitored on a regular basis to avoid upheaval or unburial, such that they would not affect trawling or anchoring in the area. Conflicts with navigation would be mitigated by USCG terms and conditions, such as lighting on the proposed action structures, boating restrictions, and annotated charts with private navigation aids that would be added to the existing network of navigation aids maintained by the USCG.

Analyses and observations of the area of the proposed action indicate Horseshoe Shoals is not used by boaters extensively like other near shore areas. Large vessels and commercial vessels would continue to use the channels in the area for safety reasons, and are, thus, not likely to navigate into the area of the proposed action. As such, interruption or change in most commercial vessel traffic patterns as a result of the proposed action would be negligible.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts to commercial fishing or boating by restricting use of those small portions of the array that may be devoted to traffic management.

**Recreational Fishing and Boating**

Space use conflicts would also occur between recreational fishing and boating and the proposed action due to the operation of the Project. Space requirements for proposed action operation are discussed in Section 2.2. Any restrictions that are necessary to protect the safety of mariners would be implemented in coordination with the USCG. Recreational fisherman would also experience aesthetic impacts while fishing within the shoals and in the vicinity of the proposed action during operation. Recreational boaters/fishermen in the waters of Nantucket Sound would experience open views of the visible components of the proposed action during clear days and nights. See Section 5.3.3.6.2 for additional discussion of recreational fishing impacts. Competing uses associated with recreational motor and sail boating are discussed in detail in the Navigation Section at Section 5.3.4.3.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts to recreational boating or fishing by restricting use of those small portions of the array that may be devoted to traffic management.

**Military Training**

The MMR has indicated that the proposed action would not impact military training operations (see letter in Appendix B).

**Onshore Activities**

The transmission cable system onshore could interfere with or prevent future utility development within the onshore area of the proposed action, but typically this merely requires careful design of new facilities, since more developed areas in and near bigger cities have streets and ROWs with many more buried utilities than would exist along the proposed action route. Therefore, only minor impacts would occur to future uses.

***Cable Repair***

Should a cable failure occur, a Cable Repair Plan would be implemented (see Section 2.4.6 for a description of this plan). Cable repair requires the addition of a loop of spliced in cable, adding a very short distance of the seafloor that is occupied by the cable system, and would prevent future or other bottom disturbing construction or installations in the area. Overall impacts from cable repair on competing uses would be negligible.

**Conclusion**

Overall competing use impacts of the proposed action operation on other existing and proposed uses would generally be minor except as noted above (i.e., the Figawi Race) because of the limited activity that currently takes place or is proposed at the site of the proposed action, the limited ways in which the proposed action would impact those activities, and the mitigation measures that would be implemented. Some minimization measures include the spacing between the WTGs, the depth of burial of the cable system, and the navigation aids created by the presence of the WTGs and ESP, which minimizes navigational impacts. The onshore portion of the proposed action is proposed within existing roadways and ROWs and would primarily compete with the installation of other utilities, which can be accommodated with adequate designs.

## 5.3.4 Navigation and Transportation

### *5.3.4.1 Overland Transportation*

#### 5.3.4.1.1 Construction/Decommissioning Impacts

Impacts on overland transportation would be negligible due to the relatively small number of workers used for construction and operation relative to the surrounding population. Both Barnstable, (the worker staging area) and Quonset Rhode Island (Equipment manufacturing/assembly/loading area), have roadways in the area to provide access as needed. The majority of activity including transporting material for the construction of the proposed action would take place on barges from a deep water port in Quonset, Rhode Island.

Transportation impacts associated with the installation of onshore transmission cable system facilities would be temporary in nature. Some combination of road detours or lane closures would be required for cable installation within roadways. A detailed Traffic Management Plan would be prepared in coordination with the Town of Barnstable, Town of Yarmouth, and MassHighway to address road detour and/or temporary closure procedures as well as maintenance of access to abutting businesses and residences. This Traffic Management Plan would also include provisions for coordination with driveway access in construction areas.

**Conclusion**

Overland transportation impacts of the construction of the proposed action would be minor due to the relatively small number of construction workers and would be mitigated via use of a Traffic Management Plan. Mitigation being considered at this time includes the installation of the onshore cable system would occur outside of the height of the summer tourist season to minimize any vehicular disruption; trenchless technologies would be used at major intersections and railroad crossings in order keep traffic disruptions to a minimum. A more detailed discussion of mitigation is provided in Section 9.0.

#### 5.3.4.1.2 Operational Impacts

Operational impacts on overland transportation would be limited to a very small number of workers associated with the operation and maintenance of the facilities. Maintenance workers would access the site via work boats from Falmouth, and the maintenance supply vessel would access the site from New Bedford. As the number of workers required for maintenance and operation would be very small, the overland transportation impacts during operation would be negligible.

### *5.3.4.2 Airport Facilities and Aviation Traffic*

#### 5.3.4.2.1 Construction/Decommissioning Impacts

The FAA has studied the impact of the proposed action on the airport facilities and aviation traffic in the area and has concluded that the original configuration of the proposed action would "have no substantial adverse effect on the safe and efficient utilization of the navigable airspace by aircraft or on the operation of air navigation facilities" (see correspondence from FAA in Appendix B). As a result of the reconfiguration of the WTG's, design changes that had increased rotor height, and the release of new lighting guidelines by the FAA, the applicant had initiated new Aeronautical Surveys by the FAA for each of the proposed turbine locations. This subsequent determination is pending. Based on the above FAA finding, and assuming a subsequent finding from FAA of no substantial adverse effect on aircraft or on operation of air navigation facilities, the potential impacts during construction would start out as negligible and increase to minor as more and more WTGs are erected. It will be important that construction activities closely match published NOTAMS since as WTGs are erected they will not have yet been published on charts. During decommissioning, impacts would start out as minor and drop to negligible as more and more WTGs are removed.

#### 5.3.4.2.2 Operational Impacts

As noted above, the FAA has studied the impact of the proposed action on the airport facilities and aviation traffic in the area and has concluded that the original configuration of the proposed action would "have no substantial adverse effect on the safe and efficient utilization of the navigable airspace by aircraft or on the operation of air navigation facilities" (see correspondence from FAA in Appendix B). The FAA is reviewing the proposed action modifications and would issue another determination.

In March of 2005 the FAA made public a draft report for marking and lighting of wind turbine farms that was developed jointly with the DOE following 4 years of research and flight evaluations of existing wind farms. The FAA formally issued the guidance document in final form in November 2005 (Development of Obstruction Lighting Standards for Wind turbine Farms; DOT/FAA/AR-TN05/50).

As a result of the new FAA guidance, the following revised lighting plan is proposed for operation of the facility:

- Each Perimeter WTG nacelle would be lighted with one red flashing FAA light fixture equipped with automatic bulb changers.
- Medium intensity lanterns (FAA L-864) would be used at corners/points of direction change with intervals of no more than 1.5 miles (2.4 km) between similar intensity fixtures.
- The balance of perimeter WTG's would be marked with low intensity lanterns (similar in intensity to the FAA L-810 with visibility to approximately 1.15 miles).
- The eight turbines adjacent to the ESP would each have one L-810 flashing red fixture.
- The balance of the interior turbines would not have FAA lighting.
- The turbines would be painted off-white (5 percent grey) and no daytime white lighting would be used.
- All FAA lighting would be synchronized to flash as one at a rate of 20 FPM.

These changes would result in the proposed action design being compliant with FAA guidance while minimizing adverse affects on other environmental resources that occur as a result of WTG and ESP lighting.

As described in Section 4.4.2, within the site of the proposed action, aviators are responsible for safe flight under Visual Flight Rules (VFR). While the WTGs do represent obstacles to flight near the ocean's surface, they would be marked on navigation charts and if unsure of safety, aviators would fly over or around the WTG array. This is consistent with the FAA findings.

**Conclusion**

Given the above lighting plan, and assuming a subsequent finding from FAA of no substantial adverse effect on aircraft or on operation of air navigation facilities, impacts to aviation are expected to be minor.

### *5.3.4.3 Port Facilities*

#### 5.3.4.3.1 Construction/Decommissioning Impacts

With respect to construction and decommissioning impacts on navigational activity, the proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction and decommissioning activities (estimated to be one to two WTG locations at any one time or short segments of the cable system) for protection of public safety. This restriction would most likely be implemented by Cape Wind's construction contractor, in coordination with the USCG. The remaining areas of the proposed action would not be unrestricted to navigational access by Cape Wind, but the USCG may decide to make the active construction area a Regulated Navigation Area, that could result in the imposition of speed restrictions and/or vessel size, in order to maintain marine safety during construction. The WTG that is closest to the Main Channel is approximately 1,190 ft (362.8 m) from the charted Main Channel edge and approximately 6,900 ft (2103.7 m) east of the Main Channel's narrowest point. The work vessels used to construct or decommission the WTGs are approximately 400 ft (122 m) long. This leaves ample room for vessels to transit past any ongoing work. These work vessels would not need to occupy or block the Main Channel during construction and decommissioning. Therefore, no restrictions or closures of the Main Channel to transiting vessels are anticipated. The USCG routinely regulates marine traffic in waterways and channels around marine construction activities, and it is anticipated that such procedures could be implemented in Nantucket Sound during construction and decommissioning.

It is not anticipated that any regulatory action, either temporary or permanent would prohibit vessels from entering or operating in the area of the proposed action. The applicant does not intend to request the establishment of exclusionary zones in the wind farm footprint. In addition, the WTGs would be constructed in a grid pattern (minimum 0.39 miles by 0.63 miles [0.63 by 1.0 km] spacing), which would help mariners by allowing them to navigate a relatively straight course through the WTG array. In addition, the 0.39 miles by 0.63 miles spacing between the WTGs is far wider than the widths of existing navigation channels in the Nantucket Sound area routinely used by commercial vessels (i.e., Cape Cod Canal is 480 ft [146.3 m] wide), and thus ample room would be provided for navigation (see Figure 5.3.4-1).

**Conclusion on Construction and Decommissioning Impacts**

Given the level of navigational impacts discussed above, and proposed mitigation including the navigational lighting of WTGs, lighting of construction vessels, spacing and placement of monopiles supporting the WTG's to allow for safe navigation, the impacts to vessels navigating in charted channels during construction and decommissioning would be negligible to minor. Note that in the later stages of construction or the early stages of decommissioning, when most of the monopiles are in place, navigational impacts are likely to be the same as those described below in the section on impacts during operations. The USCG has provided Terms and Conditions for the proposed action to help ensure navigational safety of the area during construction and operation (see Appendix B).

#### 5.3.4.3.2 Operational Impacts

**Ship, Container and Bulk Oil Handling Facilities**

There are no ship and container handling facilities in ports surrounding Nantucket Sound. Containers are carried on SSA ferries as part of a tractor trailer rig and are on and off loaded by driving the rig onto or off the vessel on its vehicle deck. There are bulk liquid facilities at Vineyard Haven and Nantucket for offloading petroleum products that are transported by the T/V Great Gull and other barges. The largest ship handling facilities are those owned and operated by the SSA and the oil storage and transfer facilities in Vineyard Haven, Martha's Vineyard and Nantucket. The referenced facilities are located in harbors far away from the proposed action and as such the proposed action would have negligible impacts on these facilities. Impacts to ferries, oil transport barges and other vessels are discussed below (Report No. 3.3.5-1 and Report No. 5.2.1-1).

**Navigational Channels**

Due to the characteristics of the waterway, most commercial traffic is restricted by its draft and for safety reasons to the navigation channels marked by the USCG and charted on NOAA charts of the area. Nantucket Sound is transected by two named channels but only one major channel provides a route for medium sized vessels to transit in an east/west direction in an area north of the Nantucket Shoals.

The separation distance between the WTGs and the Main Channel is slightly less than that of the Middelgrunden Wind Farm from a major shipping channel in Copenhagen, Denmark. The Middelgrunden Wind Farm is located approximately 1,500 ft (457 m) from this shipping channel. According to the Royal Danish Administration of Navigation and Hydrography, between 25,000 and 30,000 ships navigate this shipping channel annually, and there have been no reported incidents of collision of ships transiting this channel with the WTGs (Nielsen, 2005).

In addition, the proposed project has been reconfigured to further distance WTGs from the referenced channels. Several of the southernmost turbines shown in the 2003 Navigational Risk Assessment have been relocated from sites adjacent to the Main Channel to sites in the northwestern portion of Horseshoe Shoal; an area with significantly less deep draft commercial vessel traffic. This relocation further reduces the chance for deep draft vessel interaction resulting in a collision with the WTG, as the nearest WTG is now sited approximately 1,190 ft (363 m) from the charted edge of the Main Channel. This relocation results in a separation distance increase of approximately 515 ft (157 m) from that presented in the applicant's 2003 report. See Report No. 3.3.5-1 and Report No. 5.2.1-1.

**Cruise Ship Traffic**

As discussed above, most commercial traffic, such as cruise ships which have deep drafts (13 to 20 ft [4 to 6.1 m]), are restricted by their draft for safety reasons to the navigation channels marked by the USCG. Accordingly, cruise ships do not navigate out of the Main Channel, and would not be expected to come close to the WTGs. As a result, navigational impacts to cruise ships calling on the area are expected to be negligible.

**Ferry Operations**

Ferry operations between Martha's Vineyard and Woods Hole should not be affected by the proposed action as the ferries come no closer than 8 miles (13.0 km) from the closest WTG for the SSA vessels calling on Oak Bluffs and over 9.2 miles (14.8 km) for vessels calling at Vineyard Haven.

Vessels traveling between Hyannis and Woods Hole to Martha's Vineyard use the North Channel from the Hyannis Sea Buoy (HH) through Red Nun #8 and Green Can #7 to Green Can #11 and pass to the north of Horseshoe Shoals. The closest point of approach to a WTG on the north side of Horseshoe Shoal is in the channel gate between Red Nun #8 and Green Can #7, and is approximately 0.86 miles (1.4 km) away.

The SSA vessels traveling from Hyannis to Nantucket proceed to the Hyannis Sea Buoy (HH) and set on a course of 154° True passing Bishop and Clerks Red Nun #4 to Port, over Broken Ground and Red #2 continuing to Green #17 on the Main Channel. Horseshoe Shoal is passed down the starboard side on the southbound trip and port side of the northbound trip. The closest point of approach this vessel track takes to a WTG is approximately 1.7 miles (2.8 km) in the vicinity of Half Moon Shoal. Based on SSA published vessel schedules and transit times, it is unlikely that a meeting situation between two SSA ferries would be encountered in the immediate vicinity of a WTG.

Ferries using the Main Channel for transits between Woods Hole and Nantucket and between Martha's Vineyard and Nantucket have a closest point of approach (CPA) to the WTG at a distance of approximately 0.69 miles (1.1 km) from a track line at the center of the channel in the vicinity of Red #20 of the Main Channel. Vessels in a meeting situation with a 500 yard closest point of approach between them could potentially come within 0.4 to .46 miles (0.65 to 0.74 km) from the nearest WTG at the Red #20 and Green #21 Gate.

The SSA stated in a letter to USCG Sector Southeastern New England that its captains often use tacking maneuvers on the route between Hyannis and Nantucket to provide a smoother ride and to protect vehicles and cargo on board the ferries. This tacking maneuver is postulated to be a course line set at an angle to the sea to allow the vessel to pitch less in a head sea or to wallow less in a trough. Rather than follow a straight course of 154°/334° True, the master varies his course up to 45 degrees either side of the base course. Actual tacking maneuvers by the SSA have not been documented, but such maneuvers may result in ferry traffic closer to the eastern wind turbines than straight course navigation would. However, it appears based on channel width, water depths, and the WTG array's offset from channels, that there is room for navigation to the east of the array and for tacking maneuvers to occur. As such, impacts to navigation are expected to be minor to moderate (depending in part, on the distance of tacking maneuvers), and such impacts would be minimized through the USCG's Terms and Conditions (see Appendix B).

**Marinas and Recreational Boating**

Marinas are located along shoreline areas far from the proposed action, and as such, would not be affected by the WTGs. The proposed action may impact the Figawi sail boat race that occurs between Hyannis and Nantucket and back every year on Memorial Day based on historical tracks set for the race. This impact would be moderate, but can be overcome by selecting a race course that does not pass through the site of the proposed action. An overlay of historic race courses shows the race can still be run without crossing the area of the proposed action (see Figure 4.4.3-2).

The current proposed action design specifications call for a WTG rotor to clear sailing vessels no larger than 47 ft (14.3 m) (mast heights 72 ft [22 m] or less). Barring any custom design, as a general rule, sailing vessels greater than 47 ft (14.3 m) in length would not be able to clear a rotor due to their mast heights exceeding 72 ft (22 m). Sail boats of this size have significant drafts and would tend to stay away from the area due to the prevalent shoals and strong currents and perhaps inherent risks of navigating such a large sailing vessel through the WTG array. A sailing vessel experiencing a breakdown that could cause its penetration into the array would be mitigated as follows: If a vessel with a mast or structure height of 72 ft (22 m) or higher is in distress and drifting toward a WTG, the WTGs in the path of the vessel can be remotely shut down by the applicant upon receipt of a request to do so by the USCG.

Shutting down the WTG prior to the distressed vessel coming close to a WTG would eliminate the potential of the vessel being struck by the rotating blade. This would be a moderate impact on large sailing vessels (exceeding 72 ft [22 m] in mast height).

Finally, sail boaters, and to a lesser extent motor boaters, would be faced with a minor to moderate navigational impact, depending on the type of navigational equipment on board, as the proposed action would in general make offshore cruising more difficult requiring the operator to take more care to navigate his/her vessel to avoid the structures. Impacts during fog conditions or rainy nighttime conditions could be moderate, but would be mitigated via the USCG Terms and Conditions, which includes, among other things, appropriate marking and lighting of turbines (see Appendix B).

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in minor impacts recreational boating or sailing by restricting use of those small portions of the array that may be devoted to traffic management.

**Commercial Fishing**

Commercial fishing within the turbine array is expected to have minor to moderate impacts from operation of the proposed action. The offshore cables are buried at sufficient depth such that they would not be affected to the extent trawling takes place in the area or by anchoring in the area (a detailed assessment of anchor impacts is provided in the *Revised Navigational Risk Assessment* – (Report No. 4.4.3-1).[26] In addition, the proposed action WTGs are spaced far apart in a straight grid to allow trawlers to navigate in a relatively straight line without danger of colliding with WTGs if placed in a non-linear manner. With respect to proposed action mitigation, the revision to the WTG array has resulted in the relocation of a number of WTGs away from the from deeper water areas along the eastern portion of the array to minimize or avoid impacts to commercial fisherman who use mobile gear. The increased separation distance of the turbine array from this area provides a potential positive impact to marine navigation for commercial fishing when compared to the turbine array configuration as originally proposed.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG may reconsider these measures or require further conditions to ensure navigational safety if necessary. These safety measures themselves could result in

[26] There is generally little commercial use of anchorages in the area of the proposed action given the dangerous shoal waters and the accessibility of nearby harbors. The Steamship Authority's vessels, work vessels, and cruise ships could potentially anchor in the area, although the likelihood is slim. These types of vessels typically have anchors that would penetrate 3 to 4.5 ft (1 to 1.4 m) in and around the area of the proposed action. This is 1.5 to 3 ft (0.5 to 1 m) less than the minimum 6 ft (1.8 m) burial depth proposed for the inner array cables and submarine cable interconnection.

minor impacts to commercial fishing by restricting use of those small portions of the array that may be devoted to traffic management.

**Search and Rescue (SAR)**

The proposed action is within an area between 41°27' N to 41°32' N and 70°14' W to 70°23' W (a "SAR Study Area" of approximately 46.4 square miles [116 $km^2$]). Analysis of historical SAR data provided by the USCG indicates that there are 94 sortie records in the data within this USCG SAR Study Area. Multiple sorties occurred on the same date and time in many locations in the data, resulting in a total of 50 incidents in the area of the proposed action. These incidents occurred between November 1991 and August 2002. The majority of the incidents occurred during daylight hours, with only 22 percent occurring between sunset and sunrise. The majority (81 percent) of the responses to SAR incidents in the SAR Study Area were made by small boat. Aircraft were only used to respond to 4 incidents in the SAR Study Area during the 10-year study period. In some cases, multiple responders were required for an incident.

The proposed action is not anticipated to have negative effects on SAR operations in the area of Horseshoe Shoal. The wide turbine spacing would allow those USCG vessels that are not restricted by the existing water depths to continue to operate normally within the proposed action area. A representative of USCG Air Station Cape Cod indicated that USCG aircraft would be able to operate in and around the area of the proposed action during periods of good visibility, including nighttime operations (USCG, 2003). The representative indicated that aircraft would not likely conduct operations in the area during times of very low cloud ceilings or dense fog, and a vessel-based response would be more appropriate during those times. The USCG aircraft responding to incidents south of the area of the proposed action would either cruise over or around the WTG array, depending on their destination, and this would not adversely affect USCG response times (USCG, 2003). Additionally, in April of 2008 the commanding officer of Coast Guard Air Station Cape Cod, the unit with primary air rescue responsibility for the Nantucket Sound area, conducted an additional analysis of the potential impacts to SAR from the proposed wind facility and concluded "Impacts to aviation operations outside the boundaries of the wind farm will be slight however operations within will be limited by darkness and weather. Surface assets should be considered the primary rescue platform within the wind farm in most cases."

The presence of the WTGs within the proposed action area, as well as some of their design features, can benefit SAR operations in the area, as discussed below.

- Each WTG would be clearly marked with an alphanumeric designation on the tower, and the USCG, other local, states, and Federal agencies would be provided with a plan showing designations for each WTG. This designation could be used by mariners in distress as a primary or additional positional reference to provide to the USCG when requesting assistance. By receiving these additional easily readable positional references from mariners in distress, the USCG would be able to focus its efforts on rescuing the mariner in distress rather than spending time in the search.
- Each WTG would have a safety line with a loop at the end from the platform to the water. While tying up to WTGs under normal circumstances would be prohibited, mariners in distress would be allowed to tie up to a WTG either by their own choice or by direction from the USCG, until assistance arrives. In addition, persons in the water could swim to the WTG and hold on to the safety line until assistance arrives.
- The WTG grid pattern and spacing would provide the USCG with the opportunity to establish air and sea search grids that align with the turbines if desired. The WTGs would provide points of reference to USCG personnel as SAR missions are performed.

- During proposed action operations, proposed action work vessels in the proposed action would be conducting routine monitoring and maintenance during daylight hours when the seas are less than 6 ft (1.8 m). These work vessels would be able to assist vessels in distress within the proposed action during these times, and would do so either upon receipt of a request for assistance from the vessel or from the USCG. Proposed action personnel on these vessels would be trained in first aid, CPR, and marine survival skills.

**Ice**

There do not appear to be historical records on the frequency of sea ice events in Nantucket Sound. The National Weather Service in Taunton, Massachusetts stated they do not keep sea ice records, and are not aware of other agencies that maintain such records for Nantucket Sound (NWS, 2003). The *Coast Pilot* makes one passing reference to ice in Nantucket Sound, when it mentions that northerly winds keep the north shore of the Sound free from drift ice (NOAA, 1994); this further suggests that sea ice events in Nantucket Sound do not occur with any regular frequency. Anecdotal evidence suggests that large-scale sea ice events have occurred less frequently in Nantucket Sound during the past decade. However, sea ice was common in Nantucket Sound during the winters of 2002 to 2003, and 2003 to 2004. According to ferry operators and others interviewed, ice does not appear to affect navigation in Nantucket Sound with any regular frequency. The WTG monopiles have been designed to withstand the forces of up to six inch thick ice floes impacting the monopile.

Although rotor blades would have a slick surface for aerodynamic efficiency, which would allow most ice to slide off prior to any significant buildup, ice may collect on the WTG structure and blades under certain meteorological conditions. This ice usually takes the form of a thin sheet as it attaches to WTG surfaces. Temporary icing of a rotor blade would activate vibration sensors causing turbine shutdown in order to prevent rotor damage or hazard to proposed action maintenance staff or others from falling ice. Conditions conducive to icing would be evaluated by continuous monitoring of meteorological conditions and by monitoring the WTGs remotely (via camera). If conditions warrant, manual shut down of the WTGs experiencing icing conditions would be initiated. The ice would remain attached until meteorological conditions allow it to melt. If the WTG is no longer operating due to icing, the melting ice would break apart into fragments in the same manner as ice falls off building. The risk of ice fragments being thrown from a turning rotor and causing injury is relatively small when one considers the unique weather conditions required for icing (a combination of high relative humidity, freezing temperatures, and overcast or nighttime sky [Report No. 4.4.3-1]) and the fact that icing can only occur during the winter months when navigation activity within the site of the proposed action is likely reduced to a few vessels other than the maintenance vessels. Accordingly, impacts from icing are expected to be negligible.

**Vessel Impact Analysis**

An impact analysis was performed to assess the structural ability of the WTGs to withstand vessel strikes (Report Nos. 3.3.5-1, 4.4.3-1 and 5.2.1-1). The analysis concluded that a drifting vessel of the size that frequents the area of the proposed action would not result in collapse of a WTG after impact. However, it was concluded that the impact of a moving vessel, equal to or larger than a 1,200 metric ton barge, with a WTG could possibly result in collapse of a WTG after impact, and that the impacting vessel and persons onboard could sustain some form of injury. However, such large vessels do not typically operate in the area of Horseshoe Shoals because of inadequate water depths and safety considerations. As well, the mitigation described above reduces the likelihood of such an event from ever occurring.

**USCG Impact Assessment**

The USCG has conducted their own independent review of the proposed action as a cooperating agency and has found that in general, the proposed action would have up to a moderate impact to navigational safety, and that there are sufficient measures available to reduce risk to an acceptable level. Some examples of mitigation in the USCG terms and conditions (see Appendix B) include: 1) aids to navigation during both construction and operation (including USCG approved numbering of turbines); 2) ability to shut down operation of WTG's remotely at the request of the USCG if navigation safety is affected; 3) requirements for safety lines and mooring attachments for securing vessels in emergencies, and 4) requirements for a written control plan to be approved by the MMS after consultation with the USCG. The USCG has stated that in general there would be negligible or no adverse impact on Coast Guard missions, and that the proposed action may in some circumstances actually facilitate the prosecution of certain missions.

In a recent study sponsored by the USCG, navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired dur to WTG impacts on radar, but the USCG concluded that the effects could be mitigated. The applicant in consultation with the USCG developed mitigation measures that include traffic management and vessel operation conditions within the turbine array (see Section 9.3.4 for more details on these mitigation measures and Appendix M for the study results). Also in Section 9.3.4 and Appendix M is a discussion of the USCG's own analysis of the radar impact study, and specification of mitigation measures. The study found that the adverse effects on radar are a concern within the turbine array, but are of much less concern for vessels operating outside of the array or for inside/outside vessel interactions. The USCG concluded that until the facility is placed into operation, a full and adequate assessment may not be possible, and in their December 30, 2008 assessment (see Appendix M), they conclude the mitigation discussion by referring to the adaptive management approach that MMS is taking regarding mitigation measures, and they retain the right to modify or add to mitigation requirements to ensure that navigational safety is acceptable.

**Conclusions**

MMS has found impacts to navigational safety to range from minor to moderate depending on the specific issue at hand (see discussion throughout Section 5.3.4.3.2) and concurs with the USCG's finding of impacts as generally moderate. In light of the mitigation provided via the USCG Terms and Conditions (see Appendix B), impacts to navigational safety would be reduced to an acceptable level. Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. Vessel operators will need to take more caution when navigating in the area of the WTGs to avoid the WTGs and other boaters, and to take into account the moderate impact the WTGs can have on marine radar (see Section 5.3.4.4.2 for a discussion of radar impacts). The applicant in consultation with the USCG has proposed mitigation, including directional traffic lanes within the array, to minimize impacts to navigation safety to an acceptable level (see Section 9.3.4). The USCG has considered these measures in their own analysis (see Apendix M) and retains the right to require further conditions to ensure navigational safety, if necessary after the facility is put into operation. These mitigation or safety measures themselves could result in minor impacts to commercial fishing and recreational boating or sailing by restricting use of those small portions of the array that may be devoted to traffic management.

### *5.3.4.4 Communications*

#### 5.3.4.4.1 Construction/Decommissioning Impacts

There are two primary communication issues that arise with regard to the construction of large-scale wind turbine projects: (1) Temporary use of "itinerant" and shared repeater frequencies, point-to-point frequencies, and cell phones by construction crews can possibly cause some amount of radio traffic congestion for other users, especially cell phone users; and (2) Use of construction cranes that could temporarily cause local re-radiation of Low Frequency and Medium Frequency services. These issues are discussed below.

**Temporary Use of Radios by Construction Crews**

Temporary use of radios by construction crews is seldom an issue because there is very little (although not zero) overlap of private radio frequencies (RFs) with public safety and marine frequency bands (the primary exception is the use of private frequencies by some public entities in cases where public safety frequencies are completely subscribed). The private frequencies that are generally used by construction crews are in the VHF and UHF ranges, and, if properly licensed and maintained, operate completely outside of the marine and public safety bands.

Of primary concern are the emergency calling frequencies, which require the highest degree of protection, as follows:

**(1) VHF**

- Channel 16 (156.800 MHz) - Distress, safety and calling
- Channel 13 (156.650 MHz) – Inter-ship navigation (bridge-to-bridge)
- Channel 70 (156.525 MHz) - Digital Selective Calling

**(2) HF: HF radiotelephone emergency channel 2182 kHz**

Private use of the HF frequencies is virtually nonexistent today, because it represents obsolete technology and the antennas are insufficiently compact. It is far more likely that construction crews would use VHF, UHF, or Super High Frequency (SHF) frequencies. Among these three frequency ranges, marine applications are primarily centered on the VHF channels. Besides protection of the emergency channels listed above, additional frequencies are assigned and licensed by the FCC to marine service on a basis that protects them from interference (see Table 5.3.4-1). Temporary use of radios by construction crews can have minor impact on radio communications to these frequencies. Avoidance of these frequencies would minimize impact.

**Temporary Use of Construction Cranes by Construction Crews**

Construction cranes would have a local effect primarily upon low and high RFs. This effect would manifest itself as a distortion of the RF around the crane, which would have a magnitude similar to the wind turbine itself. Since the crane would be relatively close to the turbine position, the differential effect is not expected to be significant with respect to long range navigation (LORAN) broadcast, and HF emergency frequencies.

**Conclusion**

In conclusion, communication issues resulting from construction and decommissioning of the proposed action would be minor and easily mitigated by avoiding close approach and by utilizing properly licensed and maintained two-way radios.

### 5.3.4.4.2 Operational Impacts

Wind turbines can have impacts on many types of communications, based upon the frequency band involved and the type of service application (video, data, and/or voice). This section addresses the operational impacts with respect to microwave, HF, cell phone, satellite, TV, AM, FM, and LORAN communications. Frequently, wind turbines located near RF transmitters or receivers can cause one or more modes of RF impact, such as incidental radiation, aperture blockage (shadowing, usually caused by the support structure), time-varying occultation (usually caused by the turbine fan), and multipath reception (usually caused by RF "scattering" and re-radiation of the primary signal).

With respect to wind towers causing Radio Frequency Interference (RFI) directly to nearby receiving equipment, Section 15.109(a) of the FCC's rules (Code of Federal Regulations Volume 47) requires that turbine equipment and its ancillary service devices meet the "radiation envelope" described in this rule section. Manufacturers of all major turbine equipment are aware of this requirement, and field mitigation measures are hardly ever needed. If required, however, mitigation is straightforward and consists of installing by-pass capacitors and in-line inductors.

In some cases, wind turbines and/or their support structures can partially block the radio frequency signals originating from a microwave, land mobile or broadcast antenna, although this type of anomaly has become less prevalent since the advent of GRP (Glass Reinforced Plastic) turbine blades and available mitigation measures. For instance, previous-generation aluminum turbine blades mounted on a large hub tower could partially block the path between a RF user located close to the turbine or turbines, and a broadcast facility, such as a television or microwave tower, that may be several miles away. This blockage can reduce the received signal level, or can cause the signal to vary in strength as the turbine blades rotate, especially if the viewer or listener is using a portable or "indoor" antenna. If the local receiving equipment cannot accommodate this signal level attenuation or variation, a loss of usable video and/or audio can result. Both analog and digital signals can be affected; for microwave signals, aperture blockage is also known as "Fresnel clearance."

This type of anomaly is usually completely avoided today by manufacturing the turbine blades from dielectric materials, restricting turbine siting so that fixed receivers and transmitters are not located closer than approximately one mile to a turbine structure, and siting the turbines so that they do not impact the Fresnel regions of microwave paths.

Regarding re-radiation and multipath reception, most turbines have an electrical conductor that runs the length of each blade, and which is grounded through the hub connection. As the turbine rotates through an RF field, it results in a time-varying signal that is displaced in time from the primary (incident) signal. Depending upon the sensitivity of the RF receiver, the frequency involved and the strength of the radiated power, it is possible in some cases that interference could be caused to other services.

Today, these effects are much less serious than they have been in the past because of several factors:

a. Better receiver performance in a multipath environment. This improved performance was occasioned by required resistance to "flutter", such as is caused by an airplane flying over the receiver. Also, most services are upgrading from analog to digital modulation, which is less sensitive to multipath problems.
b. Research into methods to lower the reflectivity profile of turbines and blades.

c. Higher awareness concerning proper turbine siting with respect to AM, FM and TV broadcast facilities, public safety and land mobile stations, and other licensed RF services.

When multipath interference does occur, experience has shown that it can be mitigated by relatively simple receive antenna modifications (increasing sensitivity or directionality) or receiver upgrades. Newer digital receiver equipment is much more tolerant of multipath effects.

Table 5.3.4-2 shows the RF services and their applications that are pertinent to the Cape Wind project.

Specifically, the table shows that the lower frequencies are used primarily for voice communications and navigational beacons, while the mid-group of frequencies are used for FM-modulated voice, video and digital data. Frequencies in the microwave realm (above 3 GHz.) are used for point-to-point and radar applications. The types of interference that can be caused by turbines are different for each of these frequency groups, as follows:

a. For LF and MF frequencies, the primary effect can be distortion of the radiation pattern forming the service area. This effect is nearly eliminated by siting the wind turbines 2 to 3 miles (3.2 to 4.8 km) from the subject transmitter site and keeping receivers, such as LORAN receivers, a reasonable distance outside the turbine array (such as 0.5 miles [0.8 km]). If this is not possible, the turbine structures can be "detuned", thereby mitigating the distortion of the radiation pattern.

b. For HF, VHF and UHF frequencies, the primary effect of turbines is to cause a local rhythmic change in field intensity. Since this effect is most pronounced close to the turbine, the field strength oscillation usually is not significant because both the "high" and the "low" values of field strength are above the minimum automatic gain control (AGC) threshold of the user's equipment.

c. For SHF and EHF frequencies, which are primarily used in microwave applications, there are three types of possible interference:

    i. Aperture and Fresnel blockage to local fixed stations.

    This type of interference can nearly always be mitigated by relocating the turbine site at the planning stage or improving the clearance of the microwave antennas by increasing tower height or increasing antenna directionality.

    ii. Aperture and Fresnel blockage to long range radar.

    This type of possible interference is analyzed by government agencies, and administered through the Federal Aviation Administration (FAA). FAA clearance will not be granted if interference to long-range radar is anticipated.

    iii. Aperture and Fresnel blockage to portable, shipborne and airborne radar equipment.

    The USCG study discussed below in the Navigation and Positioning Services sub-section indicates that there are impacts on radar caused by the WTGs, both in terms of creation of false echoes and spreading the width of the return signal.

As described above, most anomalies that can be caused by wind turbines to communications facilities are benign, and relatively easily mitigated. With respect to short-range radar equipment, the USCG study suggests that the impacts to radar functionality probably cannot be readily fixed, and so other mitigation measures have been proposed by the applicant in consultation with the USCG to address this concern (see Section 9.3.4).

**Impacts associated with Various Communication Devices**

Using industry standard procedures and FCC databases for microwave links, a search was conducted to determine the presence of existing microwave paths crossing the subject property, as well as other RF facilities within or adjacent to the identified area. The turbine layout plan was then prepared as an overlay, showing microwave blackout areas and nearby land mobile (2-way) radio facilities. The resulting maps are shown in Figures 5.3.4-2 and 5.3.4-3. With respect to broadcast facilities, pertinent TV, FM and AM stations were listed and the estimated impact to broadcast consumers in the turbine area was assessed.

The following is a list of communication devices and information on how they may be affected. Table 5.3.4-3 shows a summary of the frequencies of interest with respect to possible adverse effects due to the proposed action.

**Entertainment Satellite**

Entertainment satellite equipment depends on a stationary earth receiver. If a turbine blade, which has a metal component, turns in front of the receiver dish, the received video can "freeze" or "pixilate" (turn into small squares). This impact would be minor and only apply to a vessel using an entertainment satellite system in very close proximity to the turbines.

**Entertainment Broadcasting Services (AM, FM and TV stations)**

The frequency used for entertainment broadcasting services is below 1 GHz. For shipboard analog receivers, such as traditional TV, FM and AM, the main effect of a turbine blade would be a small rhythmic variation in the transmitted signal strength that is generally compensated for by the receiver's automatic gain control, even when the receiver is quite close to the turbine. The exception to this statement would be if the particular station was quite distant (depending upon the type of service) or used a directional antenna that reduced coverage over the water. It should be noted that some ships occasionally use AM broadcast stations for positioning. The use of these signals is relatively imprecise and may be subject to a small amount of additional uncertainty when near the turbines. For digital entertainment signals, the indicated effects can be slightly greater; in these cases, the 0.5 miles (0.8 km) limit may be appropriate. While these entertainment style services can be disrupted within the turbine impact area, mitigation should generally not be required because the influence area is small, being primarily confined to a radius of 0.5 miles (0.8 km) from each turbine (it is true that there is a small residual effect outside of this distance, but it is generally considered to be insignificant). Based upon FCC database information, no significant impact is expected to the reception of FM or AM broadcast facilities. Direct over-the-air reception of full-power TV stations is unlikely in and near the turbine area, being limited to TV sets mounted in watercraft, and due to the paucity of nearby TV transmitters.

**Non-emergency Ship-to-Shore Communications (cellular communications and VHF frequencies in the marine band)**

To a first order approximation, the same blockage (more precisely, "re-radiation") effect is experienced by both the receiver and the transmitter of non-emergency ship-to-shore communications, and can disrupt both sides of a conversation or data transfer. A small additional impact is due to antenna aperture blockage of the very large turbine support structures. These effects are primarily limited to paths that pass through the turning blades within approximately 0.5 miles (0.8 km) of shipboard radios, even though the angles of interception are lower on the horizon compared to the satellite services. Ship-to-ship communications are subject to the same impacts as the ship-to-shore services, as long as either of the ships is within the impact zone (the subject antenna should be approximately 0.5 miles [0.8 km] from the nearest turbine).

**Navigation and Positioning Services**

Navigation and positioning services can be critical to ship safety. They include satellite GPS services, LORAN, and shipboard radar. The satellite GPS signals are subject to the same types of anomalies that affect entertainment satellites. Precise timing is the hallmark of accurate positioning, and the receivers used to calculate the ship's position can be "fooled" by the "multipath signals" created if it is "looking" through a wind turbine. For most ships, the 0.5 mile (0.8 km) radius should provide sufficient clearance (subtended angle above the horizon of less than 15 degrees).

To further assess impacts to marine radar at the site of the proposed action, a study of marine radar impacts was prepared that took into account impacts at European offshore wind parks (Marico Marine, 2008). The report (Report No. 5.3.4-1) concluded that the proposed wind farm at Nantucket Sound will not cause unmanageable concerns to ships operating within the area because:

- Experience in Europe has shown that mariners become increasingly aware of any effects as more offshore wind farms are built and can interpret them correctly;
- Many vessels, especially those with radar antennas mounted above and clear of masts, stanchions and other onboard structures, can be expected to experience minimum effects;
- The majority of effects will display abaft the beam and for vessels operating within a channel and harbor area this is of lower importance;
- Ship's Officers will be aware of any tendency of their vessel to produce effects due to the configuration of the radar antennas, masts and other fittings;
- Experience in UK and Europe suggests pilots will quickly become familiar with the type of effect to be expected from vessels with certain antenna configurations;
- The phenomena detected on marine radar displays near a wind farm can be produced by other strong echoes close to the observing ship, although not necessarily to the same extent. Trained mariners will recognize and understand the causes of these effects;
- Some of the effects will be transitory in relation to the speed of the vessels passing the wind farm site and will therefore be of little concern;
- Previous research has shown that small craft operating in and near the wind farm were detectable by radar on ships operating near the array and we expect that the Nantucket Sound site will experience the same; and
- When targets are on the opposite side of the wind farm array the quality of returned echoes does not appear to be adversely affected.

The situation for long-range radar requires special consideration. Radar operates by sending out a RF "pulse" in the high-Gigahertz range, and then waiting for an "Echo" from a fixed object or a ship. The time delay of the echo, along with the direction of the reflection, establishes the distance and the bearing of the object, which can be another ship or a land obstruction. The higher the frequency, the better the possible resolution (the ability to distinguish two objects close together) will be. At angles close to the horizon, wind turbines can add "clutter" to the radar's display screen, making it difficult to distinguish small objects, even with high resolution. Depending upon the power and sophistication of the radar system, this effect can extend for 57.5 to 92 miles (92.6 to 148.2 km) from the turbine farm, but would be confined to the general region of the turbines. The primary effect would be to make it difficult to resolve each wind turbine separately.

Another study (Brookner, 2008) was submitted as part of DEIS public comment period by the Alliance to Protect Nantucket Sound (see Appendix L, Comment Letter No. N00034). Unlike the Marico Marine study described above, the Brookner report asserts the proposed action will result in a "cone of silence" near and above the wind farm where small aircraft may not be detected by ILS radar. In addition, the Brookner report asserts the proposed action will result in a "shadow region" behind the turbines that may also obscure some aircraft. The report assumes that the wind turbines will generate "clutter" that may confuse traffic controllers, especially when they are dealing with VFR traffic, and may result in false echoes with respect to low-flying traffic. It should be noted that limited information was provided to document how a flight control system would be operationally impacted, and that the conclusions must be considered in light of the fact that blade manufactures today typically manufacture blades from dielectric materials that help to avoid radar impacts and "false targets." As noted in Section 1.0 of this FEIS, the FAA is currently studying the impacts of the proposed action on aviation safety including radar impacts, and the FAA Determination of No Hazard remains pending for the proposed action.

In addition to the studies above, in the Fall of 2008, the USCG undertook an assessment of the proposed actions' potential to interfere with radar, thereby possibly having a negative impact on navigation safety (see Appendix M). The USCG report revealed that aspects of the wind facility WTG array would impact radar for vessels navigating inside the array in two ways. First, it would spread the width of the radar beam that would appear on the radar screen. In other words, rather than WTGs appearing as a single dot on the radar screen, they would appear as curved and/or elongated streaks. This type of anomaly is related to the performance characteristics of the radar antenna; therefore, the type of radar antennae employed would influence the extent that this might happen. In general, antennas with better off-axis performance, or lower "side lobes" would be less likely to exhibit this effect.

The second type of impact that may occur would be "false echoes" that can result from multiple reflections of radar frequencies from the WTGs. In other words, a spot(s) could appear on the radar screen where no WTGs currently exist. This secondary reflection, however, would usually exhibit reduced amplitude (brightness) on the radar screen.

Navigation safety for vessels operating within the limits of the wind turbine array was determined to be moderately impaired, but the USCG concluded that the effects could be mitigated. The applicant in consultation with the USCG developed mitigation measures that include traffic management and vessel operation conditions within the turbine array (see Section 9.3.4 for more details on these mitigation measures and Appendix M for the study results). Also in Section 9.3.4 and Appendix M is a discussion of the USCG's own analysis of the radar impact study, and specification of mitigation measures. The study found that the adverse effects on radar are a concern within the turbine array, but are of much less concern for vessels operating outside of the array or for inside/outside vessel interactions. The USCG concluded that until the facility is placed into operation, a full and adequate assessment may not be possible, and in their December 30, 2008 assessment (see Appendix M), they conclude the mitigation discussion by referring to the adaptive management approach that MMS is taking regarding mitigation measures, and they retain the right to modify or add to mitigation requirements to ensure that navigational safety is acceptable.

**LORAN**

If a ship is within a 0.5 miles (0.8 km) distance from a turbine there is a possibility that a minor error could be introduced into the LORAN receiver. These small errors are generally not mitigated, although mitigation is possible on HF and LF frequencies by "detuning" the pertinent turbine structures with "skirt wires."

**Safety and Emergency Communications**

For nearly all voice and low-speed data applications, the effect of the turbines would be confined to the 0.5 mile (0.8 km) radius mentioned previously. For some non-standard applications, such as high-speed data above 10 or 20 Megabits per second, the throughput speed may be reduced if the communications path transverses the turbine area, especially near the center of the path. This effect is not deemed to be critical, because the communications would not be completely disrupted, merely slowed, and the geometry required for adverse effects would be a small fraction of usage, especially since communications at these higher speeds is currently quite rare. Based upon reasonable assumptions, there are no serious instances of impact potential to land mobile or public safety facilities.

**Impact of Offshore Cables**

The possible radiation from offshore cables is confined to power frequencies (60 to 120 Hz, usually 3-phase). The magnitude of the EMF is proportional to the current flowing in the cable(s). The cables are engineered structures with shielding, and are designed not to radiate and electric field. It should be noted that a wavelength at 120 Hz. is over 1,000 miles (1610 km); therefore, a significant difference of potential would not be evident from the proposed action to the shore. Therefore, there would be no significant effect.

**Micro Wave Communications - Airports**

According to previous documents, no microwave links are impacted by the present turbine arrangement. However, if turbines are relocated within the Worst Case Fresnel Zone of any other identified path as shown in Figure 5.3.4-2, those paths would need to be re-studied. If turbines must be re-located closer to the microwave path, the path would need to be field-verified by GPS survey.

**Conclusion**

The proposed action is expected to have a moderate impact on radar and a minor impact on other communications systems in the area. Radar navigation impacts can be mitigated to an acceptable level via the conditions developed by the applicant in consultation with the USCG as presented in Section 9.3.4.

## 5.4 ALTERNATIVES EVALUATED FURTHER IN DETAIL

Based on the results of the screening process described above, MMS chose the following alternatives to evaluate in further detail. These include:

- Monomoy Shoals;
- South of Tuckernuck Island;
- Smaller Alternative;
- Phased Development Alternative; and
- Condensed Array Alternative.

The locations for each of these alternatives are shown together in Figure 3.3.5-1. This section also reviews the option of taking no action.

### 5.4.1 South of Tuckernuck Island Alternative

#### *5.4.1.1 Description of the South of Tuckernuck Island Alternative*

The South of Tuckernuck Island Alternative is approximately 3.8 miles (6.1 km) southwest of Tuckernuck Island in Federal waters (see Figure 3.3.5-1). Water depth within the site ranges between 15 ft and 100 ft (4.6 m and 30.5 m) below MLLW, with an estimated average depth of approximately 57 ft (17.5 m). The South of Tuckernuck Island Alternative would be the same generation size as the proposed action (130 WTG's, 3.6 MW machines plus an ESP), but would require an area of approximately 36 square miles (93.2 $km^2$). The proposed turbine spacing for the South of Tuckernuck Island site is a grid arrangement approximately 9.0 rotor diameters (0.63 miles [1.0 km]) by 5.7 rotor diameters (0.39 miles [0.629 km]).

This site would require foundations to be placed in various water depths ranging from approximately 15 to 100 ft (4.6 to 30.5 m), but still benefits from some sheltering effects from open ocean waves due to Nantucket Island to the east. The South of Tuckernuck Island Alternative would likely require three different sized monopiles and a quad-caisson foundation depending on water depth. Water depths between 0 and 30 ft (0 and 9.1 m) would utilize a 16.75 ft (5.1 m) diameter monopile, water depths between 30 and 45 ft (9.1 and 13.7 m) would utilize an 18.0 ft (5.5 m) diameter monopile, and water depths between 45 and 65 ft (13.7 and 19.8 m) would utilize a 19.0 ft (5.8 m) diameter monopile. The quad-caisson foundation, a fabricated steel structure, would be utilized for all WTGs installed at a depth greater than 65 ft (20 m). This structure would consist of four tower foundations that support the tower interface (see Figure 3.3.5-2). This structure would require more fabrication and installation due to its large size and the more challenging sea conditions off the southern coast of Nantucket Island.

With respect to construction, the South of Tuckernuck Island Alternative is located in a more open ocean setting that presents sea conditions considerably different from the proposed action. Greater precautions for personnel safety would add to the complexity of the construction. The sea conditions would also restrict access to the site for construction and for maintenance to a considerably greater degree than the proposed action as well as some of the other alternatives. Routing for delivery of material to the site from a marshalling area (assumed to be Quonset Rhode Island for purposes of this comparison) would be from south of Martha's Vineyard.

The construction sequencing for this Alternative would be similar to that described for the Nantucket Sound alternatives. However, rather than the mechanical driving of the structure into the seabed as described for the monopiles, the caissons of the deep water foundation would be set on the seabed and then suctioned into place to the appropriate depth.

The 115 kV offshore transmission cable system for the South of Tuckernuck Island Alternative would consist of the same equipment as described in Section 2.3 of this document. The total length of the offshore cable route, from the alternative site of the ESP to the Barnstable Substation, would be 33.4 miles (53.8 km). Of this amount, approximately 14.8 miles (23.8 km) of cable would cross the OCS, 12.7 miles (20.4 km) would cross state submerged lands, and approximately 5.9 miles (9.5 km) of cable would be located in an onshore transmission ROW. The offshore cable would be routed from the ESP in a northwesterly direction for about 6.8 miles (10.9 km) and then turn in a northeasterly for about 20.7 miles (33.3 km) before making landfall.

The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-3.

#### *5.4.1.2 Environmental Resources of the South of Tuckernuck Island Alternative and Comparison with the Proposed Action*

##### 5.4.1.2.1 Regional Geologic Setting

Particle analysis of surface grab sediments collected during benthic studies in Nantucket Sound show sand sized particles predominate, derived from relict glacial sediments (Poppe et al., 1989; Theroux and Wigley, 1998). Finer-grained sediments containing silt and clay could be expected south of Tuckernuck

Island, which would indicate that depositional sediment environments may occur in some locations. Glacial sediments near the South Tuckernuck Island Alternative site could be about 60 ft (18.3 m) thick (Uchupi et al., 1996).

Approximately 8 to 10 miles (13 to 16 km) west of the South of Tuckernuck Island Alternative, vibracore samples recovered coarse to fine quartz sand and shell fragments in the upper 7 ft (2.1 m). At other core locations, sands also contained silt and clay, generally at the base of the vertical section sampled. Borings that were drilled southeast of Nantucket Island encountered approximately 90 ft (27.4 m) of fine sand overlying a silt of unknown thickness (Uchupi et al., 1996). Lenses of gravel to coarse sand and medium to fine silty sand were encountered in another nearby boring. These conditions indicate that alternating sequences of high and low energy sediment deposition during glacial stagnation and retreat occurred.

The geological setting of the South of Tuckernuck Island Alternative is similar to the proposed action with regard to sediment composition (see Section 4.1.1 of this document). Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting at the South of Tuckernuck Island Alternative is comparable and offers no significant environmental advantage over the proposed action.

With respect to coastal geomorphology, the northwest part of the South of Tuckernuck Island Alternative is located south and southeast of Muskeget Channel between Martha's Vineyard and Nantucket. Strong currents in and around this channel and ocean currents continue to shape the geomorphology of the sea bottom in this area. Migrating sand waves and shoals may be present, especially in shallow water on the northwest portion of the alternative site. Coarse-grained armor-type bottom sediments, often encountered in channels swept clean of fine-grained material, can also be expected. The regional geology and coastal morphology of the proposed action and the South of Tuckernuck Island Alternative are similar; however site-specific conditions of the two sites differ (see Section 4.1.1.1 of this document for a discussion of the site-specific conditions at the site of the proposed action). Compared to the proposed action, the geology and coastal morphology of the South Tuckernuck Island Alternative offers no significant environmental advantage over the proposed action with respect to its construction, operation, or decommissioning.

#### 5.4.1.2.2 Noise

The potential impacts from above water and underwater sound related to construction and decommissioning activities at the South of Tuckernuck Island Alternative would be equivalent to the impacts from these activities at the Nantucket Sound Alternative. However, due to the greater number of foundation supports with larger diameters and the greater distance that this site is located offshore, the South of Tuckernuck Island Alternative may require a longer construction timeframe, thereby resulting in longer duration of acoustical impacts during construction and decommissioning compared to the other offshore alternative sites.

The potential impacts from underwater sound related to operation of the WTGs at the South of Tuckernuck Island Alternative would be equivalent to the impacts from these activities at the Nantucket Sound Alternative. Acoustic modeling for the South of Tuckernuck Island Alternative was performed to predict the above-water, broadband continuous sound level $L_{eq}$ (dBA) at the closest sensitive onshore receptors for this alternative. As with the other alternatives, the worst case was assumed with the WTGs operating at their design wind speed and wind directions corresponding to onshore conditions for the sensitive receptors. Sound data for a 3.6 MW GE WTG was used in the calculations.

The onshore receptor used for the South of Tuckernuck Island Alternative in the acoustic modeling is Madaket Beach on Nantucket. The maximum predicted sound level for the South of Tuckernuck Island Alternative is approximately 30 dBA. With respect to the Nantucket Sound Alternative as discussed previously, operational noise South of Tuckernuck Island is less likely to be noticeable than the pile driving noise during construction. Furthermore, wildlife and human receptors are expected to acclimate to the low noise levels and are not likely to be adversely affected. Noise impacts are minor for both the proposed site and the South of Tuckernuck Island Alternative with respect to construction, operation, and decommissioning. Compared to the proposed action, the South of Tuckernuck Island Alternative offers no significant environmental advantage with respect to noise over the proposed action during construction, operation, and decommissioning.

#### 5.4.1.2.3 Physical Oceanography

Water depths for the South of Tuckernuck Island Alternative generally increase in a southwesterly direction. Tidal height and range information specific to the South of Tuckernuck Island Alternative are not available. However, the closest NOAA tide stations, located in similar conditions, are at Wasque Point on Chappaquiddick Island (about 8.0 miles [12.9 km] northwest of the South of Tuckernuck Island Alternative ESP) and Tom Nevers Head on Nantucket (about 18.0 miles [29 km] east of the South of Tuckernuck Island Alternative ESP). Given the open sea location of the alternative site, it is expected that tidal ranges would be similar to those at the two NOAA tidal stations (see below). The NOAA also has tidal current stations located within and northwest of the South of Tuckernuck Island Alternative.

The fetch at the South of Tuckernuck Island Alternative is restricted to the northwest by Martha's Vineyard and to the north and east by Muskeget, Tuckernuck and Nantucket Islands, and shallow shoals. Since the fetch is open to the Atlantic Ocean to the south and west the largest waves are likely to come from those directions. Oceanographic data for the site is as follows:

***Water Depth***: The estimated depths within the alternative site is between 60 and 90 ft (18.3 and 27.5 m) at MLLW except at the northwest edge which has water depths of between 10 and 25 ft (3.1 and 7.6 m) at MLLW.

***Tide***: Average Tides:
- Mean Range = 1.15 ft (0.35 m)
- MHWS = 1.40 ft (0.43 m)

***Current:*** Station ID: 1716
- Avg. Max Flood = 0.5 knots (0.26 m/s) 90˚
- Avg. Max Ebb = 1.0 knots (0.51 m/s) 270˚

***Wave Conditions***: WIS Station IDs: 87 and 86 Extreme storm waves of approximately 52.5 ft (16 m); larger value of the two WIS stations.

Compared to the proposed action, the oceanography of the South Tuckernuck Island Alternative offers no significant environmental advantage over the proposed action.

#### 5.4.1.2.4 Climate and Meteorology

The weather conditions for the South of Tuckernuck Island Alternative are similar to the site of the proposed action. However, the alternative site is estimated to have a predicted mean wind speed between 19.0 and 20.1 mph (8.5 and 9.0 m/s) in the near shore and between 20.1 and 21.3 mph (9.0 and 9.5 m/s) in the far shore. This is fairly close to the wind speed at the Horseshoe Shoal site which has a mean wind speed of 17.9 to 20.1 mph (8 to 9 m/s). Compared to the proposed action, impacts on climate and meteorology within the South of Tuckernuck Island site, including its offshore and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.5 Air Quality

The existing air quality conditions for the South of Tuckernuck Island Alternative site are similar to the site of the proposed action. Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning, and maintenance would emit, or have the potential to emit air pollutants. However, emission impacts would be minor and overall, impacts on air quality associated with the South of Tuckernuck Island Alternative, including its offshore and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.6 Water Quality

The Massachusetts Surface Water Quality Standards (314 CMR 4.06(3)) categorize surface waters adjacent to Nantucket Island as Class SA coastal and marine water bodies. According to the MassDEP standards, Class SA waters are designated as "an excellent source of habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation." It is expected that water quality at the South of Tuckernuck Island Alternative and along the approximate 33.4 mile (53.8 km) long offshore cable route, would meet this water quality designation, since there are no known major sources of pollutant input or other degrading factors. In approved areas, Class SA waters are "suitable for shellfish harvesting without depuration (Open Shellfish Areas)." Compared to the proposed action, impacts on water quality would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.7 Electric and Magnetic Fields

Electric and magnetic field strength along the offshore cables and onshore cables would have negligible impacts on the marine environment and to humans, and be of the same strength as that for the proposed action. Compared to the proposed action, impacts from electrical and magnetic fields would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.8 Terrestrial Vegetation

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site at New Hampshire Avenue, and onshore cable route (see Section 4.2.1 of this document for detailed information on terrestrial vegetation). Compared to the proposed action, impacts on terrestrial vegetation within the South of Tuckernuck Island Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay and landfall site at New Hampshire Avenue (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the South of Tuckernuck Island Alternative, including its offshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.1.2.10 Terrestrial and Coastal Faunas Other than Birds

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site at New Hampshire Avenue, and onshore cable route. See Section 4.2.2 of this document for detailed information on coastal and intertidal resources. Compared to the proposed action, impacts on coastal and intertidal resources within the South of Tuckernuck Island Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.1.2.11 Avifauna

During the winter, seaducks likely to use the South of Tuckernuck Island Alternative area include eiders, scoters, and long-tailed ducks while the summer months attract pelagic species, such as shearwaters, storm-petrels, and jaegers. Other species of waterbirds such as loons and Northern Gannets use the general area for foraging (National Audubon Society, 2002). Tens of thousands of long-tailed ducks leave Nantucket Sound each day on foraging trips (Veit and Petersen, 1993) and many may spend the day foraging in areas south of Tuckernuck, depending on the food availability. Terns and gulls are also likely to forage in the area while seaducks and other waterbirds use the area as a staging area before migrating to their nesting colonies in the spring and to wintering grounds further south. Other migratory birds such as landbird species likely pass over South of Tuckernuck Island typically at high altitudes during spring and fall migrations.

Compared to the proposed action, the South of Tuckernuck Island Alternative would have a greater potential for impacts to terrestrial, coastal, and marine birds, primarily because of the increased area in which the turbines would be located.

### 5.4.1.2.12 Subtidal Offshore Resources

Since Massachusetts Geographic Information System (MassGIS) data for eelgrass beds is limited to within the 3.5 miles (5.6 km), no eelgrass data is readily available for the proposed action (MassDEP, 2006). However, given the water depths, none would be expected at this location.

**Benthic Habitat**

As described above, water depths are variable throughout the South of Tuckernuck Island Alternative. The composition of the bottom sediments there has been documented in several studies (Theroux and Wigley, 1998; Poppe et al., 1989). Although no studies focused solely on the South of Tuckernuck Island Alternative, they did encompass the general area. The site is dominated by sand-sized particles (Theroux and Wigley, 1998; Poppe et al., 1989). In marine environments these substrates typically support the highest density and biomass of organisms per square meter, as compared to either larger or finer grained material (Theroux and Wigley, 1998).

The benthic habitat types for the South of Tuckernuck Island Alternative are similar to the site of the proposed action (see Section 4.2.5 of this document). The dominant bottom substrate of the area of the proposed action includes sand (fine- and course grained), mud, and other fine-grained sediments. The SAV (i.e., eelgrass), boulders, and cobbles are not common.

**Benthic Community Composition and Abundance**

The South of Tuckernuck Island Alternative is generally reported as a moderately productive area for benthic invertebrates. Densities of benthic organisms typically range between 65 and 510 individuals/$ft^2$ (700 and 5,500 individuals/$m^2$) and benthic organism biomass typically ranges between 0.01 and 0.1 lbs/square ft (50 and 500 grams/$m^2$) (Wigley and McIntyre, 1964 and Theroux and Wigley, 1998).

The most abundant taxa at the South of Tuckernuck Island Alternative are crustaceans and mollusks, followed by polychaete worms (Theroux and Wigley, 1998). Among the crustaceans, the amphipods are reported to be by far the most abundant, which is similar to the community found in Nantucket Sound. Several taxa are expected to occur at the South of Tuckernuck Island Alternative that would be much less common within Nantucket Sound. These include Amphipoda, Cumacea, and Isopoda, as well as the Nemeitea, Nematoda, and Sipuncula; all within the Crustacean taxa.

Twenty benthic macroinvertebrate taxa were recorded during benthic sampling programs conducted at the site of the proposed action (see Section 4.2.5 of this document). Of the sites sampled, the average faunal density was 1078 individuals/square ft (11,589 individuals/m²). Nematoda were more abundant than any other class (70 percent of the samples) and was followed by Oligochaeta (27 percent of the samples) and gastropod *Crepidula fornicata* (17 percent of the samples).

Compared to the proposed action, the benthic community composition within the South of Tuckernuck Island Alternative is smaller with regards to overall abundance of species and differs with regard to community structure. The site of the proposed action provides habitat preferred by deposit and suspension feeding species whereas the alternative site provides habitat preferred by scavenger and predator species.

The additional pilings, cross-braces, and scour protection required at the South of Tuckernuck Island Alternative substantially increase (by more than 10 times) the vertical habitat structure available for colonization by benthos for the life of the proposed action. However, anchoring impacts associated with construction would be greater at the South of Tuckernuck Island Alternative than the Horseshoe Shoal proposed site. The area of direct impact at the South of Tuckernuck Island Alternative would be nearly twice that of the Horseshoe Shoal site, likely resulting in greater overall impact to benthos at the South of Tuckernuck Island Alternative than at the proposed action. The South of Tuckernuck Island alternative also would have greater impacts on benthic resources as a result of the much longer offshore transmission cable requirement compared to that of the proposed Horseshoe Shoal site. Accordingly, benthic impacts are expected to be greater at the South of Tuckernuck Island alternative than the Horseshoe Shoal site with respect to construction, operation, and decommissioning.

#### 5.4.1.2.13 Non-ESA Marine Mammals

Three federally protected cetaceans, North Atlantic Right, humpback, and fin whales may occur in the vicinity of the proposed South of Tuckernuck Island Alternative (see Table 5.4.1-1), but are typically found in areas of deeper water. The South of Tuckernuck Island Alternative contains some features that favor dense aggregations of whale prey species, but these are not as well developed as other areas farther north (Kenney and Winn, 1986). Although preferred prey species for whales occur in the South of Tuckernuck Island area higher-use areas occur further north. The South of Tuckernuck Island area does not appear to be an important area even though there have been more recorded sightings of Northern Atlantic right whales in the South of Tuckernuck Island area than in Nantucket Sound or Buzzards Bay.

As shown in Table 5.4.1-1, several other species of protected marine mammals may be present within the vicinity of the South of Tuckernuck Island Alternative. These species include harbor, harp, and hooded seals, white-sided and striped dolphins, harbor porpoise, and long-finned pilot whale.

The species identified in Table 5.4.1-1 could also be present at the site of the proposed action (see Section 4.2.6 of this document) as could the Atlantic spotted dolphin, Risso's dolphin, and Kogia species (sperm whale).

With respect to overall impacts on marine mammals, the South of Tuckernuck Island Alternative is in closer proximity to seal haul-out and breeding sites than the proposed action, and therefore, development at this site has a greater potential to impact seals both during construction and operation. In addition, there is somewhat greater potential to impact whales at the South of Tuckernuck Island alternative during construction since the site is proximate to historical sightings of these mammals. There is a potential for greater impact to prey species at the South of Tuckernuck Island Alternative compared to the proposed action given the greater potential benthic habitat disturbance at this Alternative and anticipated longer construction duration. In conclusion, there may be a somewhat greater potential for impacts on marine mammals within the South of Tuckernuck Island Alternative than the site of the proposed action with respect to construction, decommissioning, and operational impacts.

### 5.4.1.2.14 Fish and Fisheries

Table 5.4.1-2 lists common finfish and shellfish resources which are known to occur within the general offshore vicinity of Cape Cod and the Islands. Section 4.2.7 of this document provides detailed information on fish and fisheries for the proposed action. The South of Tuckernuck Island Site contains a greater number of fish species than the proposed site, since it has habitat that is preferred by species that typically occur in deeper, cooler waters. The South of Tuckernuck Island Site has more species and life stages with designated EFH unique to this Site. There are eight species (common thresher shark, dusky shark, monkfish, ocean pout, ocean quahog, spiny dogfish, whiting, and witch flounder) that have EFH life stage designations at the South of Tuckernuck Island Alternative and not at the proposed action. There are also eight life stages of certain species that only have designated EFH at the South of Tuckernuck Island Alternative. The habitat requirements for these species/life stages typically are waters that have a deeper depth range and cooler temperatures.

Once in operation, the South of Tuckernuck Island Alternative offers a greater surface area for potential fish aggregations compared to the proposed action because of the larger foundations required as a result of the deeper water. However, the South of Tuckernuck Island Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance, resulting in greater impacts to fisheries from sediment disturbance compared to the proposed action. Finally, the South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to finfish compared to the proposed action, because that alternative would require a longer construction/decommissioning timeframe. In conclusion, the South of Tuckernuck Island Alternative would be expected to have a greater impact on finfish than the proposed action during construction, operation and decommissioning.

**Shellfish Resources**

Since the South of Tuckernuck Island Alternative is, on average, deeper than the proposed action, it is expected that the shellfish community in the area would not contain as many of the suspension (filter) feeding mollusk species. The highest abundance and diversity of suspension-feeding mollusks tend to be associated with water depths of less than 60 ft (18.3 m) in areas south of Cape Cod (Saila and Pratt, 1973). Suspension-feeding species such as northern quahog, bay scallop, sea scallop, surf clam, and soft-shelled clam are reported to be less common South of Tuckernuck Island than at the proposed site (Weiss, 1995; Saila and Pratt, 1973; Gosner, 1978). The channeled whelk (conch) and knobbed whelk are more common in shallow waters (Weiss, 1995) and would therefore be expected to be less common in the deeper waters of the alternative site.

Two species of mussel are common to the region, blue mussel (*Mytilis edulis*) and horse mussel (*Modiolus modiolus*). The blue mussel thrives in shallower waters near low tide attached to rocks and shells (Weiss, 1995). Rocky habitat is not present at the South of Tuckernuck Island Alternative; therefore, it is expected that fewer blue mussels would be found at the alternative site. The horse mussel is far less common in the region, particularly in areas south of Cape Cod. It typically lives in deeper waters to depths of 240 ft (73.2 m) (Weiss, 1995) and would be more common at the South of Tuckernuck Island Alternative than at the proposed action Ocean quahogs are also more common in deeper waters, between 60 and 90 ft (18.3 and 27.5 m), with finer sand to mud substrates (Weiss, 1995; Saila and Pratt, 1973). They too would be more common at the South of Tuckernuck Island Alternative than at the proposed site.

The South of Tuckernuck Site is expected to have somewhat fewer shellfish resources than the proposed action because of its deeper waters. However, this is balanced by the fact that at South of Tuckernuck, the area of construction impacts is more extensive as a result of the larger foundation, larger area of anchor sweep associated with deep water construction, and longer offshore transmission cable distance. In general, shellfish impacts are expected to be comparable between the South of Tuckernuck Island Alternative site and the proposed site with respect to construction, operation, and decommissioning.

**Finfish**

Commercial fishing landings data for the specific fisheries in the South of Tuckernuck Island Alternative area are not readily available. This Alternative site is located outside of the three-mile (4.8 km) territorial limit but within a small portion of the MassDMF statistical reporting Area 16 for lobsters. According to McBride and Hoopes (2001), Area 16 has one of the highest landings for lobster of all offshore statistical reporting areas in Massachusetts (1,000,001 to 2,000,000 lbs [453,593 to 907,185 kg] in 1999). Since the offshore area along the northern coast, north of Cape Cod Bay, produced the highest landings of lobsters and because statistical reporting Area 16 is so large, it is difficult to determine if and how much of the South of Tuckernuck Island Alternative contributes to the total lobster harvest.

Recreational fishing in the waters south and east of Cape Cod includes both private recreational vessels and charter services. Due to the weather conditions on Nantucket Sound, the prime season for recreational fishing occurs during late spring to late summer. Main target species for recreational fishing include striped bass, several tuna species, scup, bluefish, bonito, sea bass, sharks, and cod. Section 4.2.7 of this document provides information on commercial and recreation fish and shellfish for the proposed action.

Overall the South of Tuckernuck Island Alternative would be expected to have a greater impact on fish and commercial fisheries than the proposed action as a result of longer construction time frame and the size of the foundation. The larger foundation size is expected to result in increased fish aggregation compared to the proposed action.

### 5.4.1.2.15 Essential Fish Habitat

Habitat within the South of Tuckernuck Island Alternative has been designated as EFH for 28 federally-managed fish species and 4 federally-managed invertebrate species. Table 5.4.1-3 provides a listing and specific life stage designations of those species within the area of the South of Tuckernuck Island. The proposed action has been designated EFH for 17 federally managed fish and three federally managed invertebrates all of which overlap with those listed in Table 5.4.1-3. The EFH species included for the South of Tuckernuck Island Alternative but not the proposed action are the Atlantic sea herring (*Clupea harengus*), Common thresher shark (*Alopias vulpinus),* Dusky shark (*Carcharhinus obscurus),* Haddock (*Melanogrammus aeglefinus*), Monkfish (*Lophius americanus*), Ocean pout (*Macrozoarces americanus),* Ocean quahog *(Artica islandica),* Red hake (*Urophycis chus),* Sandbar shark (*Carcharhinus plumbeus),* Spiny dogfish (*Squalus cubensis),* Whiting (*Merluccius bilinearis),* and Witch flounder *Glyptocephalus cynoglossus).*

The Magnuson-Stevens Act requires an assessment of potential impacts to federally managed fish and invertebrate species when EFH habitat may be affected, as is the case with the proposed action (NOAA, 2006). Section 4.2.8 of this document provides information on EFH for the proposed action. Temporary and localized sediment disturbance from construction vessel anchoring, anchor line sweep, and scour protection are anticipated. The anchoring and scour protection impact for the South of Tuckernuck Island Alternative would likely be more than that of the proposed action. As a result, this alternative would be expected to result in more temporary impact than that of the proposed action during construction and during decommissioning. Greater foundation size at Tuckernuck, and thus increased aggregation, would result in somewhat greater impact during operation.

#### 5.4.1.2.16 Threatened and Endangered Species (T&E)

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the site of the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route. See Section 4.2.9 of this document for detailed information on endangered and threatened species along this cable route. Compared to the proposed action, impacts on endangered and threatened species along the near shore and onshore cable routes associated with the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

The South of Tuckernuck Island Alternative area may provide suitable foraging habitat for the federally-endangered roseate tern (*Sterna dougallii*) and suitable nesting habitat for the federally-threatened piping plover (*Charadrius melodus*) on shorelines on Tuckernuck Island and Nantucket. The Massachusetts Natural Heritage Atlas (2003 edition) indicates that the South of Tuckernuck Island Alternative site, approximately 3.8 miles (6.1 km) northeast of Tuckernuck Island, is located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife for onshore, nesting areas for shorebirds and terns. Two state species of special concern (common loon and least tern) and one state-endangered species (roseate tern) may use the waters near the South of Tuckernuck Island Alternative as a winter resident (common loon) and/or foraging (Veit and Petersen, 1993).

Potential impacts to listed species at the South of Tuckernuck Island Alternative site would be comparable to the proposed action. Piping plover is known to nest on Tuckernuck Island, but is unlikely to visit this offshore area except during migration. There would likely be fewer terns present at the South of Tuckernuck Island Alternative than the proposed action during the breeding season because of the distance from the primary breeding colonies in Buzzards Bay. However, there would be terns present at South of Tuckernuck Island Alternative during other seasons, and potential impacts would be comparable to the proposed action.

As shown in Table 5.4.1-1, three federally and/or state protected sea turtle species may be present within the South of Tuckernuck Island Alternative: loggerhead, leatherback, and Kemp's Ridley sea turtles. Kurkul (2002) reported that these sea turtles are found within Massachusetts waters at varying times of the year. Therefore it is possible that they may utilize the South of Tuckernuck Island area during some portion of the year as well. The federally protected green sea turtle is less likely to be found within Nantucket Sound. Loggerhead, leatherback, and Kemp's Ridley sea turtles may also use Horseshoe Shoal (see Section 4.2.9 of this document). Compared to the proposed action, impacts on sea turtles within the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.17 Socioeconomic Analysis Area

The existing socioeconomic conditions for the South of Tuckernuck Island Alternative are similar to that of the proposed action (see Section 4.3 of this document) as the two locations are within the same general socioeconomic area of the Cape Cod and the Islands of Martha's Vineyard and Nantucket. Compared to the proposed action, socioeconomics impacts associated with the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning.

#### 5.4.1.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure within the South of Tuckernuck Island Alternative, including its submarine and onshore cables, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.19 Population and Economics

The South of Tuckernuck Island Alternative is located in the same general socioeconomic area as the proposed action and is expected to result in negligible impacts on changes to population or the economy of the region. Hence, the South of Tuckernuck Island Alternative would be comparable to and offer no significant advantage in terms of population and economics over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area South of Tuckernuck is in the same general socioeconomic area as the proposed action and not located near any communities of higher than normal minority populations or higher than normal poverty rates nor is it located any closer to the WTGHA or the Wampanoag Tribe of Mashpee. As such, the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.21 Visual Resources

The seascape from Tuckernuck Island southwest towards the South of Tuckernuck Island Alternative consists of panoramic open ocean views of the Atlantic Ocean. The visual impacts toward the South of Tuckernuck Island Alternative would be somewhat more significant as there are no other lands or human structures visible when viewed from Nantucket or Martha's Vineyard. However, generally fewer viewers would see the WTG array at the Tuckernuck area, since it would be beyond or close to beyond visible range from Cape Cod which has the major population density in the area (see Figure 3.3.5-4, Sheets 1 - 4). As a result, a WTG array would have less visual impact at the South of Tuckernuck Island site than the proposed action for construction, operation, and decommissioning.

#### 5.4.1.2.22 Cultural Resources

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same onshore cultural resources (see Section 4.3.5 of this document). Compared to the proposed action, impacts on onshore cultural resources within the South of Tuckernuck Island Alternative, including its submarine and onshore cables, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts. With respect to visual impacts on cultural resources (i.e., historic homes and historic sites), this site is located further from historic areas of Cape Cod, but closer to the historic area of Nantucket. Thus no difference in impact is expected compared to the proposed action with respect to impact on cultural resources.

No submerged historic properties or archaeological sites are recorded in the South of Tuckernuck Island Alternative area, and there are no shipwrecks charted in the vicinity of the alternative site. Four vessel casualties ranging in date from 1817 to 1969 are reported in the Northern Shipwreck Database. A review of the MHC's records indicates that no marine archaeological investigations have been conducted in the area. The archaeological sensitivity for submerged Euro-American and Native American cultural resources near the South of Tuckernuck Island Alternative is expected to be low because of the area's homogenous bathymetry and exposed location to the open waters of the Atlantic Ocean. Since a detailed marine sensitivity assessment and marine archaeological reconnaissance survey have not been conducted for the South of Tuckernuck Island Alternative, it is difficult to determine whether any subtidal archeological resources (i.e., historic or pre-historic sites) would actually be affected by the proposed action if it were sited at this alternative location. However, if such sites were documented at the alternative site, the applicant would have to implement mitigative measures similar to those for the proposed action (see Section 4.3.5 of this document). Therefore, impacts on subtidal archaeological resources within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.1.2.23 Recreation and Tourism

The South of Tuckernuck Island Alternative is located closer to land (Nantucket Island) and the popular boating and recreational area around Nantucket Island than the proposed action, but it is located further from the popular boating and recreational areas of Cape Cod than the proposed action. In general, impacts on recreational activities within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.1.2.24 Competing Uses of Waters and Sea Bed

The 115 kV offshore transmission cable system from the ESP at the South of Tuckernuck Island Alternative to the landfall site at New Hampshire Avenue, within Lewis Bay, would traverse approximately 12.8 miles (20.6 km) of State waters and sea bed. Competing uses that exist along the offshore cable route include aquaculture, submarine electric transmission cables (2 Nantucket cables would be crossed), recreational and commercial activities, and maintenance dredging activities. Compared to the proposed action, impacts on competing use activities within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.1.2.25 Overland Transportation Arteries

Like the proposed action, the South of Tuckernuck Island Alternative is located offshore and not near any overland transportation arteries and would be expected to have comparable traffic impacts associated with onshore equipment deliveries or commuting of workers as the proposed action. Thus the South of Tuckernuck Island Alternative offers no significant environmental advantage for overland transportation arteries over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.26 Airport Facilities

The South of Tuckernuck site is located closer to the Nantucket Airport but further away from the Barnstable Airport in Hyannis than the proposed action. Regardless, both locations received FAA approval (see Appendix B). The net impact on airport facilities from the South of Tuckernuck Island Alternative would therefore likely be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.27 Port Facilities

The impact on port facilities from the proposed action and its alternatives would primarily be with respect to vessels navigating in the area. Assuming that the spacing of the WTGs remains the same for the alternative locations, the potential impacts to navigation at the South of Tuckernuck Island Alternative would be equivalent to the potential impacts for the proposed action. Installation of the wind turbines would result in structures being present where no structure has previously existed and mariners would need to navigate with consideration of these new structures. The South of Tuckernuck Island Alternative is located closer to land (Nantucket Island) than the proposed action and thus would experience vessel traffic associated with that area and nearby Nantucket Harbor, but it is further away from the popular boating area near Cape Cod and its associated ports, than the proposed action. On whole, the South of Tuckernuck Island Alternative would have an impact on ports and related marine traffic that is comparable to that of the proposed action and offer no significant advantage to Port Facilities over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.1.2.28 Communications: Electromagnetic Fields (EMF), Signals and Beacons

Recreational vessels, commercial fishing and marine cargo ships traverse Nantucket Sound via the nearby Muskeget Channel. All of these vessels use marine radios, which operate at a range of 156.05 to 157.425 megahertz (MHz). Shore radios operate at approximately 156.85 to 162.025 MHz. The NOAA weather service operates at frequencies between 162.4 and 162.55 MHz. In addition, the site is in sufficiently close proximity to allow telecommunications signals from cellular phone towers, local emergency response communication towers, radio towers, and television (TV) towers to be transmitted and received. The FAA has conducted an aeronautical study for each of the South of Tuckernuck Island Alternative turbine locations (see Appendix B). As part of these studies, the FAA has analyzed the potential for the WTGs to affect aviation radar. Based on the completion of the aeronautical studies, the FAA has issued a "Determination of No Hazard to Air Navigation."

## 5.4.2 Monomoy Shoals (East of Monomoy, Massachusetts) Alternative

### *5.4.2.1 Description of the Monomoy Shoals Alternative*

The Monomoy Shoals Alternative site is 3.5 miles (5.6 km) southeast of Monomoy Island, within the eastern approach to Nantucket Sound (Figure 3.3.5-1). Water depth within the Monomoy Shoals Alternative site ranges between 13 ft and 34 ft (3.9 and 10.4 m) below MLLW, with an estimated average depth of approximately 24 ft (7.3 m) (Navigational Chart No. 13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001). The alternative would be the same generation size as the proposed action (130 WTG's, 3.6 MW machines plus and ESP), but would require a slightly larger area (25.9 square miles [67.1 $km^2$]). The proposed turbine spacing for the Monomoy Shoals Alternative site is a grid arrangement approximately 9.0 rotor diameters (0.63 miles[1,000 m]) by 5.7 rotor diameters (0.39 miles [629 m]).

The construction and decommissioning methods at the Monomoy Shoals Alternative site would be similar to those presented in Section 2.3 of this document for the proposed action. Although driven monopile foundations and jet plow cable embedment are anticipated to be the proposed method of construction, it is possible that bed rock outcroppings and shallow surface bedrock at the Monomoy Shoals Alternative site may necessitate surface laying of the cable or other alternative installation methods. In addition, it is anticipated that the construction and decommissioning timetables for this alternative would be significantly longer than the proposed action, due to more limited accessibility (primarily due to wave conditions).

The 115 kV offshore transmission cable system for the Monomoy Shoals Alternative site would consist of the same equipment as described in Section 2.1 of this document. As shown in Table 3.3.5-2, the total length of the offshore cable route, from the alternative site ESP to the Barnstable Substation, would be 29.8 miles (48 km). Of this amount, approximately 2.9 miles (4.7 km) of offshore cable would be in Federal waters, 21.0 miles (33.8 km) would be in State waters, and 5.9 miles (9.5 km) of cable would be located in an onshore transmission ROW. The offshore cable would be routed from the ESP in a north-northwesterly direction for about 20.6 miles (33.2 km) and then turn north-northeast for about 3.3 miles (5.3 km) before making landfall. The offshore cable would be located approximately 3.0 miles (4.8 km) south of Monomoy Island. The total inner array length of 33 kV cable would be approximately 74 miles (119.1 km). The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-5.

### *5.4.2.2 Environmental Resources of the Monomoy Shoals Alternative and Comparison with the Proposed Action*

#### 5.4.2.2.1 Regional Geologic Setting

The narrow shelf east of lower Cape Cod, south of Chatham, is made up of a wave-built terrace that contains surface sediments composed of coarse sand (Schlee and Pratt, 1970; Schlee 1973; Aubrey and Gaines, 1982). Fragments of rock recovered from the terrace's seaward scarp are coated with manganese oxide suggesting that little or no sediment is being deposited on the scarp present at the Monomoy Shoals Alternative site. High-resolution seismic reflection profiles taken with an EG&G Uniboom in the wave-built terrace area show a prominent reflector about 10 to 30 m below the sea floor and an unconformity shoaling to the north and south (Aubrey and Gaines, 1982).

Offshore from Monomoy Island, and Nauset Beach, the sea floor is dominated by northeast-trending swells that can be traced to a depth of approximately 65 ft (20 m). Beyond 65 ft (20 m), the sea floor roughness diminishes to the near 130 ft (40 m) depth and sea floor declivity increases as it descends to the Wilkinson Basin complex in the Gulf of Maine.

The geological setting of the Monomoy Shoals Alternative differs from the proposed action with regard to surface sediment type (see Section 4.1.1 of this document). Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. Monomoy Shoals is generally composed of coarse sand. Compared to the proposed action, the geologic setting at the Monomoy Shoals Alternative site offers no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning.

With respect to coastal geomorphology, analyses of historical charts show changes at Nauset Beach in front-and east-of the Chatham Lighthouse and north of Monomoy Island. Nauset Beach and Monomoy Island are two barrier beaches with tidal flows between Chatham Harbor and Pleasant Bay Estuary through the South Inlet located south of Nauset Beach. A comparison of maps from 1887, 1940, 1947 through 1953, and 1961 through 1964 with stereoscopic aerial photographs taken in 1969, show that the northern end of Monomoy Island (Shooters Island) has been receding since 1948. During 1971, Oldale et al. estimated that this area could separate from the rest of the island in about 70 to 80 years. However, island separation occurred in 1978, much earlier than was estimated. The southern half of Monomoy Island has been prograding eastward at a rate of about 39 ft (12 m) per year since at least 1853. Growth of Monomoy Island would most likely slow down in the future as it continues to prograde southeast into Butler Hole.

The regional geology and coastal morphology of the proposed action and the Monomoy Shoals Alternative are similar; however specific conditions at the two sites differ (see Section 4.1.1.1 of this document for a discussion of the site-specific conditions at the sites of the proposed action). Compared to the proposed action, the geology and coastal morphology of the Monomoy Shoals Alternative site are more dynamic, since it is closer to the open ocean and the adjacent Monomoy Island is undergoing constant change in its overall structure. The Monomoy Shoals Alternative offers no significant geological advantage over the proposed action with respect to construction, operation or decommissioning impacts.

### 5.4.2.2.2 Noise

The potential impacts from above background noise related to construction and decommissioning activities at the Monomoy Shoals Alternative would be less than at the Horseshoe Shoal site due to the site's greater distance to sensitive receptors than the Horseshoe Shoal site. Because noise impacts of the proposed action are expected to be minor, those associated with the Monomoy Shoals Alternative should be considered negligible. Noise impacts to marine life are expected to be the same as for the proposed action. In general, the Monomoy Shoals Alternative would be comparable with respect to noise impacts to the proposed action during construction, operation, and decommissioning.

### 5.4.2.2.3 Physical Oceanography

Monomoy Shoals consists of numerous detached shoals extending about 5.5 miles (8.9 km) in an easterly direction and 9.5 miles (15.3 km) in a southeasterly direction from Monomoy Point. Narrow sloughs separate the many parts of the Shoal. Monomoy Shoals is shifting in character and is subject to change in location and depth.

Bearse Shoal and Pollock Rip extend about 5.0 miles (8.0 km) eastward of Monomoy Point with a series of sand shoal and ridges. The Pollock Rip Channel lies between Monomoy and Bearse Shoal. Stone Horse Shoal, Little Round Shoal, and Great Round Shoal are part of a continuous series of sand shoals and ridges in 4 to 18 ft (1.2 to 5.5 m) of water. These shoals are directly eastward of the entrance to Nantucket Sound and lie between the two main channels. Southward and eastward of these shoals are numerous other shoals, including Orion Shoal in 16 to 19 ft (4.9 to 5.8 m) of water.[27]

The following is background information on physical oceanography at the Monomoy Shoals Alternative:

***Water Depth***: The estimated average depth within the Monomoy Shoals Alternative site is approximately 24 ft (7.3 m); however the water depth ranges between 13 ft and 34 ft (3.9 to 10.4 m) below MLLW (Navigational Chart No. 13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001).

[27] Chartmaker.ncd.noaa.gov/NSD/CP2/CP2-36ed-Ch04_2.pdf

***Tide:*** Station ID: 1015 (41˚33' N, 070˚00' W) Average Tides:
- Mean Range = 3.70 ft (1.1 m)
- MHWS = 4.30 ft (1.3 m)
- Mean Tide = 1.90 ft (0.58 m)

***Current:*** Station ID: 1731 (41˚33.00' N, 070˚01.30' W)
Average Currents:
- Avg. Max Flood = 1.7 knots (0.87 m/s) 170˚
- Avg. Max Ebb = 2.0 knots (1.03 m/s) 346˚

***Wave Conditions***: Extreme storm waves of approximately 66 ft (20.1 m); shallow waters of the shoal result in breaking waves.

With regard to physical oceanography, the Monomoy Shoals Alternative offers no significant environmental advantage over the proposed action (see Section 4.1.3 of this document).

#### 5.4.2.2.4 Climate and Meteorology

The weather conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action. However, the alternative site is estimated to have a predicted mean wind speed (at a height of 70 m) of 20.1 to 21.3 mph (9.0 to 9.5 m/s) (MTC /AWS TrueWind map). This is fairly close to the wind speed at the site of the proposed action, which has a mean wind speed of 17.9 to 20.1 mph (8 to 9 m/s). Compared to the proposed action, impacts due to climate and meteorology associated with the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.5 Air Quality

The existing air quality conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action. Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning, and maintenance would emit, or have the potential to emit air pollutants. Such impacts would be somewhat greater for the Monomoy Shoals Alternative due to the longer distance between Monomoy and the construction staging area at Quonset, Rhode Island, and worker loading area in Falmouth, Massachusetts. However, in both cases, emission impacts would be minor. Overall, impacts on air quality associated with the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.6 Water Quality

The Massachusetts Surface Water Quality Standards adjacent to the Monomoy Shoals Alternative site are similar to the standards described above for the South of Tuckernuck Island Alternative. In addition, the existing water quality conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action and would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.7 Electric and Magnetic Fields (EMF)

Electric and magnetic field strength along the offshore cables and onshore cables would have negligible impacts on the marine environment and to humans, and would be of the same strength for the Monomoy Shoals Alternative as that for the proposed action. Compared to the proposed action, impacts would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.8 Terrestrial Vegetation

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site, and onshore cable route (see Section 4.2.1 of this document for detailed information on terrestrial vegetation). Compared to the proposed action, impacts on terrestrial vegetation within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay and landfall site at (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Monomoy Shoals Alternative, including its offshore transmission cable system cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.10 Terrestrial and Coastal Faunas Other than Birds

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site, and onshore cable route (see Section 4.2.2 of this document for detailed information on coastal and intertidal resources). Compared to the proposed action, impacts on terrestrial and coastal fauna within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.11 Avifauna

Monomoy Island (including the Monomoy National Wildlife Refuge) provides important resting, nesting and feeding habitat for migratory birds. Specifically, Monomoy Island is an important staging area for roseate terns, provides habitat for roseate, common and least tern nesting colonies, harbors roseate and common tern restoration sites, and is a known piping plover nesting area (Perkins, et al., 2003). A large post-breeding, pre-migration staging area for terns is located at South Beach/North Monomoy (Trull et al., 1999). Large numbers of terns (more than 10,000) gather in this area from August through September to roost and forage. Some birds stop over or cross Nantucket Sound and may rest by day at several points along the immediate shoreline. All of these birds are believed to return to South Beach each night. Generally, the foraging range is about 3 miles (4.8 km); however, some birds may travel up to 20 miles (30 km). In addition, the Monomoy National Wildlife Refuge has been designated a Western Hemispheric Shorebird Reserve Network Regional Site and an Important Bird Area (IBA).

Due to the proximity to Monomoy Island, the Monomoy Shoals Alternative would have greater potential impacts than the proposed action to terrestrial, coastal, and marine birds during construction, decommissioning, and operation.

#### 5.4.2.2.12 Subtidal Offshore Resources

Since MassGIS data for eelgrass beds is limited to within the 3.5 miles (5.6 km), no eelgrass data is readily available for the Monomoy Shoals Alternative site (MassDEP, 2006).

**Benthic Habitat**

The shallows within Monomoy Shoals are nearly continuous, forming a broad shelf. The composition of the bottom sediments at the Monomoy Shoals Alternative site has been documented in several studies (Theroux and Wigley, 1998; Poppe et al., 2004). Although no studies focused solely on the Monomoy Shoals Alternative site, they did encompass the Shoals in general. The Monomoy Shoals Alternative site can be characterized as an area dominated by sand-sized particles (Theroux and Wigley, 1998; Poppe et al., 1989), which typically support the highest density and biomass of organisms per square meter, as compared to either larger or finer grained material (Theroux and Wigley, 1998). However, Poppe et al., (2004) note that patches of gravel and gravelly sediments (between 10 and 50 percent gravel) are found locally within the area and these substrates can support a moderate density and biomass of organisms per unit area, as compared to poorly sorted till or finer grained material such as sand-silt or silt-clay (Theroux and Wigley, 1998).

The benthic habitat types for the Monomoy Shoals Alternative differ from the site of the proposed action (see Section 4.2.5 of this document). The dominant bottom substrate of the proposed action includes sand (fine- and course-grained), mud, and other fine-grained sediments. The SAV (i.e., eelgrass), boulders, and cobbles are not common. As a result the benthic community can be expected to differ.

**Benthic Community Composition and Abundance**

The Monomoy Shoals Alternative site is generally reported as a moderately productive area for benthic invertebrates, with densities of benthic organisms typically ranging between 93 and 465 individuals/square ft (1,000 and 4,999 individuals/$m^{2)}$ and benthic organism biomass typically ranging between 0.02 and 0.1 lbs/square ft (100 and 499 grams/$m^2$) (Theroux and Wigley, 1998).

The most abundant taxa at Monomoy Shoals are crustaceans and annelids, followed by hydrozoans, mollusks and echinoderms (Theroux and Wigley, 1998). Among the crustaceans, amphipods are reported to be by far the most abundant; however, mollusks are the dominant taxon followed by echinoderms and annelids. Bivalves contribute most significantly to the mollusk biomass. This is similar to the community found in Nantucket Sound; however, several taxa are expected to occur at the Monomoy Shoals Alternative site that would be much less common within Nantucket Sound (Theroux and Wigley, 1998). Table 5.4.2-1 lists the dominant benthic taxonomic groups and the corresponding densities (number of individuals/$m^2$) occurring at Monomoy Shoals.

Twenty benthic macroinvertebrate taxa were recorded during benthic sampling programs conducted at the site of the proposed action (see Section 4.2.5 of this document). Of the sites sampled, the average faunal density was 1078 individuals/square ft (11,589 individuals/$m^2$). Nematoda were more abundant than any other class (70 percent of the samples), followed by Oligochaeta (27 percent of the samples) and the gastropod, *Crepidula fornicata* (17 percent of the samples).

Compared to the proposed action area, the benthic community composition within the Monomoy Shoals Alternative site differs with regard to community structure. The site of the proposed action provides habitat preferred by deposit- and suspension-feeding species whereas the alternative site provides habitat preferred by scavenger and predator species. Construction and Decommissioning impacts on benthic habitat are expected to be somewhat more for the Monomoy Shoals Alternative than for the proposed action because of the additional offshore transmission cable length, and the greater wave heights which would tend to prolong the construction time frame. Operational impacts are expected to be the same as the proposed action.

### 5.4.2.2.13 Non-ESA Marine Mammals

As with the proposed action, four federally protected cetaceans, North Atlantic Right, humpback, long-finned pilot, and fin, may occur in the vicinity of the proposed Monomoy Shoals Alternative, but are typically found in areas of deeper water. The Monomoy Shoals Alternative site is located adjacent to the northwestern extent of a designated Northern Right Whale Critical Habitat (NOAA Chart No. 13200, 2005). Due to the location of this critical habitat, it is possible that Northern Right Whales may pass through the proposed alternative site during their annual migration to and from their summer and wintering grounds.

Several other species of protected marine mammals may be present within the vicinity of the Monomoy Shoals Alternative site. These species are similar to those described for the proposed action and include gray, harbor, harp, and hooded seals, white-sided and striped dolphins, harbor porpoise, and long-finned pilot whale. The Monomoy Shoals Alternative is located due east and southeast of gray seal pupping grounds on Monomoy Island. This pupping ground is known to be used year round with the greatest used occurring during the winter and spring (Natural Heritage and Endangered Species Program (NHESP), 2002). The species identified in Table 5.4.1-1 could also be present as could the Atlantic spotted dolphin, Risso's dolphin, and Kogia species (sperm whale). However, compared to the proposed action, the Monomoy Shoals Alternative site is located close to the designated Northern Right Whale Critical Habitat, and thus there may be a greater likelihood of construction, decommissioning, and operational impacts to Right Whales in this area.

### 5.4.2.2.14 Fish and Fisheries

Table 5.4.1-2 lists common finfish and shellfish resources which are known to occur within the general offshore vicinity of Cape Cod and the Islands. Section 4.2.7 of this document provides detailed information on fish and fisheries for the proposed action. The Monomoy Shoals Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance as a result of higher waves and longer offshore transmission cable distance, which would result in greater temporary impacts to fisheries from sediment disturbance compared to the proposed action. In addition, the Monomoy Shoals Alternative has the potential for greater acoustical impacts to finfish compared to the proposed action, since that alternative would likely require a longer construction/decommissioning timeframe. In conclusion, the Monomoy Shoals Alternative would have a somewhat greater impact on finfish than the proposed action during construction, and decommissioning, and would be expected to have similar impacts during operation.

**Shellfish Resources**

Since the greatest abundance and diversity of suspension-feeding mollusks tends to be associated with water depths of less than 60 ft (18.3 m) in areas south of Cape Cod (Saila and Pratt, 1973), suspension-feeding species are likely to be present in suitable habitat on the Monomoy Shoals Alternative site. These species include: northern quahog, bay scallop, sea scallop, surf clam, and soft-shelled clam (Weiss, 1995; Saila and Pratt, 1973; Gosner, 1978). The channeled whelk (conch) and knobbed whelk are also common in shallow waters (Weiss, 1995) and would be expected to be present in the shallower areas of the site.

Two species of mussel are common to the region, blue mussel (*Mytilis edulis*) and horse mussel, (*Modiolus modiolus*) and have been described above. As sand is abundant in the Monomoy Shoals Alternative site area, it is expected that fewer blue mussels would be found at the Monomoy Shoals Alternative site. The horse mussel is far less common in the region. Similarly, ocean quahogs are more common in deeper waters in substrates with finer sand and mud substrates (Weiss, 1995). Saila and Pratt (1973) report that the ocean quahog was found to occur at depths between 60 ft and 90 ft (18.3 and 27.5 m); therefore, it is likely to be less common at the Monomoy Shoals Alternative site.

The shellfish resources for the Monomoy Shoals Alternative site area are similar to the site of the proposed action (see Section 4.2.5 of this document). However, compared to the proposed action, construction impacts on shellfish resources associated with the Monomoy Shoals Alternative may be somewhat more, because of the longer offshore transmission cable distance to shore and longer construction timeframe associated with work in a location with much greater wave heights. Operational impacts would be similar with respect to shellfish.

**Commercial and Recreational Fish and Shellfish**

Commercial fishing landing data for the specific fisheries in the Monomoy Shoals Alternative area are not readily available. As with the proposed action described above, the Monomoy Shoals Alternative site would be located within a zone where approximately 250,000 to 500,000 lbs (113,398 to 226,796 kg) of American Lobster are collected annually (MassGIS Lobster Harvest Zones, 1997). Recreational fishing in the area includes both private recreational vessels and charter services. The prime season for recreational fishing occurs during late spring to late summer and the main target species include striped bass, bluefish, bonito, shark, and several tuna species. Section 4.2.7 of this document provides information on commercial and recreation fish and shellfish for the proposed action. Compared to the proposed action, construction impacts on commercial and recreational fish and shellfish may be somewhat more than the proposed action because of the longer offshore transmission cable distance to shore. Operational impacts would be similar to the proposed action.

### 5.4.2.2.15 Essential Fish Habitat

Habitat within Monomoy Shoals has been designated EFH for 11 federally managed fish and three federally managed invertebrates. Table 5.4.2-2 provides a listing and specific life stage designations of those species within Monomoy Shoals. The proposed action has been designated EFH for 17 federally managed fish and three federally managed invertebrates of which 12 species overlap with those listed in Table 5.4.2-2. The EFH species included for Horseshoe Shoal but not the alternative site include windowpane flounder (*Scophthalmus aquosus*), yellowtail flounder (*Limanda ferruginea*), shortfin mako shark (*Isurus oxyrhinchus*), king mackerel (S*comberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), cobia (*Rachycentron canadum*), little skate (*Leucoraja erinacea*), and winter skate (*Leucoraja ocellata*). Since EFH habitat would be affected by both the proposed action and the Monomoy Shoals Alternative, the Magnuson-Stevens Act requires that there be an assessment of potential impacts to the federally managed fish and invertebrate species (NOAA, 2006). No Habitats Areas of a Particular Concern (HAPC) have been identified within the Monomoy Shoals Alternative. Section 4.2.8 of this document provides information on EFH for the proposed action. Compared to the proposed action, construction impacts on EFH may be somewhat more than the proposed action because of the longer offshore transmission cable distance to shore. Operational impacts would be similar.

### 5.4.2.2.16 Threatened and Endangered Species (T&E)

To access the Barnstable Substation, both the Monomoy Shoals Alternative site and the site of the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route (see Section 4.2.9 of this document for detailed information on endangered and threatened species along this cable route). Compared to the proposed action, impacts on endangered and threatened species along the near shore and onshore cable routes associated with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

Monomoy Island and the Monomoy National Wildlife Refuge provide habitat for two federally threatened bird species: bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*), and one federally endangered species, the roseate tern (*Sterna dougallii*) (USFWS, 2001a). Since the Monomoy Shoals Alternative site is located outside state waters it is not located in an area identified by

NHESP as Estimated or Priority Habitat (USFWS, 2006). However, Estimated and Priority habitat occurs within state waters surrounding Monomoy Island and the Monomoy National Wildlife refuge which are located 4.5 miles (7.2 km) northwest of the alternative site. State listed species known to occur in this area include one state endangered species (roseate tern), one state threatened species (piping plover) and two species of special concern (the USACE, 2004). Six federally and/or state protected species have nested at the Monomoy National Wildlife Refuge (pied-billed grebe, northern harrier, piping plover, roseate tern, and arctic tern (USFWS, 2001a). As the Monomoy Island Alternative is located close to the avian T&E habitat associated with the Monomoy National Wildlife Refuge, avian T&E impacts would be greater than for the proposed action location.

As shown in Table 5.4.1-1, three federally and/or state protected sea turtle species may be present within the Monomoy Shoals Alternative: loggerhead, leatherback, and Kemp's Ridley sea turtles which can be found within Massachusetts waters at varying times of the year (Kurkul, 2002). Therefore it is possible that they may utilize Monomoy Shoals during some portion of the year as well. The federally protected green sea turtle is less likely to be found within Nantucket Sound. Loggerhead, leatherback, and Kemp's Ridley sea turtles may also use Horseshoe Shoal (see Section 4.2.9 of this document). Compared to the proposed action, impacts on sea turtles with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

Overall compared to the proposed action, more impacts on endangered and threatened species would occur as a result of the potential impact of T&E avian species in the vicinity of Monomoy Island and Monomoy National Wildlife Refuge (3.0 to 4.5 miles [4.8 to 7.2 km]).

#### 5.4.2.2.17 Socioeconomic Analysis Area

The existing socioeconomic conditions for the Monomoy Shoals Alternative are similar to those of the proposed action (see Section 4.3 of this document). Compared to the proposed action, impacts on social and economic conditions associated with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action, with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.19 Population and Economic Background

The Monomoy Shoals Alternative is located in the same general economic area as the proposed action and is expected to result in negligible or changes in population or the economics of the region. Hence, the Monomoy Shoals Alternative would be comparable to for population and economic impacts and offer no significant advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Monomoy Shoals Alternative is in the same general geographic area as the proposed action and not located near any communities of higher than average minority populations or higher than average poverty rates. It is not located near WTGHA or Mashpee. As such, the Monomoy Shoals Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.21 Visual Resources

The seascape from Monomoy Island east-southeast towards the Monomoy Shoals Alternative site consists of panoramic open views of the Atlantic Ocean. The site is located further from the more populated area of Cape Cod than the proposed action and is thus expected to have fewer visual impacts than the proposed action (see Figure 3.3.5-6 for photo simulations).

#### 5.4.2.2.22 Cultural Resources

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and therefore potentially affect the same onshore cultural resources (see Section 4.3.5 of this document). Compared to the proposed action, impacts on onshore cultural resources within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts. With respect to visual impacts on cultural resources (i.e., historic homes and historic sites), this site is located further from the populated and historic areas of Cape Cod and is thus expected to have fewer visual impacts on historic structures than the proposed action.

A review of the NOAA Automated Wreck and Obstruction Information System database indicates that numerous shipwrecks are located within state waters, southeast of South Monomoy; however, there are no mapped shipwrecks shown within the Monomoy Island Alternative area (US DOC, 2002). For the proposed action, three targets with moderate probability of representing submerged historic cultural resources were identified in the vicinity of Horseshoe Shoal. However, the applicant has committed to avoid ground disturbing activities around the detectable limits of each of these potentially sensitive targets. Since a detailed marine sensitivity assessment and marine archaeological reconnaissance survey have not been conducted for the Monomoy Shoals Alternative, it is difficult to determine whether any subtidal archeological resources (i.e., historic or pre-historic sites) would be affected if the proposed facilities were sited at this alternative location. However, if such sites were documented at the alternative site, the applicant would implement mitigative measures similar to those for the proposed action (see Section 4.3.5). Therefore, impacts on subtidal archaeological resources within the Monomoy Shoals Alternative would be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.2.2.23 Recreational and Tourism Activities

Fishing and boating (power and/or sail), seal-tours, bird watching, and beach-going are common activities among visitors to and off the waters off of Monomoy Island. Public access to state waters is provided at various boat ramps located in harbors and sheltered inlets inside Chatham harbor. The Monomoy Shoals Alternative site is located closer to land (Monomoy Island) and the popular recreational area of Chatham Harbor, but is located further from the popular boating areas around Hyannis and other south Cape Cod harbors than the proposed action. In general, impacts on recreational and tourism activities with the Monomoy Shoals Alternative would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.2.2.24 Competing Uses of Waters and Sea Bed

The 115 kV offshore transmission cable system from the ESP at the Monomoy Shoals Alternative site to the landfall site at New Hampshire Avenue, within Lewis Bay, would traverse approximately 21.0 miles (33.8 km) of state waters and sea bed. Competing uses that exist along the offshore cable route include aquaculture, submarine electric transmission cables (2 Nantucket cables would be crossed), recreational and commercial activities, and maintenance dredging activities. The Monomoy Shoals Alternative is located further from the Hyannis and nearby Cape Cod areas used for recreational/boating/fishing and are located closer to recreational/fishing/boating areas around Monomoy Island and Chatham Harbor. In general, the impacts on competing uses of the Monomoy Shoals Alternative are expected to be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.2.2.25 Overland Transportation Arteries

Like the proposed action, the Momomoy Shoals Alternative is located offshore and not near any overland transportation arteries and would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore impacts from the Monomoy Shoals Alternative on overland transportation arteries would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.2.2.26 Airport Facilities

The applicant has received an FAA approval for both the proposed action and for the original Monomoy Shoals Alternative described in the USACE draft EIS (located to the west of Monomoy) indicating that airport facilities would not be affected by this alternative or the original Monomoy Shoals Alternative (see FAA Determinations in Appendix B). The current Monomoy Shoals Alternative is located to the east of these locations and offset from the navigational flyways between Nantucket and Cape Cod, and Martha's Vineyard and Cape Cod. Therefore it may not interfere with FAA navigational requirement and is likely comparable to the proposed action for impacts to airport facilities with respect construction, decommissioning and operation.

### 5.4.2.2.27 Port Facilities

The impact on port facilities from the proposed action and its alternatives would primarily be to vessels navigating in the area. Assuming that the spacing of the WTGs remains the same for the alternative locations, the potential impacts to navigation at the Monomoy Shoals Alternative site would be equivalent to the potential impacts for the Nantucket Sound Alternative. Installation of the wind turbines would result in structures being present where no structure has previously existed and mariners would need to navigate with consideration of these new structures. The Monomoy Shoals Alternative site is located further from Hyannis and nearby Cape Cod and associated ports and vessel traffic, but is located closer to the vessel traffic areas associated with Monomoy Island and Chatham Harbor. Like the proposed action location, the Momomoy Alternative is also located on a shoal and thus setback from navigation channels and in a location where vessel traffic is not likely to occur. The Monomoy Shoals Alternative would be comparable to that of the proposed action and offer no significant advantage to Ports and associated vessel traffic over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.2.2.28 Communication: EMF, Signals and Beacons

Recreational vessels, commercial fishing and marine cargo ships traverse the area of Monomoy Shoals Alternative via channels to the north and south of the Monomoy Shoals Alternative. All of these vessels use marine radios, which operate at a range of 156.05 to 157.425 MHz. Shore radios operate at approximately 156.85 to 162.025 MHz. The NOAA weather service operates at frequencies between 162.4 and 162.55 MHz. Impacts on marine radar and other telecommunication devices are expected to be generally the same as for the proposed action and the Monomoy Shoals Alternative and offer no significant advantage to communications over the proposed action with respect to construction, operation, and decommissioning impacts.

## 5.4.3 Smaller Project Alternative

### *5.4.3.1 Description of the Smaller Project Alternative*

The Smaller Project Alternative is located in the same general area as the proposed action but contains only half the number of monopiles, and thus has half the generation capacity of the proposed action. Each monopile included in the Smaller Project Alternative is located within a footprint of a monopile of the proposed action. For the proposed Smaller Project Alternative, the monopile locations along the north and south of the turbine array have been removed, making it further from Cape Cod and from Nantucket than the proposed action (see Figure 3.3.5-1, which shows the Smaller Project Alternative superimposed over the proposed action). Further detail on the location of the Smaller Project Alternative is shown in Figure 3.3.6-1.

### *5.4.3.2 Environmental Resources of the Smaller Project Alternative and Comparison with the Proposed Action*

#### 5.4.3.2.1 Regional Geologic Setting

The geological setting of the Smaller Project Alternative is the same as the proposed action though impacts are focused on a smaller geographic area. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Smaller Project is therefore comparable to and offers no significant environmental advantage over the geographic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

#### 5.4.3.2.2 Noise

Noise impacts to humans would be reduced under the Smaller Project Alternative as the alternative would be located further from both Cape Cod and from Nantucket, and because there would be half as many wind turbines to construct and decommission, and hence a shorter construction time. Operational noise would also be reduced due to the smaller number of turbines and further distance to land. Underwater noise during construction would be reduced due to the reduced number of turbines. In summary, the noise impacts of the Smaller Project Alternative are less than the proposed action and therefore provide some reduction in noise impacts due to construction, decommissioning and operation.

#### 5.4.3.2.3 Physical Oceanography

Water depths for the Smaller Project Alternative are the same as for the proposed action since they are at the same location. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Smaller Project Alternative would be expected to be comparable to those of the proposed action with respect to construction, decommissioning and operation.

#### 5.4.3.2.4 Climate and Meteorology

The weather conditions for the Smaller Project Alternative are the same as for the proposed action as they are at the same location. Compared to the proposed action, impacts due to climate and meteorology would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of this alternative would emit, or have the potential to emit air pollutants. The vessels and equipment involved in constructing (and decommissioning) the Smaller Project Alternative would emit fewer air contaminants as compared to the original 130 WTG configuration, however the emissions reductions are not anticipated to be proportional to the 50 percent reduction in WTGs for the following reasons:

- The frequency of mobilization and demobilization of major construction vessels for each distinct segment of construction (pile foundation installation; ESP installation; WTG installation; 115 kV cable installation and 33 kV installation) would not change.
- Emissions related to G&G activities are not expected to be significantly different.
- Emissions related to the installation of the ESP would remain the same.
- Emissions related to the installation of the temporary cofferdam at landfall would remain the same.
- The total number of vessel trips and /or the duration of deployment required to complete the small alternative WTGs (pile installation; tower, nacelle and rotor installation; and scour protection installation) would be approximately 50 percent less than those estimated for the proposed action.
- Emissions related to installation of the 115 kV cable system would be a small percentage greater for the Smaller Project Alternative as compared to the proposed action due to an additional one mile (1.6 km) of cable required to connect to the re-sited ESP.
- Emissions related to the installation of the 33 kV inner-array cables for the small alternative would be approximately 55 percent less due to the lower number of cable miles (29.7 miles versus 66.7 miles [47.8 km versus 107.3 km]).

As a result, it is anticipated that the overall emissions from the construction vessels and equipment related to the Smaller Project Alternative would be substantially reduced relative to those estimated for the proposed action. Similarly the emissions due to decommissioning activities for the small alternative would be expected to be reduced relative to those resulting from the proposed action. However, given the normal vessel traffic volumes regularly experienced in the proposed action area, and the limited timeframe of the construction period, the impacts of air emissions from the construction and decommissioning of either alternative would be considered minor on a local and regional scale.

Maintenance activities would consist of small vessels transiting to and from the proposed action area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and is not expected to impact air quality in the proposed action area or the region.

#### 5.4.3.2.6 Water Quality

A reduction in WTGs from 130 to 65 would not have a strictly proportional reduction in impacts to water quality related to sediment disturbance. By reducing the number of WTGs to 65 under the smaller alternative, the temporary impacts to sediments related to the WTGs are reduced roughly proportional to the number of WTGs. Impacts related to the installation of the 115 kV offshore transmission cable system would increase by 1 mile (1.6 km) as the Smaller Project Alternative is further from shore. The total temporary impacts related to the construction of the smaller alternative would be less, using rock armor, than the comparable impacts estimated for the proposed action.

Other impacts to water quality associated with the construction/decommissioning of the Smaller Project Alternative would be the potential for oil spills related to work vessels transiting to and from the area of proposed action. The marine vessels used to transport maintenance workers and equipment would be required to operate under USCG regulations. Also, an OSRP would be in place during construction/decommissioning to prevent/control potential impacts to water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery. Because the number of vessels required to transit to and from the area of proposed action during construction would decrease with the Smaller Project Alternative, the probability of marine vessels spilling fuel, lubricating oils or other substances would also decrease.

Operation of the revised 65 WTG layout is not anticipated to impact hydrodynamics or water quality. The only changes in the potential impacts to water quality associated with the operation of the Smaller Project Alternative would be the decrease in the size of the ESP. This would result in a decrease in the total number of gallons of electrical insulating oil utilized on the ESP. The proposed action of 130 WTGs would require the ESP to contain approximately 40,000 gallons (151,416 liters) of naphthenic mineral oil for cooling the ESP transformers. The revised layout would likely decrease to approximately 20,000 gallons (75,708 liters) of oil. Based on analyses conducted for the proposed alternative for oil spill probabilities and impacts which showed that probabilities of a large spill are extremely small, it is anticipated that the smaller alternative would also have small probabilities of a large spill of fluids from the ESP.

Maintenance activities would consist of small vessels transiting to and from the area of proposed action in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic above current levels in Nantucket Sound, and would not impact water quality in the area of proposed action.

Overall, the water quality impacts of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and smaller impact area.

### 5.4.3.2.7 Electric and Magnetic Fields

Electric and magnetic field strength of the Smaller Project Alternative would be less than the proposed action as the Smaller Project Alternative has half the generation capacity and thus a smaller amount of electrical current in its interconnection cable and smaller EMFs than the proposed action. However, EMF impacts are negligible under the proposed action and thus reductions in the levels result in no advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.3.2.8 Terrestrial Vegetation

Impacts of the Smaller Project Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Smaller Project Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Smaller Project Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Smaller Project Alternative, including its offshore transmission cable system would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Smaller Project Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/decommissioning activities (increased vessel traffic, presence of equipment, human presence, and noise). Sediment plumes could cause fish to avoid the construction site, which could also temporarily displace some avian species. Because the number and size of the proposed action components would decrease as a result of the revised layout, the number of construction/decommissioning events that could potentially displace the birds would similarly decrease over that of the proposed action.

Maintenance activities would consist of small vessels transiting to and from the area of proposed action in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and would not impact avifauna in the area of proposed action.

Overall, the impacts to avifauna of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller size footprint and fewer turbines.

#### 5.4.3.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. Certain benthic taxa are more adapted to the shifting substrates that are characteristic of shallower waters. Productive shallow water habitats can support greater densities of these adapted organisms, but have overall lower densities compared to more stable, often deeper water benthic habitats.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles is 0.33 acres (1,335 $m^2$) for the Smaller Project Alternative (as compared to 0.67 acres [2,711 $m^2$] for the proposed 130 WTG layout).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor sweep, pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). A reduction in WTGs from 130 to 65 would not have a strictly proportional reduction in impacts to benthic communities for the following reasons.

- The smaller alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 29.7 miles (107.3 km to 47.8 km). This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 258 acres (2.3 to 1.04 $km^2$).
- The smaller alternative would increase the length of the 115 kV cable connecting the ESP to the landfall site in Lewis Bay from 12.5 miles to 13.5 miles (20.1 to 21.7 km). This is due to the ESP being sited further to the west in order to provide a more centralized location for connection of the smaller alternative 33 kV cables. This would increase the temporary impacts to benthic habitat from 86 acres to 104 acres (0.3 to 0.4 $km^2$).
- With the smaller alternative, temporary impacts to benthic habitat from the jack-up barges used to install the WTGs and ESP would decrease from 9.4 acres to 4.81 acres (38,041 to 19,465 $m^2$). Under the revised layout, temporary impacts to benthic habitat from the construction and placement of scour control structures would be reduced from 57 acres to 29 acres (0.2 to 0.1 $km^2$) if rock armor is used.
- For the complete summary of maximum anticipated temporary and permanent impacts to benthic habitat for the Smaller Project Alternative (see Tables 5.4.3-1 and 5.4.3-2).

By reducing the number of WTGs to 65 under the Smaller Project Alternative, the temporary impacts to benthic habitat and resources related to the WTGs are reduced roughly proportional to the number of WTGs. Impacts related to the installation of the 115 kV cable outside of the 3 mile (4.8 km) limit would increase in proportion to the additional one mile (1.6 km) of cable. The impacts inside of state waters would remain unchanged. The total temporary impacts related to the construction of the smaller alternative would be approximately 39 percent less, using rock armor, than the comparable impacts estimated for the proposed 130 WTG alternative.

During operation the number of WTG monopiles, would reduce the number of structures that would provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles.

Overall, the benthic impacts of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and impact area.

#### 5.4.3.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the Smaller Project Alternative area include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. The two types of potential harassment that may occur during construction are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. There would be some potential for reduction of impacts to marine mammals with the Smaller Project Alternative as there would be half as many WTGs and thus half as many vessel trips and chances for vessel strikes.

Underwater noise impacts associated with the operation of the WTGs are not expected to cause Level A harassment to non-ESA mammals. The operations and maintenance plan would not be significantly altered with a reduction in the number of WTGs. Similar maintenance intervals would be expected for the smaller alternative, with a reduction in the number of WTGs still requiring approximately 325 maintenance days (5 days/WTG x 65 WTGs). It is assumed that 2 crews would be retained to perform the required maintenance; however the number of vessel trips for maintaining the smaller alternative would be expected to be the same as for the proposed alternative. The crew boat would transport and drop off two crews rather three crews during each deployment.

Overall, the non-ESA mammal impacts of the Smaller Project Alternative would be expected to be less for construction and decommissioning and about the same for maintenance activities.

#### 5.4.3.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the Smaller Project Alternative area, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years. The changes in temporary impacts to fisheries mirror those outlined in the Benthic discussion of the Smaller Project Alternative, and are as follows:

- Length of 33 kV cable needed to connect the WTGs to the ESP would decrease from 66.7 miles to 29.7 miles (107.3 to 47.8 km) = reduction of temporary impacts to benthic habitats from 580 acres to 258 acres (2.3 to 1.04 $km^2$).
- Length of the 115 kV cable connecting the ESP to the 3 mile boundary would increase from 4.9 miles to 5.9 miles (7.9 to 9.5 km) = increase in temporary impacts to benthic habitat from 86 acres to 104 acres (0.3 to 0.4 $km^2$).
- Temporary impacts to benthic habitat from the jack-up barges used to install the WTGs and ESP would decrease from 9.4 acres to 4.81 acres (38,040 to 19,465 $m^2$).
- Temporary impacts from the construction and placement of scour control structures would be reduced from 3.0 acres to 1.6 acres (12,141 to 6,475 $m^2$) with scour mats; 57 acres to 29 acres (230,671 to 117,359 2 $m^2$) if rock armor is used.

The changes in impacts to fish and shellfish with the revised layout are roughly proportional to the reduction in habitat disturbed from construction of the 33 kV cable, scour control structures, and the use of the jack-up barges. The permanent impacts to fish and shellfish from the placement of the WTG and ESP piles would be decreased from 0.67 acres to 0.33 acres (2,711 to 1,335 $m^2$). Mortality and injury due to cabling activities would be limited to demersal fish and shellfish located in the direct path of the jet plow and or anchoring equipment. The revised 65 WTG layout would potentially increase this impact along the 115 kV route and decrease the impact for the 33 kV route.

Operation of the Smaller Project Alternative would result in half as much new hard bottom substrate associated with the monopiles, which would reduce the area for new reef-like effects that would alter fish or shellfish communities.

The potential impacts to fish from EMF and thermal emissions from the normal operation of the offshore cables are expected to be negligible (These findings are discussed in further detail in the final EIR Appendix Sec. 3.7-C). The burial depth (6 ft [1.8 m]) of the offshore cable systems would minimize the EMF and thermal impacts to shellfish resources. By reducing the number of WTGs from 130 to 65, there would be no significant reduction to these negligible impacts that have already been mitigated in the proposed layout.

Overall, impacts on fisheries of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and impact area.

#### 5.4.3.2.15 Essential Fish Habitat (EFH)

The revised 65 WTG layout under the Smaller Project Alternative would decrease the area of permanent EFH impacts from 0.67 acres to 0.33 acres (2,711 to 1,335 $m^2$). Potential temporary impacts to EFH due to construction include physical displacement of sediments due to cable installation and pile driving, suspended sediments in the water column, and acoustical impacts.

The temporary impacts to benthic EFH would result from jet plow embedment of the 33 kV and 115 kV cables, the installation of the scour control mats and/or rock armor, and the vessel positioning and anchoring activities that would be associated with all structures. Temporary disturbances of the proposed action would total up to 866 acres (3.5 $km^2$) with rock armoring. Under the small alternative layout, these disturbances would decrease to 529 acres (2.1 $km^2$) with rock armoring. The areas of benthic habitat that would be temporarily affected by construction activities are expected to recover relatively rapidly, allowing for the EFH functions of affected areas to be restored.

The Smaller Project Alternative layout would not alter the route of the 115 kV cable inside Lewis Bay. Therefore, no changes in the potential impacts to these EFH resources would occur (i.e., no changes to winter flounder impacts) with the revised layout).

The operation of the proposed action has the potential to alter EFH due to acoustical interference caused by the WTGs, the “reef effect” associated with placing hardened structures in a soft bottom substrate, EMF, and changes to water flow and sediment transport. The Smaller Project Alternative would reduce the potential for these impacts. For instance, as the Smaller Project Alternative has half the number of piles it would result in reduced duration of pile driving noise, reduced amount of hard area that could create a reef effect, and reduced EMF levels. Overall, impacts on EFH from the Smaller Project Alternative would be expected to be less than the proposed action with respect to construction, decommissioning and operation.

#### 5.4.3.2.16 Threatened and Endangered Species (T&E)

The Smaller Project Alternative would have a smaller affected area and would therefore reduce impacts to T&E species by limiting disturbance during construction compared to the proposed action. Disturbance associated with construction/decommissioning activities such as increased vessel traffic, presence of equipment, human presence, and noise would be reduced as a result of the Smaller Project Alternative scope and shorter duration of pile driving activities. The Smaller Project Alternative would also result in less interconnection disturbance between the individual WTGs and hence reduce the sediment plumes which could cause fish to avoid the construction site and displace some avian T&E species. The Smaller Project Alternative would reduce the number of wind turbines by half and thus could be expected to reduce the amount of avian T&E collisions predicted for the proposed action by half.

Because the number and size of the Smaller Project Alternative components would decrease as a result of the revised layout, the number of construction/decommissioning events that could potentially displace birds would similarly decrease over that of the proposed action.

Maintenance activities would consist of small vessels transiting to and from the WTG array area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic above current levels in Nantucket Sound, and would not impact avifauna in the area.

Overall, the impacts to avifauna of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint size and fewer WTGs.

### 5.4.3.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Smaller Project Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Smaller Project Alternative would be less in terms of number of construction jobs, electricity generated and revenues from taxes, than from the larger proposed action.

### 5.4.3.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Smaller Project Alternative and the proposed action would utilize the same near shore cable route, landfall site a, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Smaller Project Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.3.2.19 Population and Economic Background

The Smaller Project Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Smaller Project Alternative would be comparable to and offer no significant advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.3.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Smaller Project Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the WTGHA or the Wampanoag Tribe of Mashpee. As such, the Smaller Project Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.3.2.21 Visual Resources

Visual impacts of the Smaller Project Alternative would be less than those associated with the proposed action. The views of the facility show a somewhat reduced breadth of visual impacts when looking out at the horizon and it is somewhat further away from Nantucket and Cape Cod (see Figure 3.3.6-2 which shows visual simulations of the Smaller Project Alternative). Construction impacts would also be reduced due to the shorter period of construction, and less time when large construction vessels would be visible. Compared to the proposed action, visual impacts would be less than the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.22 Cultural Resources

The Smaller Project Alternative has the same monopile locations (though fewer) as the proposed action, though some inner-array cables between the monopiles are located in different areas. This area has been assessed for underwater cultural resources and it was found that this configuration would not impact such resources. The onshore portion of the cable work is in the same location as the proposed action, and therefore there would be no change in archaeological impacts. Visual impacts to historic structures may be reduced due to the more limited area occupied by the turbine array and because it is further away from the Cape Cod and Nantucket shorelines than the proposed action (see Figure 3.3.6-2).

#### 5.4.3.2.23 Recreation and Tourism

The Smaller Project Alternative is located in the same general location as the proposed action but covering a smaller area. Impacts to recreation boating would be reduced as there would be a smaller area of turbines to navigate through by recreational vessels. The breadth of visual impact from Cape Cod would appear somewhat smaller as well, though this change would not likely result in any measurable impact on tourism over that of the proposed action. (see visual resource discussion above). Overall, impacts to recreation and tourism from the Smaller Project Alternative would be comparable to and offer no advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.24 Competing Uses

Competing uses in the vicinity of the Smaller Project Alternative are the same as for the proposed action and are limited to Commercial and Recreational Fishing and Boating, and the potential for maintenance dredging of nearby channels. The impact of the proposed action on these competing uses was determined to be minor. As the Smaller Project Alternative is smaller than the proposed action, it would have even less of a potential to impact competing uses in the area.

#### 5.4.3.2.25 Overland Transportation Arteries

The Smaller Project Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore impacts from the Smaller Project Alternative on overland transportation arteries would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.26 Airport Facilities

The Smaller Project Alternative is located in the same area as the proposed action but spread out over a smaller area. The proposed action received FAA approval indicating that it would not affect navigation or associated communication systems (see Appendix B) and therefore the Smaller Project Alternative would also not affect airport facilities. In summary, the Smaller Project Alternative would be expected to be comparable to that of the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.3.2.27 Port Facilities

The Smaller Project Alternative is smaller than the proposed action and hence is less likely to impact port facilities and marine traffic related to port facilities. Overall, the impacts on port facilities from the Smaller Project Alternative would be expected to be comparable to those of the proposed action with respect to construction, operation, and decommissioning.

#### 5.4.3.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Smaller Project Alternative is located in the same area as the proposed action but covers a smaller area. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services, (AM, FM and TV stations), non-emergency ship-to-shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor (see Section 5.3.4.4). As the Smaller Project Alternative would have less surface area, it would have less effect on communication devices for those navigating in the area. As a result, the Smaller Project Alternative is expected to have comparable or less impacts than the proposed action.

## 5.4.4 Phased Development Alternative

### *5.4.4.1 Description of the Phased Development Alternative*

In order to facilitate the study of a phased approach to constructing the proposed action of 130 WTGs, it was determined that for illustrative purposes, a 50/50 split would be most effective. A split in the proposed action of 130 WTGs into two phases was accomplished by dividing the proposed action into an eastern half and a western half, each containing 65 WTGs (see Figure 3.3.5-1). The initial 65 WTG phase would be designed to allow expansion to 130 WTGs with as little re-construction as possible. The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system) used in this Phased Development Alternative are the same as presented in the proposed action.

**Phase I:**

The western half of the proposed action would be constructed during the first phase primarily because the 65 westernmost turbine sites would be located in the shallower waters of Horseshoe Shoal and would be more regularly spaced in closer proximity to each other allowing for the least amount of inner-array 33 kV cable for interconnection to the ESP. This would be the least costly construction of the two phases, thereby reducing interest costs of financing during construction on the overall two phase project. Assuming that assurances were in place for the completion of both phases, the ESP and the complete 115 kV transmission system (both circuits for the offshore and upland components) would be completed during Phase I allowing for power from the first 65 WTGs to be transformed and transmitted into the regional power grid. Both the ESP structure and the complete 115 kV offshore transmission cable system would be the same as those for the proposed action; however some portion of the electrical equipment on the ESP would be delayed until the second phase. The construction of the ESP and the installation of the 115 kV transmission cable along the eastern edge of the first phase eliminates (to the greatest degree possible) the need to conduct Phase II installation activities (eastern half) within the area of the operating first phase of the alternative. Phase I will include 65 turbines connected in 7 full strings (each made up of 8 to 10 WTGs) and one partial string (3 WTGs), requiring approximately 32.7 miles (52.6 km) of 33 kV inner-array cable (see Figure 3.3.6-3).

**Phase II:**

The eastern half of the WTG array would be constructed during the second phase. In general, a developer would seek to minimize the time between the construction of the first and second phases in order to minimize the lag time and costs associated with:

- Procurement of equipment;
- Staging area acquisition and build out;
- Mobilization of construction and installation equipment and labor; and
- At sea construction.

For analysis purposes**,** Phase II would be scheduled within a reasonable time frame of five to ten years to coincide with the state's continued desire for renewable energy sources should renewable energy still be mandated. Construction of phase two within five years would not be considered a phased approach due to the short length of time between construction cycles. Construction of phase two beyond ten years is not considered reasonable due to anticipated change to the underlying purpose and need for this project.

The balance of the ESP electrical equipment required for the additional 65 WTGs would be installed during Phase II. For the purposes of this analysis it is assumed that the complete 115 kV offshore transmission cable system would be installed during the first phase. Phase II will include 65 turbines connected in 6 full strings (each made up of 9 or 10 WTGs) and the addition of 7 WTGs to one partial string of three WTGs that would have been installed in Phase I. Phase II will require approximately 34.0 miles (54.7 km) of 33 kV inner-array cable (see Figure 3.3.6-3).

**Decommissioning**

Because it is assumed that all of the WTGs will have the same effective useful life (approximately 20 years), the decommissioning of the Phased Development Alternative will also be conducted in phases to correspond to the phased construction and duration of lag time. Phase I of the decommissioning would remove the WTGs, scour protection, and inner-array cables that were installed 20 years prior during Phase I (western half of the WTG array). Following a period of time equal to the lag between construction phases, Phase II of the decommissioning would take place 20 years after the completion of the Phase II construction and would remove the eastern half WTGs, scour protection and inner-array cables, along with the ESP and the interconnecting 115 kV transmission system. Similar to the construction phases, the decommissioning of the Phased Development Alternative will require multiple mobilizations/demobilizations and staging and is expected to have similar impacts as the phased construction.

### *5.4.4.2 Environmental Resources of the Phased Development Alternative and Comparison with the Proposed Action*

#### 5.4.4.2.1 Regional Geologic Setting

The geological setting of the Phased Development Alternative is the same as the proposed action. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Phased Development Alternative is therefore comparable to and offers no significant environmental advantage over the geologic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

#### 5.4.4.2.2 Noise

Noise impacts to humans would be increased under the Phased Development Alternative due to the longer construction and decommissioning time frames resulting from multiple mobilizations, demobilization and staging operations. Operational noise during Phase I would be less, however once the second Phase is completed there will be no difference between the Phased Development Alternative and the proposed action. The duration of underwater noise during construction would be less during each individual phase followed by some period of time with little or no construction activities. In general noise impacts would be comparable and offer no significant environmental advantage with respect to noise impacts compared to the proposed action during construction, operations and decommissioning.

#### 5.4.4.2.3 Physical Oceanography

Water depths for the Phased Development Alternative are the same as for those for the proposed action since they are at the same location. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Phased Development Alternative would be expected to be similar to those of the proposed action with respect to construction, decommissioning and operation.

#### 5.4.4.2.4 Climate and Meteorology

The weather conditions for the Phased Development Alternative are the same as for the proposed action as they are at the same location. The Phased Alternative would result in slightly more $CO_2$ emissions (a green house gas) than the proposed action due to the added work associated with two construction mobilizations. However, in general impacts to climate and meteorology would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.4.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of the proposed action would emit, or have the potential to emit air pollutants. Although the air emissions for much of the Phased Development Alternative would be similar to the proposed action (emissions related to G&G, ESP installation, cable installation, and operations), the vessels and equipment involved in constructing and decommissioning the Phased Development Alternative would emit greater amounts of air contaminants as compared to the proposed action. The increased air emissions would be the result of multiple mobilizations and demobilizations of major construction vessels for pile foundation installation/decommissioning and WTG installation/decommissioning related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete the Phased Development Alternative would also be greater than if the proposed action was constructed and decommissioned from start to finish. As a result, it is anticipated that the overall emissions from the construction/decommissioning vessels and equipment related to the Phased Development Alternative would be greater than those estimated for the proposed action.

#### 5.4.4.2.6 Water Quality

Water quality impacts related to construction (and decommissioning) of the Phased Development Alternative would be greater as the result of multiple mobilizations and demobilizations of major construction vessels for pile foundation installation and WTG installation related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish. Water quality impacts from the cable installations (both 33 kV and 115 kV) will be the same for the both alternatives.

Other impacts to water quality associated with the construction/decommissioning of the Phased Development Alternative would be the potential for oil spills related to work vessels transiting to and from the area of the proposed action. Because the overall construction (and decommissioning) duration and number of vessel trips required to transit to and from the area of the proposed action would increase with the Phased Development Alternative, the probability of marine vessels spilling fuel, lubricating oils or other substances would increase.

Additionally, the Phased Development Alternative would delay the installation of some portion of the electrical equipment on the ESP until the second phase. This would likely involve the installation of one or more transformers at sea to accommodate the Phase II WTGs, along with an additional at-sea transfer of a significant amount of transformer oil (approximately 10,000 gallons [37,850 liters] per transformer). In comparison the ESP for the proposed action would be outfitted in Port and towed to the site for installation. This additional phased build-out of the ESP presents a greater chance for a potential spill during installation and transfer, thereby further increasing the potential for impacts to water quality during the construction of the Phased Development Alternative.

During operation the temporary water quality impacts of the Phased Development Alternative would be less than those associated with the proposed action following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in water quality impacts related to operations, between the Phased Development Alternative and the proposed action. Overall, the water quality impacts of the Phased Development Alternative would be expected to be greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

#### 5.4.4.2.7 Electric and Magnetic Fields (EMFs)

Electric and magnetic field strength of Phase I would be less than the proposed action because it would have half the generating capacity and thus a smaller amount of electrical current in its offshore transmission cable system and smaller EMF's than the proposed action. However once the second phase of the development becomes operational, there would be no difference in EMF levels between the Phased Development Alternative and the proposed action. As a result, EMF impacts would be comparable and offer no significant environmental advantage with respect to EMF impacts compared to the proposed action during construction, operations and decommissioning.

#### 5.4.4.2.8 Terrestrial Vegetation

Impacts of the Phased Development Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Phased Development Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

#### 5.4.4.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Phased Development Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Phased Development Alternative, including its offshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

### 5.4.4.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Phased Development Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.4.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/decommissioning activities (increased vessel traffic, presence of equipment, human presence, and noise). Sediment plumes could cause fish to avoid the construction site, which could also temporarily displace some avian species. Impacts to birds during construction (and decommissioning) of the Phased Development Alternative is expected to be greater than the proposed action as the result of the longer construction/decommissioning time frames and multiple mobilizations and demobilizations of major construction vessels for pile foundation installation/decommissioning and WTG installation/decommissioning related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete/decommission the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish. Overall, the impacts to avifauna of the Phased Development Alternative would be expected to be greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

### 5.4.4.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. Certain benthic taxa are more adapted to the shifting substrates that are characteristic of shallower waters. Productive shallow water habitats can support greater densities of these adapted organisms, but have overall lower densities compared to more stable, often deeper water benthic habitats.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles would be the same for both the Phased Development Alternative and the proposed action (0.67 acres [2,711$m^2$]).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). There would be some increase in anchoring impacts related to the increased overall number of vessel trips and multiple construction mobilization/demobilizations. During operation the WTGs will provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles. Because of the localized, temporary nature of impacts related to the WTGs, there is no anticipated benefit or impact related to the phased approach with respect to operation.

Overall, the impacts to benthic resources of the Phased Development Alternative would be expected to be somewhat greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

### 5.4.4.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the proposed action include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

The two types of potential harassment that may occur during the construction of the proposed action are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. Because of an increased chance for vessel strike due to the increased number of vessel trips and the multiple mobilizations/demobilizations involved with the Phased Development Alternative, there is some potential for an increase of construction and decommissioning impacts to marine mammals from the Phased Development Alternative as compared to the proposed action.

The operations and maintenance plan would not be significantly altered with the phased development approach. Similar maintenance intervals would be expected for Phase I, with the 65 WTGs still requiring approximately 325 maintenance days (5 days per turbine). During the first phase it is assumed that 2 crews would be retained to perform the required maintenance; however the number of vessel trips for maintaining the smaller first phase would be expected to be the same as for the proposed action. The crew boat would transport and drop off two crews rather than three crews during each deployment. Once Phase II is completed and all 130 WTGs become operational the impacts from the Phased Development Alternative will be similar to the proposed action.

Overall, the non-ESA mammal impacts of the Phased Development Alternative would be expected to be somewhat greater for construction and decommissioning, and comparable for operations as compared to the proposed action.

### 5.4.4.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the area of the proposed action, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years.

The changes in temporary impacts to fisheries mirror those outlined in the benthic discussion of the Phased Development Alternative. Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). There would be somewhat greater anchoring impacts related to the increased overall number of vessel trips and multiple construction and decommissioning mobilizations/demobilizations. Operation of the first phase of the Phased Development Alternative would result in half as much new hard bottom substrate associated with the monopiles, for some period of time. This would reduce the area for new reef-like effects that would alter fish or shellfish communities. Following the completion of Phase II, these impacts will be similar to the proposed action. With respect to EMF impacts on fish and fisheries, operation of the Phased Development Alternative, once fully constructed, would result in the same EMF levels.

Overall, impacts on fisheries of the Phased Development Alternative would be slightly greater for construction and decommissioning, and similar for operations as compared to the proposed action.

### 5.4.4.2.15 Essential Fish Habitat

The Phased Development Alternative would have the same area of permanent EFH impacts as the proposed action (0.67 acres [2,711 $m^2$]). Potential temporary impacts to EFH due to construction and decommissioning include physical displacement of sediments due to cable installation/removal and pile driving / removal, suspended sediments in the water column and acoustical impacts.

The temporary impacts to benthic EFH would result from jet plow embedment and removal of the 33 kV and 115 kV cables, the installation and removal of the scour control mats and/or rock armor, and the vessel positioning and anchoring activities that would be associated with all structures. There will be some increase in anchoring impacts related to the increased overall number of vessel trips and multiple construction/decommissioning mobilizations/demobilizations, the temporary impacts related to the Phased Development Alternative are expected to be similar to the proposed action. The areas of benthic habitat that would be temporarily affected by construction and decommissioning activities are expected to recover relatively rapidly, allowing for the EFH functions of affected areas to be restored.

The Phased Development Alternative layout would not alter the route of the 115 kV offshore transmission cable system inside Lewis Bay. Therefore, no changes in the potential impacts to these EFH resources would occur (i.e., no changes to winter flounder impacts) with the Phased Development Alternative. Because of the same overall number of WTGs and cable lengths, the operation of the Phased Development Alternative would have similar impacts to the proposed action.

Overall, impacts on EFH of the Phased Development Alternative would be greater for construction and decommissioning, and similar for operations as compared to the proposed action.

### 5.4.4.2.16 Threatened and Endangered Species (T&E)

Impacts to T&E species would be increased under the Phased Development Alternative due to the longer construction and decommissioning time frames resulting from multiple mobilizations, demobilization and staging operations. Impacts to birds during construction and decommissioning of the Phased Development Alternative is expected to be greater than the proposed action as the result of the longer time frames and multiple mobilization and demobilization of major construction vessels for pile foundation installation/ removal and WTG installation/removal related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete and decommission the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish.

Because of the same overall number of WTGs and cable lengths, the operation of the Phased Development Alternative would have similar impacts for T&E species as compared to the proposed action.

Overall, the impacts to T&E of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended construction time frame and multiple mobilizations/demobilizations, and impacts would be the similar for operation.

### 5.4.4.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Phased Development Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Phased Development Alternative would be similar except that it would involve multiple mobilizations/demobilizations and procurement of staging areas and equipment. This would not significantly increase the number of construction jobs or revenues going into the local area, and thus socioeconomic impacts of the Phased Development Alternative are expected to be similar to that of the proposed action.

#### 5.4.4.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Phased Development Alternative and the proposed action would utilize the same near shore cable route, landfall site and onshore cable route and affect the same urban and suburban infrastructure (see 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Phased Development Alternative including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.4.2.19 Population and Economic Background

The Phased Development Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Phased Development Alternative would be comparable to and offer no significant population and economic advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.4.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Phased Development Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the Wampanoag Tribe of Gay Head Aquinnah (WTGHA) or the Wampanoag Tribe of Mashpee. As such, the Phased Development Alternative would be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

#### 5.4.4.2.21 Visual Resources

Visual impacts of the Phased Development Alternative would be less than those associated with the proposed action following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in visual impacts related to operations, between the Phased Development Alternative and the proposed action.

Construction and decommissioning impacts from the Phased Development Alternative would be greater as the result of multiple mobilization and demobilization of major construction vessels for pile foundation installation/removal and WTG installation/ removal related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete and/or remove the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish, resulting in more time when large construction vessels would be visible.

Overall, the visual impacts of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frame and multiple mobilizations/demobilizations, and impacts would be the same for operation.

#### 5.4.4.2.22 Cultural Resources

The Phased Development Alternative has the same monopile locations as the proposed action and the same inner array cabling layout. This area has been assessed for underwater cultural resources and it was found that this configuration would not impact such resources. The onshore portion of the cable work is in the same location as the proposed action. Therefore, impacts to cultural resources would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.4.2.23 Recreation and Tourism

The Phased Development Alternative is located in the same location as the proposed action. Because of the extended duration of activity, multiple mobilizations/demobilizations and increased number of vessel trips related to construction and decommissioning activities of the Phased Development, it is likely that the impacts to recreational boating, and any related visual impacts, during construction and decommissioning will be greater than the proposed action.

Once the Phased Development Alternative is completed, there would be no difference in recreation and tourism related to operations, between the Phased Development Alternative and the proposed action. Overall, the impacts to recreation and tourism of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frames and multiple mobilizations/demobilizations, and the impacts would be the same for operation.

### 5.4.4.2.24 Competing Uses

Competing uses in the vicinity of the Phased Development Alternative are the same as for the proposed action and are limited to commercial and recreational fishing and boating, and the potential for maintenance dredging of nearby channels. The impact of the proposed action on these competing uses was determined to be minor.

### 5.4.4.2.25 Overland Transportation Arteries

The Phased Development Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore, impacts from the Phased Development Alternative on overland transportation arteries would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.4.2.26 Airport Facilities

The Phased Development Alternative is located in the same location as the proposed action. The proposed action received FAA approval indicating the proposed action would not affect navigation or associated communication systems (see Appendix B) and therefore the Phased Development Alternative would also not affect airport facilities. In summary, the Phased Development Alternative would be expected to be comparable to the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.4.2.27 Port Facilities

The Phased Development Alternative is likely to have greater impacts to port facilities and marine traffic related to port facilities due to the extended duration of activity, multiple mobilizations/ demobilizations and increased number of vessel trips related to construction and decommissioning activities of the Phased Development.

During operation, impacts to port facilities and marine traffic would be reduced slightly, as compared to the proposed action, following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in impacts to port facilities and marine traffic related to operations, between the Phased Development Alternative and the proposed action.

Overall, the impacts to port facilities of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frames and multiple mobilizations/demobilizations, and the impacts would be the same for operations.

#### 5.4.4.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Phased Development Alternative is located in the same area as the proposed action. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services (AM, FM and TV stations), non-emergency ship to shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor. As a result, the Phased Development Alternative is expected to have comparable impacts to the proposed action during construction, operation and decommissioning.

## 5.4.5 Condensed Array Alternative

### *5.4.5.1 Description of Condensed Array Alternative*

In designing an offshore wind energy project, turbine spacing is considered which effectively balances the capture of the wind resource (and ultimately the power production), with a number of site specific physical and economic constraints such as water depth and watersheet use. Pre-project modeling of wind wake[28] effects can be performed by several proprietary computer models. In the case of proposed action, there is a predominately southwest wind direction that dictates the spacing necessary not only to reduce adjacent row wind wake effects (in order to optimize efficiency of operations), but to follow industry practice to reduce structural fatigue from turbulence created by the wake and associated higher maintenance costs. As a general rule, manufacturers of the WTGs recommend a minimum spacing of greater than 5 rotor diameters in order to avoid catastrophic structural fatigue and guarantee efficiencies.

In order to facilitate the study of a condensed configuration alternative with 130 WTGs, a 6 x 6 rotor diameter spacing was chosen (the proposed action has a 9 x 6 rotor diameter spacing). The 6 x 6 rotor spacing was chosen as a reasonable example that falls within the range of some existing offshore wind energy projects (see Table 3.3.6-1). The Condensed Array Alternative would maintain the same ESP location as the proposed action (see Figure 3.3.5-1), and therefore the interconnecting 115 kV transmission system would remain the same in all aspects of design, length, installation and routing as the proposed action. Both the ESP structure and the complete 115 kV offshore transmission cable system would be the same as those under the proposed action. The WTG locations in the proposed action currently are spaced approximately 6 rotor diameters apart in the north-south "columns" of the array. The 130 WTGs of the Condensed Alternative have been arranged with the same central column of WTGs as the proposed action's "F" column (WTGs F1 through F14), maintaining the same location with 6 rotor diameters separation (see Figure 2.1.2-1). The WTGs of the proposed action are separated by 9 WTGs within the east-west "rows." To reduce the spacing within these rows to 6 rotor diameters for the Condensed Alternative, the WTGs to the west of the ESP and the "F" column have been shifted to the

[28] As wind passes through the rotor of a wind turbine generator, it becomes turbulent behind the rotor. This area on the downwind side of the rotor is termed "wind wake". The wind wake dissipates and returns to smooth, laminar flow at some distance beyond the turbine.

east, and WTGs to the east of the ESP and the "F" column have been shifted to the west, providing for a 130 WTG array with 6 x 6 rotor diameter spacing condensed around a similar ESP location as the proposed alternative.

The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system) used in this Condensed Alternative are the same as presented in the proposed action (see Figure 3.3.6-4). The WTGs in the Condensed Alternative have been arranged in similar interconnecting strings (14 strings of 8-10 WTGs each) as the proposed action. The overall inner-array 33 kV cable lengths would be reduced to 58 miles (93.3 km) (from 66 miles [106.2 km] for the proposed action). The reduction would not be proportionate to the 25-30 percent east – west reduction of the WTG array because the inner-array cables of the proposed action have been arranged to minimize overall length by maximizing the use of the shorter north – south transects and minimizing the cabling east to west.

The footprint area of the Condensed Array Alternative is approximately 16 square miles (41.4 $km^2$) (as compared to 25 square miles [64.7 $km^2$] for the proposed action). The distances to shore are presented in Table 3.3.6-2.

### *5.4.5.2 Environmental Resources of the Condensed Array Alternative and Comparison with the Proposed Action*

#### 5.4.5.2.1 Regional Geologic Setting

The geological setting of the Condensed Array Alternative is the same as the proposed action. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Condensed Alternative is therefore comparable to and offers no significant environmental advantage over the geologic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

#### 5.4.5.2.2 Noise

Noise impacts to humans related to construction activities would be slightly less under the Condensed Array Alternative because of the increased distance to shore from the perimeter WTG pile driving. In particular those receptors on Cape Poge would be located further from the WTGs on the western edge of the array. However, this decrease is expected to be of little significance since the temporary construction noise from the proposed action is expected to be inaudible with the possible exception during installation of those WTGs closest to Martha's Vineyard. Underwater noise during construction of the Condensed Array Alternative would be the same as the proposed action.

Impacts from operational noise, both above and below water, from the Condensed Array Alternative are expected to be the same as those of the proposed action. Decommissioning noise, which would not involve pile driving, would be the same as that of the proposed action.

In summary, the noise impacts from the construction of the Condensed Array Alternative are slightly less than the proposed action, but would be the same for operations and decommissioning.

#### 5.4.5.2.3 Physical Oceanography

Water depths for the Condensed Array Alternative are generally the same as for the proposed action since they are at the same area. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Condensed Alternative would be expected to be comparable to those of the proposed action with respect to construction, decommissioning and operation.

### 5.4.5.2.4 Climate and Meteorology

The Condensed Alternative would emit $CO_2$, a green house gas. The $CO_2$ emissions produced from the alternative would be related to emissions from construction and maintenance vessels and equipment, and not from the WTGs. The amount of $CO_2$ discharged and the impact on climate would be negligible. Accordingly, the Condensed Array Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of the proposed action would emit air pollutants. It is expected that the air emissions for construction of the Condensed Array Alternative would be slightly less than those of the proposed action primarily due to the 8 mile (12.9 km) reduction in the amount of inner-array 33 kV cabling required. Although the distances the construction and maintenance vessels must travel from the proposed staging area in Quonset RI to reach the furthest WTGs on the eastern edge of the Condensed Array Alternative is slightly less than the proposed action, this minor reduction is offset by the increased travel distances to reach the nearest WTGs on the western edge of the Condensed Array Alternative. As a result, there would be no significant change in air emissions between the two alternatives during construction. Emissions related to G&G, ESP installation, 115 kV offshore transmission cable system cable installation, and WTG installation would be expected to remain comparable to the proposed action.

### 5.4.5.2.6 Water Quality

Water quality impacts related to construction of the Condensed Array Alternative would be less than the proposed action due to the 8 mile (12.9 km) reduction in the amount of 33 kV cabling required. The total number of vessel trips and/or the duration of deployment required to complete the Condensed Array Alternative would also be the same as for the proposed action. Water quality impacts from the cable installation of the 115 kV transmission system would be the same for both alternatives.

Other impacts to water quality associated with the construction/decommissioning of the Condensed Array Alternative would be the potential for oil spills related to work vessels transiting to and from the area of the proposed action. The marine vessels used to transport maintenance workers and equipment would be required to operate under USCG regulations. Also, an OSRP would be in place during construction/decommissioning to prevent/control potential impacts to water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery. Although the distances the construction and maintenance vessels must travel from the proposed staging area in Quonset RI to reach the furthest WTGs on the eastern edge of the Condensed Array Alternative is slightly less than the proposed action, this minor reduction is offset by the increased travel distances to reach the nearest WTGs on the western edge of the Condensed Alternative. As a result, there would be no net change between the two alternatives in the probability of marine vessels spilling fuel, lubricating oils or other substances.

During operation there would be no difference in temporary water quality impacts related to operations, between the Condensed Array Alternative and the proposed action. Operation of the 130 WTGs of the Condensed Array Alternative is not anticipated to impact hydrodynamics or water quality.

Overall, the water quality impacts of the Condensed Array Alternative would be expected to be less than those of the proposed action with respect to construction. The impacts would be similar with respect to operation and decommissioning.

### 5.4.5.2.7 Electric and Magnetic Fields

As a result of the less efficient spacing of the Condensed Array Alternative, there would be less power generated than the proposed action and therefore less electric and magnetic field strength (EMF) levels produced. However, since the EMF impacts are already negligible under the proposed action there is no advantage from the Condensed Array Alternative with respect to construction, operation and decommissioning impacts.

### 5.4.5.2.8 Terrestrial Vegetation

Impacts of the Condensed Array Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Condensed Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

### 5.4.5.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Condensed Array Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Condensed Array Alternative, including its 115 kV offshore transmission cable system, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

### 5.4.5.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Condensed Array Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/decommissioning activities (increased vessel traffic, presence of equipment, human presence, and noise). Sediment plumes could cause fish to avoid the construction site, which could also temporarily displace some avian species. Although impacts to birds from the construction of the WTGs, ESP and 115 kV offshore transmission cable system are expected to be the same, the 8 mile (12.9 km) reduction in inner-array cable installation would slightly reduce impacts. However, construction activities are not expected to take place over the entire area of the proposed action simultaneously; thus the smaller footprint of the Condensed Array Alternative is not expected to result in any greater displacement impacts than would be expected for the proposed action. Overall impacts to birds during construction (and decommissioning) of the Condensed Array Alternative are expected to be slightly less than the proposed action as the result of the reduction in the length of 33 kV inner array cabling.

When compared to the proposed action, an alternative with condensed spacing is expected to have a greater “barrier” effect due to the higher concentration of structures, thereby increasing the potential for avoidance, collision or other impacts during operation. Maintenance activities would consist of small vessels transiting to and from the area of the proposed action in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and would not impact avifauna in the area of the proposed action for either the Condensed Array

Alternative or the proposed action. Overall, the Condensed Array Alternative is expected to have increased impacts during operations.

#### 5.4.5.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. Certain benthic taxa are more adapted to the shifting substrates that are characteristic of shallower waters. Productive shallow water habitats can support greater densities of these adapted organisms, but have overall lower densities compared to more stable, often deeper water benthic habitats.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles would be the same for both the Condensed Array Alternative and the proposed action (0.67 acres [2,711 $m^2$]).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). The Condensed Alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 $km^2$). The temporary impacts related to the Condensed Array Alternative are expected to be less as compared to the proposed action. Impacts related to decommissioning of the Condensed Array Alternative would also be less due to the shorter inner-array cable.

During operation the WTGs would provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles. There is no anticipated difference in operational impacts between the two alternatives.

Overall, the impacts to benthic resources of the Condensed Array Alternative would be expected to be less than those of the proposed action with respect to construction and decommissioning and would be similar with respect to operation.

#### 5.4.5.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the proposed action include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

The two types of potential harassment that may occur during the construction of the proposed action are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. Because of a slightly reduced chance for vessel strike due to the shorter inner-array cabling activities involved with the Condensed Array Alternative, there is some potential for a reduction of impacts to marine mammals from the Condensed Array Alternative as compared to the proposed action.

Underwater noise impacts associated with the operation of the WTGs are not expected to cause Level A harassment to non-ESA mammals. The operations and maintenance plan would be the same for the Condensed Array Alternative as for the proposed action.

Overall, the non-ESA mammal impacts of the Condensed Array Alternative would be expected to be somewhat less for construction and decommissioning, and similar for operations and maintenance, as compared to the proposed action.

### 5.4.5.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the area of the proposed action, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years.

The changes in temporary impacts to fisheries mirror those outlined in the benthic discussion of the Condensed Array Alternative. Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). The Condensed Array Alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 $km^2$). The temporary impacts related to the Condensed Alternative are expected to be less as compared to the proposed action. Impacts related to decommissioning of the Condensed Alternative would also be less due to the shorter inner-array cable.

Operation of the Condensed Array Alternative would result in the same amount of new hard bottom substrate associated with the monopiles as the proposed action. Both alternatives would have the same amount of surface area with the potential for new reef-like effects that would alter fish or shellfish communities, and therefore similar impacts.

Overall, impacts on fisheries of the Condensed Array Alternative would be slightly less for construction and decommissioning, and similar for operations as compared to the proposed action.

### 5.4.5.2.15 Essential Fish Habitat

The Condensed Alternative would have the same area of permanent EFH impacts as the proposed action (0.67 acres [2,711 $m^2$]). Potential temporary impacts to EFH due to construction include physical displacement of sediments due to cable installation and pile driving, suspended sediments in the water column and acoustical impacts. Because of the reduced amount of 33 kV inner-array cable required with the Condensed Array Alternative the temporary impacts to benthic habitat during construction (and decommissioning) are expected to be less than for the proposed action and thus reduce the extent of temporary impacts to EFH functions of affected areas.

Because of the same overall number of WTGs, the operation of the Condensed Array Alternative would have similar impacts to the proposed action.

Overall, impacts on EFH of the Condensed Array Alternative would be less for construction and decommissioning, and similar for operations as compared to the proposed action.

### 5.4.5.2.16 Threatened and Endangered Species

The disturbances associated with construction/decommissioning activities, including cable embedment, involve increased vessel traffic, presence of equipment, human presence, and noise. Sediment plumes from jet plowing could cause fish to avoid the construction site, which could also temporarily displace some avian species. Although impacts to birds from the construction of the WTGs, ESP and 115 kV offshore transmission cable system are expected to be the same, the 8 mile (12.9 km) reduction in inner-array cable installation would reduce impacts. Although jet plowing on Horseshoe Shoal is not expected to have any impact on piping plovers who forage along the rack line of beaches, there may be some impact on roseate terns that do forage in the area to some degree. Overall impacts to birds during construction (and decommissioning) of the Condensed Array Alternative are expected to be slightly less than the proposed action as the result of the reduction in the length of 33 kV inner array cabling.

Impacts during operation of the Condensed Array Alternative would be increased when compared to the proposed action. This is due to the condensed spacing of WTGs, which would be expected to have a greater “barrier” effect due to the higher concentration of structures, thereby increasing the potential for avoidance, collision or other impacts.

Overall, the impacts to T&E species of the Condensed Array Alternative would be expected to be less than the proposed action during construction and decommissioning, and greater than the proposed action during operations.

### 5.4.5.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Condensed Array Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Condensed Array Alternative would be the same in terms of number of construction jobs and revenues from taxes. However, the Condensed Array Alternative would generate somewhat less electricity, producing less downward pressure on electricity costs. Overall, the Condensed Array Alternative does not offer any significant advantage over the proposed action with respect to socioeconomics.

### 5.4.5.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Condensed Array Alternative and the proposed action would utilize the same near shore cable route, landfall site and onshore cable route and affect the same urban and suburban infrastructure (see 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Condensed Array Alternative including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.19 Population and Economic Background

The Condensed Array Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Condensed Array Alternative would be comparable to and offer no significant population and economic advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Condensed Array Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the Wampanoag Tribe of Gay Head Aquinnah (WTGHA) or the Wampanoag Tribe of Mashpee. As such, the Condensed Array Alternative would be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.21 Visual Resources

Potential visual impacts during construction and decommissioning activities of the Condensed Array Alternative would be based on the number, size, and spacing of construction vessels employed during the construction period and would not be expected to be significantly different than construction related visual impacts under the proposed action. With respect to operations, the breadth of the array would likely be reduced as viewed from the north, and remain very similar when viewed from either Martha's Vineyard or Nantucket. Distances to shore would be slightly increased for the Condensed Array Alternative, making the turbines look smaller and reducing the visual impact. Thus in terms of overall breadth of impact, the Condensed Array Alternative would have less of a visual impact than the proposed action. However, the concentration of structures would be increased for the Condensed Array Alternative, and thus the visual intrusion of the portion of the Condensed Array Alternative that is visible, would create more of an impact than the proposed action.

### 5.4.5.2.22 Cultural Resources

The Condensed Array Alternative has been laid out along the same previously surveyed area transects as the proposed action. This general area of the proposed action of Horseshoe Shoal has been assessed for underwater cultural resources and it was found that the proposed action configuration would not impact such resources. Although the specific cable routes and WTG locations of the Condensed Array Alternative have not been fully surveyed, it is expected that due to the extent and overlap of previously surveyed area incorporated into the Condensed Array Alternative that the impacts would be similar. The onshore portion of the cable work is in the same location as the proposed action. Therefore, impacts to cultural resources would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

### 5.4.5.2.23 Recreation and Tourism

The Condensed Array Alternative is located in the same general location as the proposed action. The smaller overall footprint of construction activities and the shorter inner-array cabling would reduce some impacts to recreational boating. However, this would be offset by the concentration of construction activities within the Condensed Array Alternative footprint as compared to the proposed action resulting in greater impacts to boating. During operation, impacts to recreational boating would be reduced somewhat by the smaller overall size of the turbine array area, but this would be offset by the tighter spacing between WTGs which would make navigation more difficult. Overall, the impacts to recreation and tourism of the Condensed Array Alternative would be expected to be similar to the proposed action during construction, operation and decommissioning.

### 5.4.5.2.24 Competing Uses

Competing uses in the vicinity of the Condensed Array Alternative are the same as for the proposed action and are largely limited to commercial fishing and boating, and the potential for maintenance dredging of nearby channels. Any vessels involved in commercial fishing (i.e., trawling activities) within the area of the proposed action would experience increased impacts due to the tighter spacing between WTGs. The impact of the Condensed Array Alternative on these competing uses would therefore be greater than the proposed action during construction, operations and decommissioning.

##### 5.4.5.2.25 Overland Transportation Arteries

The Condensed Array Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore, impacts from the Condensed Array Alternative on overland transportation arteries would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

##### 5.4.5.2.26 Airport Facilities

The Condensed Array Alternative is located in the same general location as the proposed action. The proposed action received FAA approval indicating the proposed action would not affect navigation or associated communication systems (see Appendix B) and although the new specific locations for the WTGs in the Condensed Array Alternative would need to be evaluated by the FAA, it is assumed that there would be no change in their determination of no hazard. Therefore, it is expected that the Condensed Array Alternative would also not affect airport facilities. In summary, the Condensed Array Alternative would be expected to be comparable to the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

##### 5.4.5.2.27 Port Facilities

The Condensed Array Alternative is likely to have similar construction and decommissioning impacts to port facilities and marine traffic related to port facilities as the proposed action. During operations, marine traffic would have to contend with navigating through WTG configuration that is closer together. However, this is offset by the fact that the Condensed Array Alternative is located further away from shipping channels and takes up less water sheet area. Overall, the impacts to port facilities of the Condensed Array Alternative would be expected to be similar to the proposed action during construction, operation and decommissioning.

##### 5.4.5.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Condensed Array Alternative is located in the same general area as the proposed action. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services, (AM, FM and TV stations), non-emergency ship to shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor (see Section 5.3.4.4). The Condensed Array Alternative is expected to have comparable impacts to the proposed action during construction, operation and decommissioning.

### 5.4.6 Assessment of No-Action Alternative and Comparison with Proposed Action

#### *5.4.6.1 Description of the No-Action Alternative*

Under the No-Action Alternative, the facilities associated with the proposed action would not be constructed, the associated impacts would not occur and the proposed action would not make a significant contribution to meeting the projected demand for power in New England (ISO, 2007). In lieu of this proposed facility, it is expected that the demand for electricity in the New England area would be met by the development of one or more generating technologies (Table 5.4.6-1) and/or adopting energy conservation measures. In accordance with 40 CFR Section 1502.14(d), the consequences of selecting the No-Action alternative have been analyzed to the degree where impacts normally associated with the generation of electricity by means other than wind are considered. Four of the eleven technologies listed were considered feasible on the scale of the proposed action and are able to be developed within the timeframe of the proposed action (i.e., meet both criteria Nos. 3 and 5).[29] These technologies are: (1) New Natural Gas Fired Power Plants; (2) New Oil Fired Power Plants; (3) New Clean Coal Fired Power Plants; and (4) Repowering of Existing Facilities. This section provides a brief comparison of the impacts generally associated with the development of these technologies. Other electric generating technologies that are not feasible in the near future are not assessed.

#### *5.4.6.2 Impacts Associated with Technologies considered under No-Action*

Under the No-Action alternative, it can be assumed that demand for energy would be met by other means including conservation measures and the construction of other generating facilities (both fossil fuel fired and renewable). Identifying the consequences of selecting the No-Action alternative in regards to energy production requires the consideration of other means of producing energy without the knowledge of the type, location, number or size of the facility or facilities that would be constructed to meet the energy projected to be produced by the proposed action. Therefore, this analysis cannot provide the site specific detailed impact assessment of an energy producing facility that may be constructed under the No-Action alternative. Table 5.4.6-2 provides a simplified picture of the energy generation process.

This simplified presentation of the generation process highlights that in comparing wind to the other technologies, wind generally has no input related environmental-effects (other than minor impacts associated with manufacturing and transport of wind turbine components). Differences, therefore, in environmental costs and benefits directly associated with these other technologies can be addressed by focusing on 5 variables. These are defined as follows:

1. **Land disturbance**. This variable seeks to capture three aspects of land disturbance: (1) the area and natural resources (i.e., flora and fauna and wildlife habitat) that would be permanently disturbed by a building footprint; (2) the total area where there would be some land use restriction of activity such as a larger property boundary; and (3) what is often defined for thermal facilities as the "affected area" or the point at which changes in facility-related air concentrations are negligible.

2. **Air emissions**. A principal difference among the technologies is the emissions to the atmosphere resulting from fossil fuel burning. Compounds of interest are the pollutants $NO_x$, $SO_x$, PMHg as well as $CO_2$.

3. **Water use**. Water is an important resource in power generation with consumptive use varying depending generally on the type of cooling that the facility uses, type of fossil fuel, and type of generation and pollution control technology. In the case of cooling via surface water sources, entrainment of fish and fish larvae are also an important impact related to water use.

4. **Solid waste generation and waste management**. Depending on the fuel used to generate power, there can be relative little solid waste generated or alternatively there can be large amounts that require use of an onsite or offsite disposal facility.

[29] Other technologies could possibly become available (i.e., ocean thermal, solar photovoltaic, floating wind turbines), but at this time do not appear commercially viable on a large scale within the timeframe of the proposed action.

5. **Water discharge (both amount and quality)**. Depending on the fuel used to generate power and the type of facility cooling, the quantity of water discharged from a facility will vary along with the quality. Important variables include absolute temperature, difference in temperature from the receiving water body; and several chemical constituents regulated by federal and state water quality programs.

**Summary of impacts associated with potential facility development under the No Action Alternative**

***Gas Fired Electric Generation Facilities***

A natural gas facility burns natural gas to run a combustion turbine to generate electricity or in the case of a combined cycle facility the recovered heat is also used to run a steam turbine. Natural gas would likely be delivered by underground pipeline via a new interconnection line attached to the existing intrastate natural gas pipeline system. The facility could be cited in an already designated industrial area or in an appropriately zoned greenfield site and would have to comply with zoning regarding setbacks, height limits, noise, and landscaping. If the turbines and associated facilities were enclosed, the facility would resemble a commercial 5 story structure with an associated 150 to 250 ft (45 to 76 m) stack for each gas turbine. Depending on location, water for facility cooling could be provided by the local municipality, a nearby river or it could use greywater from a publicly owned treatment works (POTW). Likewise, wastewater, with appropriate pretreatment, could be discharged to a POTW or nearby stream. In order to operate, the facility would have to comply with all federal, state and local regulations relative to air pollution, water discharge and waste management. Emissions of regulated pollutants therefore would be at or below levels designed to be protective of human health and the environment.

For a gas fired facility, the principal pollutant of concern is $NO_x$. Emissions of $NO_x$ result from the combustion of nitrogen contained in fuel and the air supplied for combustion. $NO_x$ contributes to the formation of ground level ozone and acid rain. Natural gas facilities also emit VOC and carbon monoxide (CO) as a result of incomplete fuel combustion, which occurs to some degree even in state-of-the-art combined cycle systems being installed today. Although efficient combustion techniques employed in today's combustion turbines combined with the use of relatively clean burning natural gas reduce VOC and CO emissions below any other fossil fuel fired combustion technology, large quantities of these pollutants would still be emitted. $SO_2$ emissions from natural gas fired facilities are the lowest of all fossil fuel fired combustion facilities due to the low sulfur content of natural gas. PM also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash).

In addition to the emissions of criteria pollutants, a gas-fired facility would also emit non-criteria pollutants and $CO_2$. Non-criteria pollutants include Hazardous Air Pollutants (HAPs), which the EPA considers of special concern and for which the EPA has developed national emission standards for specific source categories such as combustion turbines. Some of the hazardous air pollutants emitted by a natural gas fired combustion turbine include formaldehyde, xylene, toluene, and benzene.

In many studies $CO_2$ has been attributed to an increase in average global temperatures. The emission of greenhouse gases and climate change is a concern to many in the scientific community. Natural gas fired energy facilities represent one method to reduce the total emissions of $CO_2$ from fossil fuel burning power plants as compared to other combustion technologies because of the combustion efficiency of the combined cycle system and the low carbon content of natural gas per MW of energy produced.

***Coal Fired Electric Generation Facilities***

Coal fired facilities typically use pulverized coal to fire a boiler to produce steam to operate an electric generator. Because of current air quality regulations a coal facility would likely be a low sulfur, "clean coal" facility. While the turbine building could be similar in size to the gas turbine facility, the overall property area would be larger due to the need for coal delivery (i.e., railroad unloading area or coal wharf), coal storage and ash storage. The coal for the facility would be delivered by rail or ship and limestone if used for emissions control could be delivered by truck or rail. Each would be processed prior to firing in the turbine. Waste generated would be a combination of fly ash from the air pollution control device and bottom ash or unburned coal from the combustion turbine. These would be collected and disposed of on or off site or recycled and reused as road bed material or for making concrete.

In light of current air quality regulations and economic considerations a coal-fired facility would be either a circulating fluidized bed boiler with a complex emission control system or integrated gasification combined cycle. Either of these types of facilities would emit significantly more criteria pollutants, non-criteria pollutants and HAPs than a natural gas or oil-fired facility. Emissions of Hg, a persistent bioaccumulative toxin, have also been associated with coal combustion and are the focus of new regulations for existing coal-fired power plants. The storage of coal and the likely use of evaporative cooling technology increase the potential for particulate emissions.

A coal facility would emit $SO_2$, which contributes to acid rain, sulfate deposition and can react with other compounds in the atmosphere to form particulates. PM also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash). Elevated particulate levels have been attributed to a variety of health effects such as respiratory ailments, especially in the young and the elderly. A coal facility would also emit $CO_2$, a greenhouse gas.

Coal-fired facilities require significantly more water than natural gas or oil-fired facilities. A coal-fired boiler has a greater heat load than a natural gas fired turbine resulting in increased water consumption. Dry cooling technology can often become too large for this type of unit requiring the use of wet cooling towers that further increase evaporative losses and water consumption. Coal burning facilities consume water within scrubber systems used for the control of $SO_2$ and acid gas emissions. The source of water would vary depending on the site but could include a surface water body, municipal supply or greywater from a POTW.

Stormwater runoff from coal storage areas can have impacts on wetlands, groundwater quality, and the local environment. The stormwater runoff can contain toxic chemicals found in coal, which can be washed to surrounding surface water bodies through the stormwater collection systems.

***Oil Fired Electric Generation Facilities***

New oil fired facilities, like new coal facilities, are a cleaner design, specifically designed to use fuels with lower sulfur content than is typical in older oil fired facilities. As with a gas and coal fired power plant, a new oil fired facility would have to meet local zoning requirements and applicable federal, state and local air emission, water discharge and waste management requirements. Oil for the facility would likely be delivered via ship while limestone used for air pollution control would be delivered by truck or rail. Several large tanks would be required to store the oil, and oil fired facilities involve risks of oil spills during delivery, storage and operation, which can affect natural resources and water quality in the area. Like the other fossil fuel based generation facilities, discharges of air emissions to the atmosphere and/or local water bodies would extend beyond the facility property boundary. Types of air pollutants emitted would be similar to that of a coal facility described above. In addition to pollutant concerns, the U.S. currently depends heavily on foreign oil supplies, and this reliance coupled with regional instability in primary oil producing regions presents potential concerns with the long-term reliability and economic stability of an oil-fired energy facility.

***Re-Powered Electric Generation Facility***

As the name suggests, a re-powered facility is one where new equipment is installed, typically for the purpose of improving the facility to make it more efficient or to bring it into compliance with new regulations. The most common re-powering is where an oil fired facility is changed to one that uses gas as the main fuel. One of the advantages of re-powering is that the original facility property is "reused" along with much of the supporting infrastructure. Re-powered facilities can typically be brought on line more quickly than can new facilities. They do not represent a new land use so there are no issues of compatibility with surrounding land uses. By changing to a cleaner burning fuel the facilities typically can demonstrate a reduction in air emissions. Redesign can also result in more efficient operation and decreased use of water.

## 5.4.7 Transmission Line Siting

### *5.4.7.1 Results of Environmental Facilities Siting Board Decision on Siting*

On September 17, 2002, the applicant and NSTAR jointly filed a petition with the EFSB and a petition with the DTE to construct, operate and maintain two new 115 kV electric transmission lines to interconnect the proposed action with the regional electric grid in New England.

As part of its review process, the EFSB was required to evaluate whether there is a need for additional transmission resources and evaluate the proposed action in terms of its consistency with providing a reliable energy supply to the Commonwealth with a minimum impact on the environment at the lowest possible cost. A project proponent must present to the EFSB alternatives to its planned action which may include: (a) other methods of generating, manufacturing, or storing electricity or natural gas; (b) other sources of electrical power or natural gas; and (c) no additional electric power or natural gas.

The applicant identified and presented four alternatives to the EFSB that would potentially meet its Project need, each of which could provide reliable service for the applicant's proposed action. These approaches included connecting the proposed action: (1) to NSTAR's 115 kV Barnstable Switching Station; (2) to NSTAR's 115 kV Harwich Substation; (3) to NSTAR's 115 kV Pine Street Substation in New Bedford; and (4) to a new 115 kV substation on Martha's Vineyard, then proceeding on to the mainland.

Upon its review, the EFSB concluded that the Martha's Vineyard Alternative did not warrant further consideration because of the magnitude of increased cost over the Barnstable Interconnect without any offsetting benefits. Although the Harwich and New Bedford Alternatives would be somewhat less costly than the Martha's Vineyard Alternative, each would cost approximately $50 million more than the Barnstable Interconnect. Because the Barnstable Switching Station is the major bulk substation on Cape Cod, with six 115 kV transmission lines available to carry energy to various parts of Cape Cod, interconnection at this location would provide high reliability in that energy from the proposed action could be reliably delivered to the grid even if one of the lines emanating from the Barnstable Switching Station is out of service. Therefore, the EFSB determined that, all other considerations being equal, a direct connection at the Barnstable Switching Station provides greater reliability than an indirect connection through another, smaller substation at a greater distance from the Barnstable Switching Station.

The EFSB found that the Barnstable Interconnect was preferable to both the Harwich and New Bedford Alternatives with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost. In addition, the EFSB found that, with the implementation of the proposed mitigation and conditions, the environmental impacts of the proposed facilities along the primary route would be minimized with respect to marine construction impacts, land construction impacts and permanent impacts. Therefore, the EFSB approved the applicant and NSTAR's proposal to construct two approximately 18 mile (29 km), 115 kV underground electric transmission lines along the primary route identified by the applicant.

The applicant has conducted a comprehensive analysis to identify the best route to provide the needed transmission interconnection from the facility to the mainland electrical grid system. A detailed assessment of alternative routes was conducted that concluded that the route proposed would be preferable to alternative routes with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost (EFSB, 2004). The EFSB Final Decision was issued on May 11, 2005.

### 5.4.8 Conclusion

Impacts are summarized for the five economically and technically feasible alternatives relative to the site of the proposed action in Table 3.3.5-1. The South of Tuckernuck Island Alternative would have the same environmental impacts as the proposed action in most categories of impact (22 of 28 impact categories evaluated, would be expected to have somewhat more impact than the proposed action with respect to five categories (avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, and EFH), and would be expected to have less impact than the proposed action in one category (visual impacts). The Monomoy Shoals Alternative would be expected to have the same level of impact as the proposed action in 20 of 28 impact categories, would be expected to have more impact than the proposed action in six impact categories. (Avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species.)[30] The Monomoy Shoals Alternative would be expected to have less impact than the proposed action in two impact categories (visual resources and cultural resources as they relate to visual impacts to historic structures).

The Smaller Project Alternative has less impact than the proposed action in 13 impact categories: noise, air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, cultural resources (as they related to visual impacts) competing uses of waters and sea bed, and port facilities.

The conclusions with respect to Smaller Project Alternative should be considered in light of the actual level of impacts expected for the proposed action. Table E-1, which summarizes the impacts for the proposed action, shows that the impacts in almost all the categories are minor or negligible, indicating that potential environmental savings with respect to impacts of the Smaller Project alternative relative to the proposed action would not be significant. The Smaller Project alternative would reduce visual impacts (ranked as moderate from the shoreline for the proposed action) though the amount of visible area reduced is not proportional to the 50 percent reduction in generation capacity of the Smaller Project (see Figure 3.3.6-2).

The Condensed Array Alternative would have greater impact than the proposed action for the competing uses impact category during construction, operation, and decommissioning. Additionally, the Condensed Array Alternative would have less impact during construction for 8 impact categories: noise, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species. Of these impact categories noise and water quality would be expected to have similar impact as the proposed action during decommissioning while

[30] Under the Monomoy Shoals Alternative, the impact categories: subtidal offshore resources, fish and fisheries, and essential fish habitat, have impacts that would be greater than the proposed action but only with respect to construction and decommissioning. Operational impacts would be expected to be the same for these impact categories as for the proposed action.

the other 6 would have a lesser impact. There would be greater expected impact compared to the proposed action during operation for the avifauna and threatened and endangered species impact categories. The remaining 19 impact categories would have the same level of impact as the proposed action during construction, operation, and decommissioning.

The Phased Deployment Alternative would have greater impact than the proposed action for 10 of 28 impact categories (air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, and recreation and tourism). The impacts on these categories would be similar to the impacts of the proposed action during operation. There would be no change in impacts for the other 18 impact categories for the Phased Deployment Alternative compared with the proposed action during construction, operation, or decommissioning.

# 6.0 CUMULATIVE IMPACT ANALYSIS

The "cumulative impact" of a proposed action under 40 CFR Section 1508.7 of the NEPA regulations is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or persons undertake such other acts." In order to measure cumulative impacts, a point from which measurements begin must be established, called a "baseline." The baseline for impact-producing factors for this cumulative effects analysis is current conditions. That is, the analysis of cumulative effects focuses on the current aggregate effects of all past actions that have taken place within the geographic area without itemizing the historical details of individual past actions. The proposed action is within a non-pristine, but unindustrialized area where current competition for OCS space is not intense. Competition for OCS space in this area is not expected to become intense during the reasonably foreseeable future (20 years) encompassed by this cumulative scenario. No past or present wind energy or other renewable energy projects exist in the geographic area defined for this cumulative analysis.

Geographically, the cumulative impact study area is shown in Figure 6.1-1. It extends northeastward from Nantucket Island to Monomoy Island including Monomoy Shoals and northwestward from Nantucket Island through Narragansett Bay to Quonset, Rhode Island including Martha's Vineyard. The northernmost boundary would be defined as the northern shore of Nantucket Sound and the easternmost boundary would be a point described as Latitude 41.4571, Longitude -69.8676. This geographic study area includes a broad scope of onshore and offshore projects that have been constructed, or may have the potential to be constructed in the future that could affect the location of the Project.

Temporally, projects included in the cumulative impact analysis were limited to present activity that includes: (1) the proposed action; (2) any ongoing projects or known proposed projects (i.e., projects for which an application has at least been filed or for which planning documentation exists); and (3) projects not now taking place, but which may occur periodically over the next 20 years because they have occurred in the recent past. Maintenance dredging of channels and harbor areas would be an example of such an activity. In combination, these three classes of activities comprise a cumulative scenario that explains expectations for the kinds of activities that could take place within the study area.

The following agencies were contacted in order to determine what projects were under review or proposed for the near future within the cumulative impact study area: the USACE, New England Division; Massachusetts Division of Conservation and Recreation (MassDCR); the Coastal Zone Management Program (CZMP); and the Massachusetts Department of Environmental Protection (MassDEP). The impact levels characterizing cumulative impacts are those used in Section 5.0. Direct impacts occur at the same time and place that the activity occurs. Indirect impacts are displaced in time and space from the factor producing the impact.

## 6.1 ACTIVITIES IN THE CUMULATIVE SCENARIO

Activities included in the cumulative scenario are as follows:

- Cape Wind Energy Project
- Offshore Wind Energy Projects
- Offshore Sand and Gravel Mining
- Tidal Energy Projects
- Marina Development

- Onshore Wind Energy Projects
- Submarine Cable and Pipeline Projects
- Maintenance Dredging and Beach Nourishment
- Upland Pipeline Projects
- Commercial Fishing Activities
- Small Marine Projects
- Vessel Traffic
- Population Growth and Onshore Development
- Wave Energy Projects

### 6.1.1 Cape Wind Energy Project

The Cape Wind Energy Project (the proposed action) is included in the cumulative scenario in order to evaluate the impacts of the proposed action along with other projects that make up the cumulative scenario described in the remainder of Section 6.1. The location of the proposed action is shown in Figure E-1, the description of the proposed action is provided in Section 2, and its existing environment and potential impacts are described in Sections 4 and 5 of this EIS, respectively.

### 6.1.2 Offshore Wind Projects

Currently there is only one other known offshore wind project proposed within the spatial scope of this analysis, for which there is potential for cumulative impacts on environmental resources. This is the South Coast Offshore Wind Project, which is proposed by Patriot Renewables, LLC. The South Coast Offshore Wind Project would be located in the Cape and Islands Ocean Sanctuary of Buzzards Bay (Figure 6.1-1). M.G.L Chapter 132A, Section 15, prohibits among other things, the construction of “electrical generation stations” in an ocean sanctuary. As such, the approval and schedule of the South Coast Offshore Wind Project will depend on if and when the ocean sanctuary legislation can be amended to allow for the construction of wind facilities in an ocean sanctuary.

Patriot Renewables proposes to construct between 90 and 120 WTGs within three general study areas of Buzzards Bay. Study area 1 is an area south of Sconticut Neck and Weset Island and north of Buzzards Bay navigational channel, running from the east edge of the channel to New Bedford Harbor to the east of West Island and terminating at Nasketucket Bay. Study area 2 is located between the Buzzards Bay navigational channel and the Elizabeth Islands, running from Sow and Pigs Reef to Wood’s Hole. Study area 3 is located between the mainland of Dartmouth and Westport and the north edge of the Buzzards Bay Navigational channel, running from Hen and Chickens Reef to the west edge of the channel to New Bedford Harbor. The project is expected to produce 300 MW of electricity. Electricity would be transmitted to the mainland electrical transmission system via a submarine cable interconnection to a location in Fairhaven (Patriot Renewables, LLC, 2006). Due to the distance of this project away from the proposed action (approximately 17 miles [27.4 km]) away at its closest point), cumulative impacts are expected to be minor, with the exception of impact to the roseate tern, as discussed in more detail in the BA in Appendix G, where the Patriot Renewables project has the potential to add direct effects to the breeding islands and breeding activities that would not occur with the proposed action.

In addition to the above project, the state of Rhode Island has recently selected a developer for an offshore wind facility off Rhode Island's coast in designated offshore wind development locations. While Rhode Island would not finance the project, the State is looking to expedite the process by conducting its own environmental assessments of these locations, and to support this, the State has designated several million dollars for various studies, some of which are underway.

### 6.1.3 Offshore Sand and Gravel Mining

In September 2003 Massachusetts entered into a multi-year cooperative agreement with the MMS to locate and assess the quality of sand and gravel resources situated on the continental shelf offshore of Massachusetts. Initial efforts are to document sand and gravel deposits in the inner continental shelf of the Merrimack embayment using geophysical techniques and grab sampling from small vessels. Numerous beaches along the embayment have experienced long-term erosion. Sand and gravel resources on the inner shelf could be found suitable and available for future public works projects to restore beaches or wetlands in this region. The Merrimack embayment is north of Cape Cod and not within the cumulative impact study area, but future characterization activities conceivably could be extended to include the southern inner shelf area of Cape Cod, Martha's Vineyard, and Nantucket Island. For sand and gravel mining in Federal waters beyond 3.5 miles (5.6 km) from shore, a permit from the MMS is needed.

Presently there is one proposal for an offshore sand mining project in the vicinity of Nantucket Sound within state waters. The Sconset Beach Nourishment Project is proposing that approximately 2.6 million cubic yards of beach compatible sediment be hydraulically dredged from a 195 acre (0.78 $km^2$) borrow site located approximately 2.9 miles 4.6 km) east of Nantucket Island in water that is 30-60 ft deep. The material would then be transported to Sconset Beach on Nantucket and pumped onto the project shoreline from a barge or dredge as a slurry of sand and water. This project would provide beach and dune nourishment for approximately 3.1 miles (4.9 km) of shoreline on eastern Nantucket extending south from Sesachacha Pond, past Sankaty Head Lighthouse to Codfish Park and the Village of Siasconset, and includes dune restoration at Codfish Park and dune construction at the Town Sewer Beds. This sand mining project is in development and environmental review and is contingent upon approval and permitting from several state agencies and the USACE. The start date is uncertain as this will depend on when and if the Project gets permitted (Kotelly, 2008).

The Town of Barnstable has expressed interest in conducting sand mining projects outside the Cape Cod Ocean Sanctuary boundaries for future beach nourishment. Although there are presently no approvals for sand mining projects, the potential for future activities and associated construction do exist. In the event that two projects occur concurrently in close proximity, there is a potential risk for cumulative impacts associated with the proposed action on environmental and socioeconomic resources, which are discussed in Section 6.2.

### 6.1.4 Tidal Energy Projects

At present there are two proposed TISEC technology development projects within the cumulative impact study area: one proposed by the Massachusetts Tidal Energy Company (MATidal) in Vineyard Sound called the Cape and Islands Tidal Energy Project, and one proposed by the Town of Edgartown in Muskeget Channel called the Nantucket Tidal Energy Plant Water Power Project.

#### *6.1.4.1 Cape and Islands Tidal Energy Project*

The Massachusetts Tidal Energy Company proposes to construct one or more clusters of TISEC devices to generate electricity via tidal currents in Vineyard Sound and sell the electricity to the grid. The project is located in navigable waters of the United States in Vineyard Sound in approximately 40 to 75 ft (12.2 to 22.9 m) of water. The underwater area begins at the southeast end of Naushon Island in Vineyard Sound and extends northeast in two separate areas located on either side of Lucas Shoal and Middle Ground, to their terminus at an existing underwater cable crossing that runs between Nobska point in

Falmouth and an area west of Lake Tashmoo on Martha's Vineyard. Potential transmission line routes to the shore would intersect an existing underwater cable crossing and would come ashore in Falmouth and/or on the north shore of Tisbury, in Martha's Vineyard (FERC Preliminary Permit Application, 2006).

The project would consist of 50 to 150 TISEC devices, each having the generating capacity of 500 kW to 2 MW (FERC Preliminary Permit Application, 2006). The proponent has stated that the TISEC devices would consist of: (1) rotating propeller blades, approximately 20 to 50 ft (6.1 to 15.2 m) each in diameter; (2) an integrated generator, producing 500 kW to 2 MW of electricity; (3) anchoring systems supporting the TISEC device at varying depths underwater; (4) a mooring umbilical line to an anchor on the sea bottom; and (5) an interconnection transmission line to shore. Monitoring systems for parameters including but not necessarily limited to pressure, temperature, vibration, revolutions per minute, and power output may be located on the TISEC devices and onshore. Transmission from the TISEC device cluster to shore would also be by submerged cable, which may be buried beneath the seabed in its inshore portion. Onshore underground transmission cables would carry the electricity to where it would be fed into the land-based electrical use infrastructure (FERC Preliminary Permit Application, 2006). Potential transmission line routes to the shore would intersect an existing underwater cable crossing and would come ashore in Falmouth and/or on the north shore of Tisbury, in Martha's Vineyard. Information regarding the location of on-land interconnects is not provided in the FERC preliminary permit filing (FERC Preliminary Permit Application, 2006).

The schedule indicates that the project would take place in three phases. The first phase would involve testing the devices and would take approximately 20 months to permit, followed by approximately 17 months of testing. The schedule shows that this in turn would be followed by permitting and installation of a partial build-out, followed by permitting and installation of the full build-out. The entire timeline for the project from start to completion of permitting for full build-out is approximately 51 months (FERC Preliminary Permit Application, 2006). This tidal energy project is 10 miles (16.1 km) away from the proposed action at its closest point.

#### *6.1.4.2 Nantucket Tidal Energy Plant Water Power Project*

On September 12, 2007, the Town of Edgartown applied to FERC for a preliminary permit for a tidal energy plant entitled Nantucket Tidal Energy Plant Water Power Project. FERC's statement that a preliminary permit would be issued to Edgartown was issued on March 31, 2008. The project proposed by Edgartown would be located in Nantucket Sound and Muskeget Channel, between Nantucket Island and Martha's Vineyard, in Nantucket and Dukes Counties, Massachusetts. Muskeget Channel is a six-mile wide stretch of open ocean between Martha's Vineyard and Nantucket with strong tides. The area is mostly shoal, but there is an underwater trough approximately 1.5 miles (2.4 km) off Wasque Point on Martha's Vineyard. The project would be approximately 10 miles south of the proposed action. The project would consist of 50 horizontal hydrokinetic cross flow turbine generation units from Ocean and Renewable Power Company, LLC, or a similar technology, having a total installed capacity of 20 MW. It would also include a proposed 3 mile long transmission line connected to a 4.8 kV circuit and appurtenant facilities. The project would have an estimated average annual generation of 50.48 gigawatt-hours, which would be sold to a local utility.

### 6.1.5 Marina Development

Local marina development was also considered when determining the spatial and temporal scope of the cumulative impact analysis. Whether this activity involves new marina development or maintenance of existing locations, the environmental impacts associated with this activity do exist, but are expected to be relatively small and generally far-field relative to the majority of the proposed action location.

### 6.1.6 Onshore Wind Energy Projects

The Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative is likely to result in a number of small community initiated wind projects for additional onshore wind power installations. These community based projects are small scale (generally only one or two WTGs). The environmental impacts associated with the construction, operation, and maintenance of these distributed and small land based projects are expected to be localized.

### 6.1.7 Submarine Cable and Pipeline Projects

Presently, there are three existing submarine cable systems located in Nantucket Sound that connect the mainland with the offshore islands to provide reliable island-wide power supply. There are no known active proposals for new submarine pipelines in the Nantucket Sound area. There are five 25 kV distribution cables that connect Martha's Vineyard with Cape Cod, the closest being 13 miles (21 km) to the west of the area of the proposed action. There are two 46 kV submarine cable systems that connect the mainland transmission system from Harwich and Barnstable (Lewis Bay) to Nantucket Island located approximately 8 miles (13 km) east of the proposed action area. There are no publicly available plans at this time for any future submarine cable system installations in Nantucket Sound or Vineyard Sound except for those associated with the proposed action.

### 6.1.8 Maintenance Dredging and Beach Nourishment

Another marine construction activity analyzed for cumulative impacts to environmental resources is the maintenance dredging of navigational channels and the disposal of dredged materials for beach nourishment in and around the shores of Nantucket Sound. As part of the U.S. Army Corps of Engineers nationwide program, the New England District reviews approximately 200 dredging and dredged material disposal permit applications each year, as well as ensures maintenance dredging of, and improvements to, more than 100 congressionally authorized Federal navigation projects serving the five coastal states in New England (USACOE, 1992). The only active dredge material disposal site is Cleveland's Ledge in Buzzards Bay that receives dredged material from activities in the Cape Cod Canal and most recently material from Falmouth Harbor (Buzzards Bay National Marine Estuary, 1991).

Maintenance dredging is defined by 301 C.M.R. 11.02 as "any maintenance work or activity carried out on a regular or periodic basis in a manner that has no potential for damage to the environment or for which performance standards have been developed that avoid, minimize, or mitigate potential environmental impacts to the maximum extent possible." About 90 to 95 percent of dredged material is considered to have low or undetectable contaminant levels and can be used in a variety of beneficial projects. Such dredged sediments have been used to create new islands and marshes which serve as breeding grounds for birds and marine animals. Clean sand from dredging operations also is used for beach nourishment. In urban areas, dredged materials have been used as landfill for the creation of industrial developments and municipal projects, such as Boston's Logan Airport, and as sanitary landfill cover (USACOE, 1992).

The County of Barnstable carries on maintenance dredging in dozens of harbors and inlets for the various waterfront communities around Cape Cod on a rotational basis using the cutterhead DRAGON dredge "*Cod Fish*". Because of the high boat traffic peaking in late June, dredging halts for the summer and does not start again until October. On Martha's Vineyard, the dredge "*Edgartown*" carries out scheduled maintenance dredging of channels, tidal inlets, and pools.

The submarine cable system for the proposed action would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Hyannis Harbor was dredged in 1985, 1991, 1998, and 1999. No future dredging activities are currently scheduled. Nonetheless, if dredging activities were to occur concurrently with the jet-plow installation of the submarine cable system into Lewis Bay, and due to the close proximity of the two activities; they could potentially result in cumulative impacts. Another example is Oak Bluffs Harbor dredging, which is a project consisting of dredging the entrance to Oak Bluffs Harbor with beneficial use of the dredged sand as nourishment on an adjacent town beach.[31] Sediment suspension, deposition, and some mortality of benthos and shellfish in the area of temporary disturbance could take place with concurrent construction activities. Therefore, geology and sediment conditions, benthic and shellfish conditions, and fish resources and commercial/recreational fisheries are discussed in detail in Section 6.3.

### 6.1.9 Upland Pipeline Projects

This cumulative impact analysis has also taken into consideration the proposed onshore KeySpan Sagamore Line Reinforcement Project with respect to the onshore components of the onshore cable system for the proposed action. KeySpan proposes the construction of approximately 13.1 miles (21.1 km) of a new high-pressure, distribution gas pipeline that is planned to be constructed from the present up until 2013. This reinforcement project is an upgrade to an existing pipeline and the proposed route would be constructed in three segments: Western, Middle, and Eastern. The Western Segment would begin near the intersection of Route 130 and Service Road in Sandwich and extend along Service Road to Route 149 in Barnstable, approximately 5 miles (8 km) from the nearest point along the onshore cable route of the proposed action. The Middle Segment installation runs from KeySpan's South Yarmouth LNG facility on White's Path to the Depot Street and Main Street intersection in Harwich, nearly 2 miles (3.2 km) from the nearest point along the onshore cable route of the proposed action. The Eastern Segment, the farthest segment from the proposed action (approximately 12 miles [19.3 km]), would involve the installation of 1.6 miles (2.6 km) of pipeline from the Depot Road and Route 139 intersection in Harwich to the intersection of Church Street and Route 39 in Harwich. The three segments of the KeySpan Sagamore Line Reinforcement Project do not intersect the proposed onshore cable route and therefore there would be no gas line construction in the vicinity of the proposed action's onshore cable route.

### 6.1.10 Commercial Fishing Activities

Nantucket Sound experiences a wide range of disturbances on a regular basis in and around the study area. Anthropomorphic disturbances (commercial fishing, anchoring, etc.) repeatedly and regularly affect the environmental resources associated with the water column and the seabed. For example, Churchill (1989) has measured near-bottom TSS to be up to 1,500 mg/liter as a result of trawling operations. With the seafloor conditions found in portions of Nantucket Sound, it is possible that upwards of 1.32 $yd^3$ (1.01 $m^3$) of sediment could be re-suspended in the water column for every foot of commercial trawling. Commercial fishing is a baseline disturbance factor in Nantucket Sound, resulting in minor temporary disturbances to benthos and brief episodic increases in suspended solids, along with the harvesting of fish, and shellfish. The WTGs represent a new set of navigation obstacles that would need to be avoided, but they should not significantly alter the ability to undertake commercial fishing within the boundary of the WTGs given the turning radius for commercial fishing vessels even while trawling.

### 6.1.11 Small Marine Projects

Other marine projects that could be considered in the cumulative impact scenario include the construction of sea walls, docks, piers, shoreline stabilization/erosion control measures, etc, which collectively are considered as part of the cumulative scenario.

[31] The referenced dredging projects are reflective of near-shore sediment transport, deposition and erosion that occurs in these relatively near-shore areas and are not necessarily reflective of sediment transport, deposition and erosion that takes place in the area of the proposed action. Refer to Section 4.1.3 for information on physical marine processes that take place in the area of the proposed action.

### 6.1.12 Vessel Traffic

Vessel traffic associated with Nantucket Sound includes ferry services between Cape Cod and the Islands, limited cruise ship traffic, use of the area by commercial fishing vessels, and recreational boating use. The SSA operates up to 56 transits per day between Wood's Hole and Martha's Vineyard and 28 between Hyannis and Nantucket during the summer months and Hyline cruises operates an additional 30 transits with high speed and traditional ferries during the peak season. The majority of boating traffic travels along channels setback from the proposed Project (i.e., commercial ferry traffic, cruise ships, large recreational vessels) with boating traffic limited to some recreational boating and commercial fishing in the specific area of the proposed turbine array. Cumulative impacts on vessel traffic are generally expected to be minor due to the limited vessel traffic in the specific area of the proposed action. However, in the instance of navigation safety relative to the operation of radar within the WTG array, the USCG sponsored radar impact study (see Appendix M) found that navigation safety impacts are moderate, and additional mitigation has been developed (see Section 9.0).

### 6.1.13 Population Growth and Onshore Development

Land-based activities near the ocean may contribute to indirect or associated cumulative impacts on a particular sensitive coastal resource area and may include power plant cooling water intake and discharge facilities, non-point and point source runoff, agricultural activities, storm water runoff, and accidental pollutant discharges. Such far-field impacts can have varying degrees of impact on the marine environment in the geographic area of the proposed action depending on the location, extent, and type of activity to the adjacent receiving waters in Nantucket Sound. They are included as a general group of impacts called Population Growth and Onshore Development.

The Massachusetts statewide population over the last century has been continually increasing. Cape Cod and the Islands are no exception. Specifically, Barnstable, Dukes and Nantucket County populations have increased by 19, 29, and 58 percent, respectively between 1990 and 2000. Table 6.1.13-1 gives the population and housing unit estimates from the U.S. Census Bureau for 2000 and 2004. Barnstable County gained 6,453 residents from 2000 to 2004 to reach an estimated total population of 228,683 (a 2.9 percent increase over 4 years), according to the U.S. Census. Nantucket County had a 3.5 percent increase and Dukes County increased its total population by 7.5 percent from 2000 to 2004. From 2000 to 2005 the number of housing units in Barnstable County increased by an estimated 6,715 from the U.S. Census count of 147,083 in April 2000 to reach 153,798 in 2005. This 4.6 percent housing growth rate (in 5 years) led the state’s 12 mainland counties topped only by Nantucket County’s 9 percent growth rate up from 9,210 in 2000 to 10,042 in 2004 and Dukes County’s 5.6 percent, where homes on Martha’s Vineyard and the Elizabeth islands increased from 14,836 in 2000 to 15,670 in 2004 (see Section 4.3.3.1 for further discussion of Cape Cod population trends). This trend of fast-growing population suggests that onshore residential and commercial development would also continue to increase. This increase in onshore development would in turn result in point and non-point source discharges and increased air pollution, which in turn may contribute cumulatively to water and air pollution in the area. The possible contribution of the proposed action to pollution associated with population growth and onshore development is discussed in Section 6.3 as applicable. The alteration of native vegetation, increased human activity on area beaches, and greater recreational boating on the Sound, all have the potential to create cumulative impacts on birds, protected species, aesthetics, noise, wildlife, and air quality.

### 6.1.14 Wave Energy Projects

Offshore wave energy devices are typically tethered to the seafloor, and could use either suction or gravity anchors. Cables are then connected between the wave energy device and the anchors. Larger wave energy projects would have the devices positioned in an array to take maximum advantage of the prevailing wave direction. Some impacts associated with wave energy devices may include impacts to the benthic environment as a result of anchoring device used, potential for collision or entanglement between marine mammals and device hardware or fishery impacts, impacts associated with navigation, and impacts associated with the public use of the waterway.

At present there is a Rhode Island state-funded pilot wave energy project proposed off of Block Island, which is just beyond the southwest edge of the cumulative impact study area. After this is constructed, there are plans for another larger wave energy facility at an unspecified location off of Rhode Island. The developer of the two Projects, Oceanlinx Limited, proposes to first generate 1.5 MW with the pilot project, and then subsequently generate between 15 and 20 MWs as part of the larger project. The wave energy project would use oscillating water technology, whereby waves compress air to drive a turbine. The device includes computers to measure the air pressure and alter the angle of blades in the turbine so that, although the wave action ebbs and flows at different speeds, the turbine spins at a constant rate in a single direction. The wave energy project is anticipated to result in negligible cumulative impacts with the proposed action because it is located far from the area of the proposed action.

In addition to the above referenced wave energy project, two other wave energy projects are proposed south of the cumulative impact study area. These two wave energy projects are both proposed by Grays Harbor Ocean Energy Company, LLC and both would be 100 MWs in size. The wave energy projects may also generate power from wind turbines on the wave energy converters. One of the projects is located south of Block Island, approximately 12 to 25 miles (19.3 to 40.2 km) from shore, and the other is located south of Nantucket, approximately 12 to 25 miles (19.3 to 40.2 km) from shore. Both projects would proceed in phases, beginning with a pilot program phase (i.e., construction of two 1 MW wave energy conversion platforms at each site) and then proceeding to full buildout. The wave energy projects are anticipated to result in negligible cumulative impacts with the proposed action because they are located far from the area of the proposed action.

The small wave energy associated with the waters of Nantucket Sound relative to other locations makes it unlikely that a wave energy Project would be constructed near the area of the proposed action.

### 6.1.15 Ocean Development/Construction Projects Located Outside the Cumulative Impact Study Area

In addition to the projects and activities discussed above, there are numerous ocean development/construction projects located outside of the cumulative impact study area for this proposed action. These include a floating wind turbine project proposed by Blue H USA, LLC located approximately 23 miles (37 km) south of the coast of Martha's Vineyard and 45 miles south of New Bedford, several proposals for meteorological towers in locations outside the cumulative impact study area, that are proposed by wind power developers under the MMS interim limited leasing policy for resource data collection and technology testing, and other wind projects proposed off the coast of Long Island. In addition to wind projects, several LNG projects are proposed or are in development that are located beyond the study area including Broadwater LNG facility in Long Island Sound, and the Neptune and Northeast Gateway LNG projects north of Boston. All of these projects are geographically distant from the proposed action and the cumulative impact study area.

Although MMS understands that some migratory marine and avian species could conceivably pass through the areas of these activities as well as through the area of the proposed action, migratory passages by sea and air are one more competing, but temporary, use of the OCS and cumulative impacts resulting from migratory passages would be negligible on the species transiting these areas. Radar studies of migrating birds have shown that they tend to avoid the existing Danish wind parks at Horns Rev and Nysted (Danish Energy Authority, 2006, p. 102). Monitoring of marine mammals at the Danish wind parks was reported in 2006 (Danish Energy Authority, 2006). Harbor seals that were resident or transited the areas around Horns Rev and Nysted returned to pre-construction numbers soon after construction ended at both locations. Porpoises had returned to pre-construction numbers at Horns Rev shortly after construction ended, but had not returned to Nysted in numbers recorded before construction began (Danish Energy Authority, 2006, p. 90).

## 6.2 CUMULATIVE IMPACT ANALYSIS

The following section discusses impacts of the cumulative scenario and then assesses the extent that the proposed action would incrementally contribute to that impact. The discussion addresses the proposed action and each of the main impact areas discussed in this EIS including: geology and sediment conditions; physical oceanographic conditions; benthic and shellfish resources; fish resources and commercial/recreational fisheries; protected marine species; terrestrial ecology; wildlife and protected species; marine mammals; avian resources; coastal and freshwater resources; water quality; cultural/recreational resources and visual studies; noise; transportation and navigation; electric and magnetic fields; telecommunications; air and climate; and socioeconomics.

### 6.2.1 Geology and Soft Sediments

Activities that are part of the cumulative scenario that may impact physical oceanographic conditions within the cumulative impacts study area include: (1) sand and gravel mining; (2) undersea pipeline or cable installation; (3) channel maintenance; (4) commercial fishing activities (trawling); (5) other tidal, wave, or wind energy projects; (6) other small marine projects; and (7) the proposed action. Direct impacts for all activities have the potential to disturb sediment by contacting the surface, by temporarily suspending sediments, or by temporarily increasing biologic oxygen demand in the water column from re-suspended organic matter in the sediment.

Impacts to the geology and sediment conditions within Nantucket Sound are likely to occur during construction and decommissioning of the proposed action (i.e., installation and removal of undersea cables and monopiles). Given the dynamic sediment transport and depositional/erosional environments within and surrounding the area of the proposed action, natural processes are anticipated to rapidly restore seabed topography and benthic biology following completion of all construction phases. This would include all proposed phases of construction, operation, and decommissioning including pile-driving, jet plow embedment of submarine cable systems, landfall transition interconnections and onshore cabling and conduit installations, including anchoring, winching and spudding activities associated with construction vessels, and cutting and structure removal. Mitigation measures, such as scour mats would also be implemented to reduce the impacts on geology and sediments (see Section 9.3). Given the implementation of mitigation techniques used in the construction activities of the proposed action, the impacts would be localized and short-term, and therefore the incremental cumulative impacts on geology and soft sediment conditions as a result of the proposed action are expected to be minor, even if such impacts occur at the same time as activities that are part of the cumulative scenario.

No existing bottom-founded infrastructure exists within the area of the proposed action for which setback could be established, with the exception of the meteorological data tower. If sand borrowing is an activity that takes place on Horseshoe Shoal over the next 20 years, borrow areas would require setbacks from monopiles that typically are determined on the basis of a specific dredge plan. Direct impacts from sand dredging that could occur would be equipment that punctures or strikes bottom-founded or buried infrastructure, particularly if locations are poorly known or if transmission cables have moved as a result of storm activity. Indirect impacts from sand dredging could be partial exhumation or spanning of transmission cables when the slopes at the edges of burrow pits undergo erosion to re-equilibrate with the slope of the surrounding sea floor over time. Pipelines or cables buried in the sediment could have cover reduced or be exhumed if sand dredging takes place too close to infrastructure, making them vulnerable to commercial fishers who bottom trawl, or recreational boaters dropping anchors, for example.

Setback distances from existing infrastructure are needed in the event of dredging or sand mining on Horseshoe Shoal. MMS (USDOI, MMS, 2005) determined that bottom substrates that are sandy need shorter setback distances; on the order of 150 ft (50 m) for borrow pits that are 15 ft (5 m) deep. The time periods needed for borrow pits to either fill or re-equilibrate with the sea bottom are generally on the order of three to six years for sandy bottom substrates (USDOI, MMS, 2005, p. 161). The area of the sea bottom disturbed by the 130 WTG monopoles and the piles for the ESP totals 0.67 acre (2,711 $m^2$). Additionally scour mats would cover 1.96 acres (7,946 $m^2$) and rock armoring, 8.75 acres (35,417 m2). Rock armor would replace scour mats in any areas for which the mats do not prove effective. This would be up to 47.8 acres (0.19 $km^2$) of rock armoring if all 130 turbines and the ESP use rock armoring. The sea bottom disturbed by construction or decommissioning vessels, either by direct contact or increased turbidity, is estimated to be 0.25 acre per monopile or 32 acres (0.12 $km^2$) for 130 monopiles.

The area of sea bottom disturbed by constructing or decommissioning the proposed action is very small in comparison to the available area of sandy bottom on Horseshoe Shoal that would remain undisturbed between the monopiles as well as the area outside the wind park envelope. Bedrock geology below soft sediments will be completely undisturbed by the proposed action and the activities that are part of the cumulative scenario.

**Conclusion**

Minor long-term impacts to geology and soft sediments as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario. The total area of permanent benthic impact for the proposed action due to the WTG and ESP piles is 0.67 acres (2,711 $m^2$) and the total area of temporary impact for the cable that connects the WTGs to the ESP is 580 acres (2.3 $km^2$). The temporary impact of the area disturbed from installation of the cable from the ESP to the shore is 86 acres (0.3 $km^2$). The majority of the impacts are temporary and localized relative to the size of Nantucket Sound.

### 6.2.2 Physical Oceanographic Conditions

Activities that are part of the cumulative scenario that may impact physical oceanographic conditions within the cumulative impacts study area include: (1) sand and gravel mining; (2) pipeline projects; (3) submarine cable projects; (4) the South Coast Offshore Wind Project, or other offshore tidal, wave or wind energy projects; and (5) the proposed action.

In the unlikely event that a nearby sand and gravel mining project was approved in proximity to the proposed action it would not be expected to have any impact on waves, currents, tides or other physical oceanographic conditions because of the design parameters for the proposed action. The proposed action is not expected to result in changes to existing erosion patterns on the sea bed or on adjacent coastlines or beaches. Studies have determined that the zone of influence of each WTG pile on current conditions is estimated to be limited to an area of several pile diameters around each WTG (Report No. 4.1.1-4).

**Conclusion**

Negligible long-term impacts on physical oceanographic conditions are expected as a result of the proposed action or the activities that are part of the cumulative scenario, since none of these potential activities would have anything other than a very small and localized affect on features such as tides, waves, or currents.

### 6.2.3 Benthic Fauna and Shellfish

Activities that are part of the cumulative scenario that may impact benthic fauna and shellfish include: (1) sand and gravel mining; (2) maintenance dredging; (3) pipeline projects; (4) submarine cable projects;

(5) commercial fishing activities; (6) other tidal, wave, or wind energy projects; (7) small marine projects; and (8) the proposed action. Direct impacts from all of these activities are limited to the area in which the activity takes place.

If the proposed action was permitted and constructed, sand and gravel extraction within the designated MMS lease area would be precluded, but sand mining could possibly take place near the perimeter of the leased area. In the unlikely event that sand and gravel extraction was approved by MMS over the next 20 years, and took place in proximity to the proposed action, there is the potential for cumulative impacts on the benthic fauna and shellfish resources within the cumulative study area.

Potential impacts to benthic and shellfish resources associated with the construction, operation and maintenance of the proposed action relate directly to that area of the seafloor either displaced by monopiles and scour control systems, or temporarily disturbed during construction and decommissioning. Direct impacts would include crushing or smothering of benthic infauna and epifauna by construction equipment and anchors, monopile foundations, and scour mats. Indirect impacts could be increased turbidity that interferes with filter-feeding organs of benthic invertebrates. These impacts on benthic and shellfish conditions would be localized and short-term.

The applicant has attempted to plan, site, and design the proposed action to avoid and/or minimize impacts to benthic and shellfish resources. In addition, jet-plow embedment for the submarine cable system is minimally intrusive on the seabed and natural conditions are quickly restored after completion of construction due to the predominantly sandy bottom of Nantucket Sound and Lewis Bay (see Section 9.0 for more mitigation discussion).

The sea bottom area is living space for invertebrates living in, and on, the sediment surface. The degrees of disturbance of benthic area by the proposed action are discussed in 6.3.3. Benthic recolonization and succession have been reviewed to varying extents for a wide variety of habitats throughout the world (e.g., Thistle, 1981; Thayer, 1983; Hall, 1994; Coastline Surveys Limited, 1998; Newell et al., 1998). Re-colonization is highly variable and ranges from within months (e.g., Saloman et al., 1982) to more than 12 years (e.g., Wright, 1977), depending on the habitat type and other physical and biological factors. Focusing on dredging, Coastline Surveys Limited (1998) and Newell et al. (1998) suggested that in general, recovery times of six to eight months are characteristic for many estuarine muds, two to three years for sand and gravel, and five to ten years as the deposits become coarser.

Once installed and operating, monopile foundations would offer hard substrates in an area that otherwise consists of predominantly soft sediments. Each monopile is expected to increase the habitat heterogeneity from what had been only soft bottom communities of invertebrates living in or on the sediment surface to hardground communities having increased abundance of individual species as well as species diversity. The 130 monopiles and rock armor of the proposed action are expected to become encrusted by attached epifauna such as mussels, but could also include barnacles, sponges, bryozoans, and macroalgae, within 5 to 6 years. Abundance and biomass of benthic communities increased 50-150 times at the Danish wind park sites at Horns Rev and Nysted compared with the biomass of native soft bottom communities existing before emplacement of foundation structures (Danish Energy Authority, 2006, p. 44).

Upon decommissioning and removal, what had been a net benefit to benthic community biomass, will be conversely degraded unless artificial reefing of monopiles takes place to some degree.

**Conclusion**

Minor long-term impacts to the benthic community as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario. Recolonization of sediment disturbed after the proposed WTG monopile and scour system installation and other bottom-disturbing work that could occur over the next 20 years, such as sand borrowing on Horseshoe Shoal, would occur rapidly. Although the number of individuals, species, and biomass of benthic infauna may approach pre-disturbance levels within two to three years on sandy substrates, recovery of community composition and trophic structure may take somewhat longer. Undisturbed areas between monopiles and outside of the wind park envelope are sources for faunal in migration and larval recruitment for recolonizing the small areas that are disturbed. The increase in benthic biomass from installation of hard substrate will be degraded in a converse manner after monopiles are decommissioned and removed unless artificial reefing of monopiles takes place to some degree.

### 6.2.4 Fish Resources and Commercial/Recreational Fisheries

Activities that are part of the cumulative scenario that may impact fish and commercial or recreational fisheries within the cumulative impacts study area include: (1) sand and gravel mining; (2) commercial fishing activities; (3) maintenance dredging; (4) other offshore tidal, wave, or wind energy projects; and (5) the proposed action. Direct and indirect impacts are the result of habitat conversion that may improve or degrade existing bottom substrates.

Sand mining would have the potential of disturbing bottom substrates used by shellfish that are commercially fished; however, these disturbances would be limited to the mined area. Construction of the proposed action is not expected to result in measurable direct mortality to adult and juvenile pelagic fish since these life stages are mobile in the water column and are capable of avoiding or moving away from any disturbances associated with construction. Once installed and operating, the presence of the WTGs and ESP may make it more difficult for commercial trawling in the immediate vicinity of each structure. Any adverse impacts to commercial/recreational fisheries would be localized and minor given that commercial fishing activities would still occur in the area of the proposed action. In addition, it is likely that recreational fishing may increase due to the potential for the wind turbine bases to become FADs. As a result, incremental cumulative impacts to fish resources and commercial/recreational fisheries from the Project are expected to be minor.

Once installed and operating monopiles would be hard substrates in an area that otherwise consists of soft sediments. Each monopile is expected to increase the habitat heterogeneity from what had been only soft bottom communities of invertebrates living in, or on, the sediment to hardground communities having increased abundance of individual species as well as species diversity. At the Danish offshore wind parks at Horns Rev in the North Sea and Nysted in the Baltic Sea, the submerged WTG foundations became colonized and encrusted by the common mussel *Mytilus* within 5-6 years after emplacement (Danish Energy Authority, 2006, p. 53). At this latitude and marine setting the mussel is a superior competitor for space compared to other sedentary invertebrate species or algae. Abundance and biomass of benthic communities increased 50-150 times at both Danish wind park sites compared with the biomass of native soft bottom communities existing before emplacement of foundation structures (Danish Energy Authority, 2006, p. 44). Artificial hard substrates are generally considered beneficial to the reproduction and growth of some native mobile species, such as crab, by providing shelter and nursery habitat. At Horns Rev the edible crab *Cancer* colonized the foundation structures as juveniles and adults.

Environmental monitoring studies at Horns Rev and Nysted showed few effects on the fish fauna that could be attributed to the establishment and operation of the wind parks. The use of advanced survey techniques and intensive surveys did not document any clear effects on fish communities. Fish abundance and diversity were not higher inside the wind parks than in the areas outside. At Nysted the effect of the wind park was inferred to be weak because the hard substrate monocultures of mussels encrusted on the foundation elements are only moderately attractive to fish. At Horns Rev investigators performed the fish surveys during the early stages of colonization of the turbine foundations, where a correlation between fish and the wind park may not have been measurable (Danish Energy Authority, 2006, p. 64).

Over the operating lifetime of the wind park, monopiles are expected to cause net increases in biomass on Horseshoe Shoal. In effect these small islands will be enriched ecosystems for duration of the project and are attractants to the invertebrates that live within and among encrusting mussels as well as birds and fish that could favor these associated communities as opposed to mussels alone. The degree of correlation between fish and monopiles in cold water has yet to be firmly established. If monopiles do attract fish they may also be attractants for recreational or commercial fishers.

Upon decommissioning and removal, what had been a net benefit to benthic community biomass, and possibly to fish and birds, will be removed from the setting of Horseshoe Shoal, and these resources will be conversely degraded unless artificial reefing of monopiles takes place to some degree.

**Conclusion**

Minor long-term impacts on fish and commercial and recreational fisheries as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario. Environmental monitoring at Danish offshore wind parks to date has been inconclusive as to whether or not wind parks are net attractants for fish. Whether or not monopile foundations would serve as attractants for recreational or commercial fishers is equally inconclusive at this time.

### 6.2.5 Sea Turtles and Marine Mammals

Activities that are part of the cumulative scenario that may impact sea turtles and marine mammals within the cumulative impacts study area include: (1) vessel traffic and potential vessel strikes; and (2) underwater noise. Loss of habitat or access to food sources is not anticipated. The main potential for deterring marine mammals from an area under this proposed action is related mostly to acoustic harassment from construction noise. However, this noise will be confined within Nantucket Sound which is an area of relatively low marine turtle and marine mammal density and therefore not expected to significantly alter sea turtle or marine mammal presence and habitat use.

These impacts could originate from construction and service vessel traffic in support of the proposed action as well as vessel traffic that is not part of the proposed action, including that which is routine traffic, ferries for example, and vessel traffic supporting installation of other offshore tidal, wave, and wind energy projects. All vessel traffic activity, regardless of origin, can cause direct impact by accidentally striking a marine mammal or turtle with consequences that could range from lacerations and broken bones to internal injuries and death. Direct impacts caused by underwater noise could cause short- to medium-term habitat displacement (i.e., harassment due to decibel level) if marine mammals or sea turtles avoid the wind park area during construction, as a result of underwater noise. It is likely that only marine turtles and marine mammals in immediate proximity to pile driving could experience physically harmful sound levels.

Increased vessel traffic could be due to construction and operation of the proposed action or for other marine renewable energy projects (i.e., South Coast Offshore Wind Project or the Cape and Islands Tidal Energy Project), marina development or other marine related work. The proposed action has been sited and designed to avoid, minimize, or mitigate potential impacts to marine turtles and marine mammals. Some mitigation measures include having a NOAA Fisheries-approved observer on-site during all pile driving activities and using state-of-the-art hydraulic jet plow technology for cable installation and monopile foundations for the WTGs (see Section 9.0 for more mitigation discussion). If marine mammals or sea turtles are present in the area of the proposed action, they are likely to temporarily avoid the area during construction activities. Given the low densities of sea turtles and marine mammals in

Nantucket Sound and the significant distances between activities within the turbine array and seal haul-out and breeding sites, the potential impacts to these species is further reduced.

During construction of the Danish wind parks at Horns Rev and Nysted, general changes were noted in porpoise and seal behavior during and after construction activities. At Horns Rev porpoises showed a weak negative effect (avoidance) during the construction period as a whole and a strong, but short lived reaction (absence), to monopile driving operations (Danish Energy Authority, 2006, p. 90). At Nysted porpoises showed a strong negative reaction (absence) during the construction phase (emplacing gravity caissons). Porpoise avoidance of the area around Nysted has occurred over the first two years of operation of the wind park and was unexpected (Danish Energy Authority, 2006, p. 91). During construction there was a fall off in the number of harbor seals at haul out sites during pile driving operations at Horns Rev and no significant effects on seal use of the Nysted area (Danish Energy Authority, 2006, p. 90).

**Conclusion**

Minor long-term impacts on sea turtles and marine mammals are expected as a result of the proposed action and the activities that are part of the cumulative scenario. Mitigation is expected to effectively minimize the chance for vessel strikes during support of the proposed action as well as reduce the potential for acoustic and other types of harassment during the construction and operation of the proposed facility. Increased commercial fishing, recreational fishing, and pleasure boat activity as a consequence of gradually increasing population and economic activity in the area over the next 20 years could result in several unreported or unrealized collisions with protected marine species, primarily turtles or seals.

### 6.2.6 Terrestrial Ecology, Wildlife and Protected Species

Activities that are part of the cumulative scenario that may impact terrestrial ecology, wildlife and protected species within the cumulative impacts study area include: (1) onshore sand and gravel mining; (2) beach nourishment; (3) upland pipeline projects; (4) onshore wind energy projects; (5) other offshore tidal, wave or wind energy projects with onshore connections; (6) population growth and onshore development; and (7) the proposed action.

Sand and gravel mining and beach nourishment onshore, upland pipeline projects, other offshore tidal, wave, and wind energy projects with onshore connections, and onshore wind energy projects have the effect of converting land to these uses making less land available for undisturbed terrestrial ecosystems, wildlife, and wildlife habitat. Residential and commercial development can cause loss of wildlife habitat due to vegetation clearing. General population growth and increased intensity of land use may pressure wildlife habitat. Bats are subject to the additional hazard of lethal collision with WTGs. The collision hazard is discussed in further detail below in section 6.2.7.

The proposed action has been planned, sited, and designed to avoid or minimize impacts to terrestrial ecology, wildlife and protected species and their mapped habitats within the area of the proposed action. For example the proposed onshore route for the cable system is configured to utilize previously developed or disturbed transportation and utility corridors.

**Conclusion**

Negligible to minor long-term impacts on terrestrial ecology, wildlife and protected species are expected as a result of the proposed action and the activities that are part of the cumulative scenario. The growth of population and economic activity over the next 20 years is expected to place conversion pressure on land now available for terrestrial ecosystems and wildlife. Land conversions would create degraded habitats in some areas that are disturbed, completely displace habitat and wildlife within the footprints of constructed structures, and cause wildlife accustomed to wild habitat to adjust to a more intense human influence and presence.

### 6.2.7 Avian Resources and Protected Bird Species

Activities that are part of the cumulative scenario that may impact avian resources within the cumulative impacts study area include: (1) sand and gravel mining; (2) other offshore tidal, wave, or wind energy projects; (3) onshore wind projects; (4) onshore development; and (5) the proposed action. Direct effects would be restricted to lethal collision hazard to birds or bats posed by operating WTGs. Indirect effects would include the wind park serving as a barrier to movement as a result of the 25 $mi^2$ (64.7 $km^2$) area of the proposed action and temporary disturbance of avian resources in the area during construction and decommissioning activities.

The increase in biomass expected by colonization of the monopile foundations by monocultures of mussels and the invertebrates that live among them could enrich local food sources around monopiles that could attract coastal and marine birds. Environmental monitoring at the Danish wind parks has shown that most of the more numerous bird species showed avoidance responses at both Horns Rev and Nysted (Danish Energy Authority, 2006, p. 15). Radar tracking has shown that birds tended to avoid the wind parks and individual WTG structures and that individual bird tracks wrapped around the periphery of the wind parks. Post-construction studies showed almost complete absence of divers and scoters within the wind park at Horns Rev and significant reductions in long-tailed duck densities within Nysted. Other species showed no significant change or occurred in too few numbers to allow statistical analysis (Danish Energy Authority, 2006, p. 15).

Although the type and extent of impacts to migratory birds are not yet well defined for offshore wind projects in the United States, some level of bird-strike impacts and mortality associated with the turbine structures from the proposed action and any future offshore projects should be anticipated.

Sand mining could temporarily degrade sea bottom conditions by disturbing the substrate. If birds relied upon elements of the soft bottom fauna for food, they could be displaced from the sand borrow area until re-establishment of the normal community in two to three years time.

Onshore wind projects in Massachusetts are limited in size and scope due, in part, to a lack of large tracts of available land with adequate wind resources. As a result, all of the proposed onshore projects range from single turbine installations to less than ten WTGs. These projects are proposed in near-shore communities and in towns further inland that have forested hills or ridge tops. The addition of small numbers of widely scattered onshore wind turbines, each of which would have to go through regulatory review to determine appropriate siting and levels of environmental impacts, is not expected to have a significant cumulative effect in combination with the proposed action.

The estuaries, shoals, salt marshes, tidal flats, dunes, and beaches that comprise the Nantucket Sound ecosystem provide important breeding, nesting, and foraging habitat for many species of resident and migratory birds. Nantucket Sound is located along the Atlantic flyway and is recognized as an important migratory stopover area for millions of birds each year. General impacts on birds associated with human activities occurs wherever land development happens and where there is a high level of outdoor recreation, such as on Cape Cod and the Islands. Therefore, human activity results in ongoing and continuous minor impacts on birds that can have a large cumulative effect as bird habitat is being altered by residential and commercial development, hundreds of thousands of people visiting coastal beaches, myriads of watercraft (more so in summer months than winter) traversing the ocean and resources being harvested from the ocean. The range of anthropogenic causes of bird mortality is broad and is primarily the result of collisions with man-made structures that include: cars, trains, and airplanes; buildings and windows; high tension wires; communication towers; and wind turbines. Other non-collision causes of bird mortality include cat predation, pesticides, oil spills, fishing by-catch, and electrocutions. Annual bird mortality from anthropogenic sources may easily approach 1 billion birds a year in the U.S. alone (Erickson, et al., 2005). Erickson et al. (2005, Table 2) estimated that 28,500 birds are killed each year by wind turbines, and 550,000,000 in collisions with buildings and windows.

In contrast, the incremental impact of the proposed action on birds during construction and decommissioning of the project are short-duration effects that would only occur twice. Based the discussion in Section 5.3.2-4 operational impacts of the proposed action on birds with respect to habitat modification, human disturbance, and risk of collision, is expected to be moderate. Avian populations are expected to exhibit some avoidance behavior as has been documented at the Danish wind parks. Whether or not birds become habituated to marine WTGs over time is unknown at this time.

One of the avian populations of most concern is the roseate tern, and studies have shown that several areas adjacent to the proposed South Coast Offshore Wind Project in Buzzards Bay (specifically Bird Island and Ram Island) are important breeding areas for endangered roseate terns. Mortality to breeding terns at these locations in Buzzards Bay may have a significant impact on the species. Therefore, although the exact location of the South Coast Offshore Wind Project is unknown, it is reasonable to anticipate that, if constructed, it would have substantially greater impacts than the proposed action on roseate terns. Thus, while the proposed action has the potential for some cumulative impacts, future evaluation and approval of the South Coast Offshore Wind Project would need to undertake the necessary evaluations for potential impacts on the roseate tern. The incremental cumulative impact from the proposed action combined with the South Coast Offshore Wind Project on the roseate tern population could range from minor to at least moderate. Cumulative impacts to the existing predator-prey relationships in Nantucket Sound are expected to be negligible.

Future onshore development would lead to more clearing and, therefore, less avian habitat, but the incremental impacts from the proposed action would be negligible. The greatest threat to birds, in general, continues to be loss or degradation of habitat due to human development and disturbance. For migratory birds requiring multiple areas for wintering, breeding, and stopover points, the effects of habitat loss can be complex (USFWS, 2002). The greatest threats to birds would be collisions with buildings and obstructions such as communication towers and collision or electrocution by high-tension transmission lines (USFWS, 2002). On the water, bird deaths would not result from domestic or feral cats and collision hazard with marine vessels and structures built upon the water would be accentuated.

**Conclusion**

Minor long-term impacts on birds as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario, especially in comparison to accepted causes of bird losses that result from anthropogenic influences. The proposed action would result in minor to moderate cumulative impacts on roseate terns. The addition of the potential activities that are part of the cumulative scenario (i.e., the South Coast Offshore Wind Project, refer to Section 6.1.1 for details on this proposed project) has the potential to result in greater cumulative impacts to this species. Existing monitoring devices for bird mortality, such as infra-red detectors, may not uniquely identify an individual species, nor can radar monitoring uniquely identify individual species within a resources area. If individual deaths occur within these populations they may not be able to be conclusively attributed to construction or operation of the proposed action. Monitoring may provide circumstantial evidence, for example, bird carcasses on the water.

### 6.2.8 Coastal and Freshwater Wetland Resources

Activities that are part of the cumulative scenario that may impact coastal and freshwater wetland resources within the cumulative impacts study area include: (1) sand and gravel mining; (2) pipeline projects; (3) other offshore tidal, wave, or wind energy projects; (4) onshore development, and (5) the proposed action. Direct impacts from all of these activities are limited to the area in which the activity takes place.

It is highly unlikely that any sand mining projects would be permitted and approved by Massachusetts inside the state 3.5-mile (5.6 km) limit and Cape and Islands Ocean Sanctuary that would have the potential to affect coastal and freshwater wetland resources. Other offshore wind projects are expected to have similar coastal and freshwater resource impacts (as the proposed action) and implement similar mitigation measures in order to avoid or minimize any coastal or wetland resource impacts. Wetlands have been identified in the vicinity of the area of the proposed action seaward and within the state territorial limit of Nantucket Sound and Lewis Bay, and along the onshore transmission cable route. The proposed action does not directly impact freshwater wetlands.

**Conclusion**

Negligible long-term impacts on coastal and freshwater wetlands as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario.

### 6.2.9 Water Quality

Activities that are part of the cumulative scenario that may impact water quality resources within the cumulative impacts study area include: (1) other offshore tidal, wave, or wind energy projects; (2) sand and gravel mining; (3) tidal or wave energy demonstration projects; (4) small marine projects and marina development; (5) submarine cable and pipeline projects; (6) maintenance dredging and beach nourishment; (7) vessel traffic; (8) population growth and onshore development; and (9) the proposed action. All of these activities have potential for direct impacts that degrade water quality as a result of increased nutrient inputs, biological oxygen demand, and turbidity. These direct impacts occur from multiple and mobile point sources, are spatially dispersed, and range from temporary to semi-permanent.

Oil and grease can enter the water from vessel discharges, machinery sumps, deck wash, and bilge discharges. Accidental diesel fuel spills and spills of fluids in the nacelles of the WTGs and spills on the Electrical Service Platform. Increased turbidity and biological oxygen demand can result from dredging or sand mining operations that disturb the bottom to re-suspend sediment and organic matter. Increased marina activity as well as population growth and onshore development could result in more storm and septic system runoff that may have enriched nutrient contents. In addition to these non-point sources, vessel traffic from marine construction projects or pipelines and more fishing or pleasure boats on the water increase the likelihood that deficient, poorly maintained, or out of compliance waste treatment systems could leak untreated human waste or biodegradable materials. The cumulative impact can include: degraded water quality, odors, floating debris, poor underwater visibility, and beach closings from higher bacterial counts on popular beaches.

Potential marine water quality impacts from the proposed action would be limited to sediment disturbance along the cable corridors and at monopile locations from construction vessel anchoring, anchor line sweep, and installation of the scour protection, foundation and cables. Potential impacts to water quality associated with construction and operation of the proposed action and the submarine cable system across Lewis Bay and within Nantucket Sound would be short-term and localized. Further, water quality impacts related to sediment disturbance from installation would be comparable to disturbance already occurring within Nantucket Sound from natural events and fishing gear (see Section 5.3.1.6).

**Conclusion**

Minor long-term impacts on water quality are expected as a result of the proposed action and the activities described above that are part of the cumulative scenario (i.e., other offshore renewable energy projects, sand and gravel mining, small marine projects, etcetera). Direct impacts, such as increased turbidity as a result of monopole emplacement or decommissioning and removal are temporary and distributed among 130 monopile sites. The operation of onboard waste treatment systems can help to minimize water quality impacts (for further information on mitigation, refer to Section 9.0).

### 6.2.10 Visual Impacts

Activities that are part of the cumulative scenario that may affect visual resources within the cumulative impacts study area include: (1) other offshore tidal, wave, or wind energy projects; (2) onshore wind projects; (3) increased vessel traffic; (4) onshore development; and (5) the proposed action. Direct impacts result from the presence of offshore infrastructure that can be seen from shore. Direct impacts can be temporary as vessels come and go, short-term as construction vessels temporarily anchor for monopile construction or removal, and continuously over the operating lifetimes of renewable energy projects located offshore or on land.

Visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures would affect historic properties, tribal areas of traditional cultural and religious importance, and recreational areas (see Section 5.3.3.4). However, at this time the only other large scale wind farm proposed, the South Coast Offshore Wind Project, would be located in Buzzards Bay more than 17 miles (27.4 km) north and separated from the proposed action area by the Elizabethan Islands. Thus, most areas that have a view of the proposed action would not likely have a view of the South Coast Offshore Wind Project. No information is available at this time about whether the Cape and Islands Tidal Energy Project would require the installation of above water moorings or structures that could cause visual impact. The above discussion also applies to the historic properties and tribal areas of traditional cultural and religious importance analyses discussed in Section 5 in that there are unlikely to be significant cumulative visual impacts on historic structures or tribal areas from those other projects known to be proposed at this time (i.e., South Coast Offshore Wind Project and Cape and Islands Tidal Energy Project).

Within the cumulative impact study area, no other activity in the cumulative scenario other than the proposed action or onshore wind projects includes activity that has more than a temporary presence on Horseshoe Shoal. Construction or decommissioning vessels will be seen as monopiles are installed or removed and WTGs will be visible from land and on the water over the operating lifetime of the project.

**Conclusion**

Moderate long-term visual effects are expected as a result of the proposed action and the activities that are part of the cumulative scenario. Perceptions of visual effects are highly subjective. Some people believe that WTGs on the water are relatively unobtrusive, while others believe that WTGs represent an unwelcome presence by intruding on a vista with comparatively little man-made infrastructure upon it.

### 6.2.11 Cultural Resources

Activities that are part of the cumulative scenario within the cumulative impacts study area that may impact prehistoric and historic cultural resources, and areas of traditional cultural and religious importance to local Indian tribes include: (1) sand mining; (2) other offshore tidal, wave, or wind energy projects; (3) submarine pipeline or cable projects; (4) onshore wind projects; (5) onshore development; (6) small marine projects; and (7) the proposed action.

Sand mining is an extractive process that could have physical effects on submerged historic and prehistoric (i.e., ancestral Tribal) resources that include ground disturbance, disruption of important contextual relationships, or destruction of the resource itself. The MMS requires that any submerged land approved for sand and gravel mining be assessed for cultural resources prior to the start of any mining activities. The authorities responsible for tidal, wave, or wind energy projects (MMS on the OCS), or pipeline or submarine cable projects have similar requirements stemming from the National Historical Preservation Act.

Similar to the proposed action, sand and gravel activities would be sited and designed to avoid adverse impacts on cultural resources. Based on results of the terrestrial archaeological intensive survey, no significant prehistoric or historic archaeological resources have been identified within the Project's APE for ground disturbance along the onshore transmission line route (see Section 5.3.3.5). The proposed action has been sited and designed to avoid disturbance or destruction of submerged prehistoric and historic resources. An archaeological survey has been carried out over the footprint of the proposed action and cable route and has been reviewed by MMS.

**Conclusion**

Negligible long-term impacts on cultural or archaeological resources are expected as a result of the proposed action and the activities that are part of the cumulative scenario (with the exception of visual impacts on historic properties and Tribal areas of traditional cultural and religious importance, which will be evaluated pending Section 106 review).

### 6.2.12 Recreational Resources

Activities that are part of the cumulative scenario that may impact recreational resources, such as beach-centric activity, touring, birding, and recreational fishing, boating or diving, within the cumulative impacts study area include: (1) sand mining; (2) other offshore tidal, wave, or wind energy projects; (3) submarine pipeline or cable projects; (4) onshore wind projects; (5) onshore development; (6) small marine projects; and (7) the proposed action.

Increased vessel traffic from these various projects, to the extent they occur concurrently, could cause some marine traffic and temporarily affect recreational boating. Offshore construction of more than one project at the same time could require temporary access restrictions to recreational boaters of small areas in the immediate vicinity of the construction work, for example in deepwater areas of the Gulf of Mexico The USCG typically assigns a 1,000 ft safety zone around producing platforms. While the proposed action would have visual impacts, they are not expected to affect tourism or the general use and enjoyment of recreational areas including beaches, parks, and use of Nantucket Sound (see Section 4.3.4). The proposed action has been sited and designed to avoid recreational disturbance to the extent possible. Furthermore, sand mining, onshore wind projects, other offshore tidal, wave, and wind energy projects, pipeline, and cable projects would also be sited and designed to avoid or minimize potential recreational impacts according to permit requirements of the various applicable regulatory agencies.

**Conclusion**

Minor long-term impacts on recreational resources are expected as a result of the proposed action and the activities that are part of the cumulative scenario since the proposed action does not preclude any existing recreation and only creates a minor change in the navigation scenario for recreational boaters.

### 6.2.13 Noise

Activities that are part of the cumulative scenario that may impact above or below-water noise level within the cumulative impacts study area include: (1) vessel traffic; (2) vessel traffic and construction activity for the South Coast Offshore Wind Project, the Cape and Islands Tidal Energy Project; (3) sand and gravel mining; (3) dredging; (4) other marine construction activity such as beach nourishment, submarine pipeline or cable construction, or small marine projects; and (5) the proposed action. Direct impacts would involve hearing damage, annoyance, or change in behavior patterns as a result of noise above or below water.

Direct impacts caused by underwater noise could cause short to medium-term habitat displacement if marine mammals or sea turtles avoid the wind park area during construction, either as a result of underwater noise or otherwise. However, given the low densities of marine mammals and sea turtles within the proposed action area where the potential for vessel strikes, acoustic and other types of harassment and habitat displacement are greatest, impacts to sea turtles and marine mammals are expected to be minimal. The Danes monitored behaviors in the resident marine mammal populations during and following construction at the wind parks at Horns Rev and Nysted. At Horns Rev porpoises showed a weak negative effect (avoidance) during the construction period as a whole and a strong, but short lived reaction (absence), to monopile driving operations (Danish Energy Authority, 2006, p. 90). At Nysted porpoises showed a strong negative reaction (absence) during the construction phase (emplacing gravity caissons). Porpoise avoidance of the area around Nysted has occurred over the first two years of operation of this wind park and was unexpected (Danish Energy Authority, 2006, p. 91). During construction there was a fall off in the number of harbor seals at haul out sites during pile driving operations at Horns Rev and no significant effects on seal use of the Nysted area (Danish Energy Authority, 2006, p. 90).

It is expected that similar construction vessel noise from mining and channel maintenance vessels would be comparable to normal vessel traffic existing within Nantucket Sound. Mining equipment noise associated with offshore sand mining projects is likely to have sound levels above and below water that is less than the pile driving sounds from the construction of the proposed action. The South Coast Offshore Wind Project is expected to have similar noise impacts during construction and decommissioning as the proposed action, though it is located 17 miles (27.4 km) away and would not likely result in cumulative noise impacts. Operation of the South Coast Offshore Wind Project could also create low intensity noise above water or vibrations below water.

The sound impacts of construction of the proposed action would be temporary and are associated with the installation of the monopiles, installation of six smaller diameter piles for the ESP, and vessel traffic for transporting equipment, piles, and workers to and from the site. The jet plow embedment process for laying submarine power cables with a cable barge produces no sound beyond typical vessel traffic in Nantucket Sound. Therefore, the principal sound from construction would be temporary pile driving of the WTG monopiles. There would be no significant underwater sound from the proposed action beyond the general area of the WTG array. Project construction and decommissioning is expected to have minor noise impacts. Operating wind turbines would not be heard from shore, but they would be audible to boaters in proximity to them and marine mammals are likely to sense vibrations from the WTGs underwater.

**Conclusion**

Minor long-term impacts on above- or below-water noise are expected as a result of the proposed action and the activities that are part of the cumulative scenario.

### 6.2.14 Transportation and Navigation

Activities that are part of the cumulative scenario that may impact transportation and navigation within the cumulative impact study area include: (1) sand and gravel mining; (2) channel maintenance; (3) submarine pipeline or cable projects; (4) other offshore tidal, wave, or wind energy projects; (5) commercial fishing activities; (6) vessel traffic, and (7) the proposed action.

For example, impacts associated with sand mining projects would only be short-term and temporary during the time of mining activities. It would be expected that any approved mining activities would not occur in authorized shipping channels. If projects were constructed at the same time, they could result in minor cumulative impacts on navigation, namely a degree of increased congestion. For example, to the extent the South Coast Offshore Wind Project, the Cape and Islands Tidal Energy Project, sand mining projects and other projects were to occur at the same time, construction vessels may have to share navigational channels. However, such contractors would follow required safe vessel navigational practices and channel widths and water depths in these areas allow for ample room for navigation. There would be minimal temporary impacts to navigation in the immediate vicinity of ongoing construction of the proposed action. Any restrictions that are necessary during construction to protect the safety of mariners would be implemented in coordination with the USCG. Details of the marine-based construction would be closely coordinated with the USCG and local Harbor Pilots. However, in the instance of navigation safety relative to the operation of radar within the WTG array once constructed, the USCG sponsored radar impact study (see Appendix M) found that navigation safety impacts are moderate, and additional mitigation has been developed (see Section 9.0). This level of impact on navigation safety occurs regardless of what other types of projects are assessed in a cumulative manner with the proposed action, but because other activities would occur outside of the WTG array, they are unlikely to further exacerbate navigation safety impacts.

**Conclusion**

Minor long-term impacts on airborne, marine transportation or navigation activities are expected as a result of the proposed action and the activities that are part of the cumulative scenario. WTG lighting and audible proximity warnings provide adequate surface identification of the location of the wind park structures. Adequate lighting of commercial and pleasure vessels are a Coast Guard requirement. The proposed action would not be located in aircraft ascent/decent corridors and its presence would not interfere with military radar. However, in the instance of navigation safety relative to the operation of radar within the WTG array once constructed, the navigation safety impacts are moderate, and additional mitigation has been developed (see Section 9.0 and the December 30, 2008 findings of the USCG in Appendix M).

### 6.2.15 Electrical and Magnetic Fields

Activities that are part of the cumulative scenario that may impact electrical and magnetic fields within the cumulative impacts study area include: (1) submarine electrical cable installation; (2) other offshore tidal, wave, or wind energy projects requiring electrical cable connections, and (3) the proposed action. A direct impact would be demonstrable link between electromagnetic field strength and a detrimental effect on fish or benthic communities. Direct impacts are limited to behavior changes when in proximity to, or when crossing over, an electromagnetic field from a buried submarine electrical cable that may or may not be correlative with harmful effects or distress.

There are no existing sources of power frequency fields present in the offshore area of the proposed action or underground cables that are proposed near the site other than the proposed action. Electric cables for the South Coast Offshore Project and the Cape and Islands Tidal Energy Project would be 17 and 10 miles (27.4 and 16.1 km) away from the area of the proposed action, respectively, and would not interact with electric or magnetic fields from the proposed action. The addition of the onshore transmission line would not change the existing electric field levels. The new underground transmission line electric fields within the ROW are anticipated to be approximately the same as the existing condition, which is due to the presence of the overhead 115 kV lines. The predominant fields within the existing NSTAR ROW are those generated by the existing overhead lines, whose loading under this interconnection option is not changed by the addition of the proposed action. The predicted impact of adding the underground transmission lines is a negligible change from existing conditions within the ROW and no change in field strength at the ROW edges. The proposed submarine cable system for the transmission line would create no perceptible electric field. Therefore, impacts on humans and marine life from electric and magnetic fields would be negligible. The proposed action would not produce or add to any electric-field exposures in offshore waters or onshore; and any localized affect of magnetic fields is weak and localized to the immediate area around the cables.

The investigation performed at Nysted to detect any effects from the electromagnetic fields on migration and behavior of fish were characterized by a high degree of complexity and many challenges and difficulties in collecting and interpreting the data. The investigations along the cable route show some effects from the cable on fish behavior, but the analysis of these data have only shown a very limited correlation between behaviors and the strength of the electromagnetic field (Danish Energy Authority, 2006, p. 76). In the study above, observed fish behaviors appear to indicate that some types are able to detect electromagnetic fields from buried cables, but it is not indicative that electromagnetic fields cause deleterious effects or biologic damage to the fish.

**Conclusion**

Negligible long-term impacts on electrical and magnetic fields as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario. There may be a demonstrable effect between electromagnetic field strength and fish behavior for certain bottom oriented fish, but such behavior cannot be shown to be detrimental to the individual or interfere with life activities.

### 6.2.16 Telecommunication Systems

Activities that are part of the cumulative scenario that may impact telecommunication systems within the cumulative impacts study area include: (1) other offshore tidal, wave, or wind energy projects; and (2) vessel traffic such as effects to sea-borne radio communications on marine vessels, and aircraft communications; and (3) the proposed action. A direct impact would be a demonstrable link between the proposed action or other offshore wind parks and interference or degradation of communication signals for existing and necessary means of communications on land, air, or water.

Most telecommunication devices operate on a line-of-sight basis; therefore only large physical obstructions can impede the transmission line-of-sight signals. These large physical obstructions could include multi-story buildings, wind turbines, communication towers, etc. Existing and proposed land based FCC licensed communications towers have been evaluated and were determined not to negatively impact these communication systems. Future projects, such as the South Coast Offshore Energy Project would also be required to obtain FAA approval to ensure they would not interfere with radar communications and to also ensure that they do not interfere with other forms of communications.

**Conclusion**

Minor long-term impacts on telecommunications systems are expected as a result of the proposed action and the activities that are part of the cumulative scenario.

### 6.2.17 Air and Climate

Activities that are part of the cumulative scenario that may impact air quality or climate within the cumulative impacts study area include: (1) vessel traffic such as commercial and recreational marine vessel emissions, air traffic emissions, personal and commercial vehicle emissions, construction equipment emissions; (2) population growth and onshore development such as power generation, industrial processing; and (3) emissions from the activities of sand and gravel mining, submarine pipeline and cable emplacement, onshore renewable energy facilities, other offshore tidal, wave, or wind energy projects, small marine projects, channel dredging, beach nourishment, and marina development; and (4) the proposed action. Direct impacts constitute the emission of $NO_x$, $SO_x$, VOCs, particulate matter, and $CO_2$. All of the activities in the cumulative scenario produce incremental emission because all activities rely on the combustion of fossil fuels in one form or another. Indirect impacts would include the results of the build-up of air emissions over time, or displacement in time or space for impacts based on these emissions.

The turning of the WTG rotors, which react to the wind rather than create or modify it, would not affect the wind speed and/or wind direction in the waters of Nantucket Sound. Overall, the proposed action by itself would have a minor positive, beneficial effect on air quality by generating electricity for use in New England without producing emissions from the burning of fuel (see Air Benefits Analysis in Section 5.3.1.5.2). The activities associated with the construction, maintenance, and decommissioning would result in some temporary level of emissions over Nantucket Sound due to the fossil fuel fired mobile sources (e.g., material supply vessels, crew boats, cranes, pile drivers, and other powered construction equipment). However all of the vessels and equipment would comply with applicable air emission standards.

**Conclusion**

Minor long-term impacts on air quality and climatic conditions are expected as a result of the proposed action and the activities that are part of the cumulative scenario.

### 6.2.18 Socioeconomics

Activities that are part of the cumulative scenario that may impact air quality or climate within the cumulative impacts study area include: (1) sand and gravel mining; (2) other offshore tidal, wave, and wind energy projects; (3) onshore wind projects; (4) commercial fishing activities; (5) small marine projects; (6) onshore development; and (7) the proposed action. Direct impacts would be the number of jobs and paychecks attributable to all of the people directly employed who perform these activities. Indirect impacts are the multiplier effects that would result from goods and services purchased to support these activities, or the number of jobs attributable to employers that are needed to supply goods and services.

Overall, the proposed action would have a positive socioeconomic effect. During the 27-month construction and installation phase, an estimated 371 full-time positions would result from the proposed action in Massachusetts and Rhode Island. In addition to this employment benefit, IMPLAN input/output economic model predicts secondary induced employment benefit of 206 to 622 jobs in Massachusetts and 388 to 1,150 jobs in Rhode Island. While there may be some minor economic losses should commercial fisherman find they are unable to fish some areas of Horseshoe Shoal during construction, recreational fishing and related spending would likely increase and become an economic benefit. The proposed action's incremental cumulative impact on socioeconomics relative to the other projects mentioned would be minor.

If environmental monitoring shows that monopiles that have been colonized by mussels which then serve to act as fish attracting devices, there would be a small incremental effect on commercial or recreational fishers who direct some of their activity to the areas around monopiles. Monitoring at Horns Rev and Nysted has not convincingly established that fish are attracted to the hard substrate benthic invertebrate community that formed on WTG foundations (Danish Energy Authority, 2006, p. 77).

**Conclusion**

Minor long-term impacts on socioeconomic resources as a whole are expected as a result of the proposed action and the activities that are part of the cumulative scenario.

## 6.3 CUMULATIVE IMPACT ASSESSMENT OF ALTERNATIVES

In addition to assessing the potential cumulative impacts of the proposed action relative to other potential activities and developments that might occur in the cumulative study area, a cumulative impact assessment has been undertaken of the alternatives to the proposed action. The following subsections provide cumulative impact discussion of the alternatives that have been studied in detail in this FEIS in a comparative manner with the proposed action.

### 6.3.1 Monomoy Shoals Alternative

Assessing cumulative impacts of the Monomoy Shoals Alternative takes into account all past, present, and reasonably foreseeable future actions that will or may occur in the cumulative impact study area. The cumulative impact study area described above in the introduction, encompasses the proposed action and the Monomoy Shoals Alternative. As a result, the location of the Monomoy Shoals Alternative within the study area suggests that the impacts described in Section 6 for the proposed action, would be similar in a geographic and temporal sense as for the Monomoy Shoals Alternative. This assumption is based upon the similarity between the proposed action and the Monomoy Shoals Alternative in facility design, construction methodology, service area, installation timing, environmental effects and geographic proximity. Should the Monomoy Shoals Alternative be selected, it is not anticipated that in the aggregate, the cumulative effects, as described in Section 6.2, would be significantly different than that for the proposed action.

Although cumulative impacts are generally expected to be similar overall between the Monomoy Shoals Alternative and the proposed action as described above, there are likely some specific cumulative impacts that may differ depending on the particular resource in question. The alternatives analysis at Section 5.4.2.2 shows that the Monomoy Shoals Alternative would have greater environmental impacts than the proposed action with respect to avifauna, subtidal resources, non-ESA mammals, fish and fisheries, essential fish habitat, and T&E species, and have less impact than the proposed action with respect to impacts on visual resources and impacts to cultural resources as they relate to visual impacts on historic structures. These differences in environmental impacts are likely to result in similar corresponding differences in cumulative impacts between the Monomoy Shoals Alternative and the proposed action. Another important issue with the Monomoy Shoals Alternative site is that it is located adjacent to the northwestern extent of a designated Northern Right Whale Critical Habitat, and thus within the context of other activities that have the potential to impact whales, such as commercial shipping, there is a greater potential for cumulative environmental impacts to whales than at the area of the proposed action. Another important difference between Monomoy Shoals Alternative and the proposed action is that the Monomoy Shoals Alternative is in close proximity to Monomoy Island, which provides important resting, nesting and feeding habitat for migratory birds, and thus there would be greater potential for cumulative environmental impacts than the proposed action with respect to terrestrial, coastal, and marine birds as well as T&E avian species. With respect to subtidal offshore resources, cumulative impacts from construction and decommissioning would be greater at the Monomoy Shoals Alternative because of the additional interconnection line length resulting in more acreage of temporary bottom disturbance associated with installation, and the greater wave heights, which would tend to prolong the construction time frame.

### 6.3.2 South of Tuckernuck Island Alternative

Assessing cumulative impacts of the South of Tuckernuck Island Alternative takes into account all past, present, and reasonably foreseeable future actions that will or may occur in the cumulative impact study area. The cumulative impact study area described above in the introduction encompasses the proposed action and the South of Tuckernuck Island Alternative. As a result, the location of the South of Tuckernuck Island Alternative within the study area suggests that the impacts described in Section 6 for the proposed action, would be similar in a geographic and temporal sense as for the South of Tuckernuck Island Alternative. This assumption is based upon the similarity between the proposed action and the South of Tuckernuck Island Alternative in facility design, construction methodology, service area, installation timing, environmental effects and geographic proximity. Should the South of Tuckernuck

Island Alternative be selected, it is not anticipated that in the aggregate, the cumulative effects, as described in Section 6.2, would be significantly different than that for the proposed action.

Although cumulative impacts are generally expected to be similar overall between the South of Tuckernuck Island Alternative and the proposed action as described above, there are likely some specific cumulative impacts that may differ depending on the particular resource in question. Section 5.4.1.2 of the alternative analysis shows that the South of Tuckernuck Island Alternative would have greater impact than the proposed action with respect to avifauna, subtidal resources, non-ESA mammals, fish and fisheries, and essential fish habitat, and less than the proposed action with respect to impacts on visual resources. These differences in environmental impacts are likely to result in similar corresponding differences in cumulative impacts between the South of Tuckernuck Island Alternative and the proposed action.

One difference that exists with respect to cumulative impacts is on avifauna. The South of Tuckernuck Island Alternative would have a greater potential for cumulative impacts to terrestrial, coastal, and marine birds than the proposed action, because of the increased area in which the turbines would be located (the South of Tuckernuck Island Alternative would require an area of approximately 36 $mi^2$ (93.2 $km^2$) versus the area of the proposed action, which is 25 $mi^2$ (64.7 $km^2$). The larger area of disturbance increases the potential for avian impacts, and thus to the extent other construction projects affect avian impacts in the area, the South of Tuckernuck Island Alternative would contribute more toward cumulative impacts than the proposed action. Another cumulative impact that would be greater is with respect to subtidal resources as the South of Tuckernuck Island Alternative would be constructed in deeper water and contribute more toward cumulative impacts of benthic habitat (as a result of larger foundation sizes and related alteration of the seafloor) than the proposed action.

### 6.3.3 Condensed Array Alternative

Assessing cumulative impacts of the Condensed Array Alternative takes into account all past, present, and reasonably foreseeable future actions that will or may occur in the cumulative impact study area. The cumulative impact study area described in the introduction above encompasses the proposed action and the Condensed Array Alternative. As a result, the location of the Condensed Array Alternative within the study area suggests that the impacts described in Section 6.2 for the proposed action, would be similar in a geographic and temporal sense as for the Condensed Array Alternative. This assumption is based upon the similarity between the proposed action and the Condensed Array Alternative in facility design, construction methodology, service area, installation timing, environmental effects and geographic proximity. Should the Condensed Array Alternative be selected, it is not anticipated that in the aggregate, the cumulative effects, as described in Section 6.2, would be significantly different than that for the proposed action.

Although cumulative impacts are generally expected to be similar overall between the Condensed Array Alternative and the proposed action as described above, there are likely some specific cumulative impacts that may differ depending on the particular resource in question. Section 5.4.5.2 of the alternative analysis shows that the Condensed Array Alternative would have greater impacts than the proposed action with respect to the competing uses resource category (i.e., commercial and recreational fishing and boating, mining, etc.) during construction, operation, and decommissioning, and less impact during construction for eight resource categories: noise, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species. These differences in environmental impacts are likely to result in the similar corresponding differences in cumulative impacts between the Condensed Array Alternative and the proposed action. One difference that exists with respect to cumulative impacts is that the Condensed Array Alternative may further exacerbate radar impacts and increase navigation safety concerns, since the side lobes created by the WTGs may cover a greater percentage of the area within the array under the

Condensed Array Alternave. Another difference would be the decrease in length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts during construction and decommissioning to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 $km^2$). The decrease in length of the 33 kV cable would also decrease temporary impacts to fish and fisheries, and EFH as a result of decreased area of turbidity and disturbed sea bottom. Therefore to the extent other projects occur at the same time or near the same location, the Condensed Array Alternative would contribute less toward cumulative impacts on these resources than the proposed action. Cumulative impacts to T&E species would also be slightly less than for the proposed action as the shorter construction timeframe for the 33 kV cable would result in less disturbance to T&E avian species that could be in the vicinity. The tendency for birds to avoid a wind park as a unit, as documented by radar-tacking at the Danish wind parks, may be enhanced by a denser WTG array (Danish Energy Authority, 2006, p. 102-103).

### 6.3.4 Phased Development Alternative

Assessing cumulative impacts of the Phased Development Alternative takes into account all past, present, and reasonably foreseeable future actions that will or may occur in the cumulative impact study area. The cumulative impact study area described in the introduction above encompasses the proposed action and the Phased Development Alternative. As a result, the location of the Phased Development Alternative within the study area suggests that the impacts described in Section 6.2 for the proposed action, would be similar in a geographic and temporal sense as for the Phased Development Alternative. This assumption is based upon the similarity between the proposed action and the Phased Development Alternative in facility design, construction methodology, service area, installation timing, environmental effects and geographic proximity. Should the Phased Development Alternative be selected, it is not anticipated that in the aggregate the cumulative effects, as described in Section 6.2, would be significantly different than that for the proposed action.

Although cumulative impacts are generally expected to be similar overall between the Phased Development Alternative and the proposed action as described above, there is the potential that some specific cumulative impacts that may differ depending on the particular resource in question. Section 5.4.4.2 of the alternative analysis shows that the Phase Development Alternative would have greater impact during construction and decommissioning than the proposed action for 10 of 28 resource categories (air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, and recreation and tourism). These differences in environmental impacts are likely to result in similar corresponding differences in cumulative impacts between the Phased Development Alternative and the proposed action. One difference is with respect to cumulative impacts on avifauna. Avifauna impacts would be greater for the Phased Development alternative than for the proposed action because of the longer timeframes of the additional mobilizations and demobilizations of major construction vessels for pile driving and WTG installation/decommissioning related to each distinct phase. There may be additional benefits, based upon assessment of impacts and mitigation strategies between phases, which cannot currently be anticipated. The total number of vessels required to complete the construction and decommissioning would also be greater than required for the proposed action, increasing potential impacts. The longer duration of the phased construction work would result in greater chance of cumulative impacts to avifauna with other ocean related construction projects. For this same reason the longer construction time frame would also increase the chances of additional cumulative impacts to subtidal resources, marine mammals, and fishery resources.

### 6.3.5 Smaller Project Alternative

Assessing cumulative impacts of the Smaller Project Alternative takes into account all past, present, and reasonably foreseeable future actions that will or may occur in the cumulative impact study area. The cumulative impact study area described in the introduction above encompasses the proposed action and the Smaller Project Alternative. As a result, the location of the Smaller Project Alternative within the study area suggests that the impacts described in Section 6.2 for the proposed action, would be similar in a geographic and temporal sense as for the Smaller Project Alternative. This assumption is based upon the similarity between the proposed action and the Smaller Project Alternative in facility design, construction methodology, service area, installation timing, environmental effects and geographic proximity. Should the Smaller Project Alternative be selected, it is not anticipated that in the aggregate the cumulative effects, as described in Section 6.2, would be significantly different than that for the proposed action.

Although cumulative impacts are generally expected to be similar overall between the Smaller Project Alternative and the proposed action as described above, there are likely some specific cumulative impacts that may differ depending on the particular resource in question. Section 5.4.3.2 shows that the Smaller Project Alternative has less impact than the proposed action in 13 resource categories including: noise, air quality, water quality, avifauna, subtidal offshore resources, non-T&E marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, cultural resources (as they relate to visual impacts on historic structures) competing uses of waters and sea bed, and port facilities. These smaller impacts are likely to result in corresponding smaller cumulative impacts. One notable difference in cumulative impacts would be with respect to benthic impacts, which would be reduced by half (an area roughly proportional to the reduction in the number of WTGs). Thus to the extent other projects are taking place that could result in cumulative impacts, the contribution of impacts from the smaller project toward cumulative impacts would be much less. For this same reason, the difference in benthic disturbance is much smaller and results in a similar reduction in cumulative water quality impacts and cumulative fishery impacts.

### 6.3.6 No Action Alternative

Assessing cumulative impacts of the No Action Alternative includes analysis of past, present, and reasonably foreseeable future actions that will continue or may occur in the cumulative impact study area of the proposed action. Cumulative impacts associated with adopting this alternative instead of the proposed action would be derived from the absence of an alternative energy source to contribute to the Massachusetts RPS. The extent and degree of impact would be measured by how the loss of energy anticipated by the proposed action would be replaced by other renewable and/or non-renewable sources, and the cumulative impact of those energy sources. The continuation of the development of new non-renewable energy producing facilities would be more likely due to the lack of technology to produce renewable energy other than wind at the scale proposed.

If this energy is replaced by non-renewable sources (fossil fuel), cumulative impacts would be the sum total of the difference between energy facility development in a future that includes the proposed action, and one that does not. That is, the total projected facility development that would occur along with and including the proposed action, compared to the incremental increase of facility development due to the proposed action not being developed. The Massachusetts Energy Facilities Siting Board has indicated an increasing need for energy in the New England area over the project lifespan of the proposed action. The Independent System Operator, New England 2005 Regional System Plan found that New England needed to supply its own resources to minimize its dependence on neighboring systems throughout the planning period (2009-13). Therefore, it is concluded that this demand will have to be met by the development of some type of energy production facility in the New England area.

The cumulative effect of the No Action Alternative on physical, biological, socioeconomic and human resources would be apportioned to the number and kind of facilities that would be developed to replace the loss of the proposed action’s 454 MW of electricity. Impacts from new facility operation attributed to no action taken on the proposed project would be an increase of air emissions to those from existing sources that affect air quality; an increased demand for cooling water with the potential to contribute to water quality impacts in surrounding water bodies with associated environmental degradation; plots of land or sea bed upon which facilities are built that cause inaccessibility for competing uses, and an expansion in the adverse socioeconomic impact zone from the placement of a variety of fossil fuel (natural gas, oil, coal) or nuclear facilities at multiple locations that may or may not be in proximity to the cumulative impact study area. An extensive analysis of impacts associated with the No Action Alternative is included in Section 5.4.6.2.

# 7.0 CONSULTATION AND COORDINATION

## 7.1 PUBLIC REVIEW OF DEIS

On January 18, 2008, the Minerals Management Service published a notice in the Federal Register stating the availability of the Draft Environmental Impact Statement. Copies of the DEIS were available for download from the MMS website, by request from the MMS, and, in an initial mailing to agencies, public libraries and some public officials. A similar process has occurred for the FEIS, with the initial mailing list for the FEIS included in Appendix K. The public comment period was initially noticed as lasting 60 days (until March 20, 2008) but then was extended another 30 days to April 21, 2008, in order to provide the public with additional time to read the DEIS and comment. MMS received comments through its public connect website on its Web page at http://ocsconnect.mms.gov/pcs-public/, via emails, via oral or hard copy comments provided at the four public hearings (i.e., the Mattacheese Middle School in West Yarmouth, Massachusetts, the Nantucket High School, in Nantucket, Massachusetts, the Martha's Vineyard Regional High School, in Oak Bluffs, Massachusetts, and at the University of Massachusetts Boston Campus, in South Boston, Massachusetts), and via hard copy comments mailed in. In all, more than 42,000 comment document submittals were received. All comment documents received were logged and addressed as appropriate and are included on a CD in this Final Environmental Impact Statement (see Appendix L). Appendix L also provides a description of the process employed in reviewing comment documents, how individual comments were identified and organized, and how comment responses were prepared. In essence, comments were categorized and summarized into topics that ranged from procedural, regulatory, or policy, to specific resources such as water quality, benthos, or birds. Lastly, Appendix L includes the responses to these summarized comment topics.

### 7.1.1 Summary of Comments Received

Comments received on the draft EIS generally fell within the following topic categories:

- Regulatory Process
- Alternatives Analysis
- Construction, Operations, Decommissioning
- Geology and Sediments
- Oceanography
- Water Quality
- Air and Climate
- Noise
- Electric Magnetic Fields
- Avian and Bat Resources
- Freshwater and Coastal Wetlands
- Wildlife
- Fisheries – Socio-economic Impacts to Commercial and Recreational Fishing
- Fisheries – Environmental Impacts
- Benthos and Eelgrass

- T&E Species
- Socioeconomics
- Navigation and Transportation
- Communications
- Cultural Resources

  Aesthetic/Landscape/Visual
- Transmission Interconnection

As provided in Appendix L, for most of these topics, in order to capture the breadth and variety of comments, subtopic categories were developed, such that well over 100 sub-topic categories were developed, summarized, and responses prepared.

## 7.2 REQUIRED AGENCY CONSULTATIONS

Cooperating Agency meetings were held in Boston, Massachusetts on November 2, 2005; June 27, 2006; February 28, 2007; and July 24, 2008. Consultation correspondence is provided in Appendix B and a list of agencies consulted is provided in Table 7.2-1. The following is summary information about each agency consulted and its jurisdiction.

**Consultation with Advisory Council on Historic Preservation (ACHP) (Section 106 of the NHPA, as Amended Through 2000)**

Section 106 of the NHPA of 1966, as amended through 2000, requires that Federal agencies consider the effects of their undertakings (as defined in 36 CFR § 800.16(y)) on properties included in or eligible for inclusion in the NRHP (known as historic properties per 36 CFR Part 800. The MMS would fulfill the requirements set forth in the NHPA, including consultation with the SHPO in accordance with the implementing regulations.

An undertaking has an effect on a historic property when that undertaking has the potential to alter the characteristics of the property that qualified the property for inclusion in the NRHP. Effects can include physical disturbance, noise, or visual effects. If an adverse effect on historic properties is found, the MMS would notify the ACHP, consult with the SHPO, and encourage the applicant to avoid, minimize or mitigate the adverse effect(s). Ground-disturbing activities associated with construction, as well as visual effects of the aboveground WTGs, are subject to Section 106 review.

The regulations at 36 CFR Part 800 require the identification of historic properties in the project's Area of Potential Effect. This process has been completed along the proposed onshore transmission route; submarine cable system located within state waters, and is currently under review for those portions of the proposed action located in Federal waters. Studies included development of a predictive model for the presence of potentially significant submerged archaeological resources, which may exist in the offshore portions of the proposed action area and a marine reconnaissance archaeological survey, as requested by the cooperating state agency MHC (which includes the SHPO and State Archaeologist) and also the MBUAR. Historic properties within the viewshed of the wind turbine array have been identified on Cape Cod, Nantucket and Martha's Vineyard. Visual simulations of the built turbine array from representative locations have been completed (see Section 5.3.3.4.2 for more details).

In June 2008 MMS initiated formal consultation under Section 106. In order to further understand Section 106 issues of concern and address these impacts to the extent possible, MMS has consulted with the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officers of the federally recognized Wampanoag tribes of Mashpee and Aquinnah, the Martha's Vineyard Commission, the ACOE, the Alliance to Protect Nantucket Sound, and the National Trust for Historic Preservation. Consultations included a meeting in Boston on July 23, 2008, and September 8 and 9, 2008 in which the above referenced parties were invited to discuss concerns to help inform the final EIS and resolve Section 106 impacts if possible. MMS is not utilizing 36 CFR 800.8 for conducting formal consultations under Section 106 concurrently with NEPA, but rather is pursuing the consultation independent of the EIS.

**Consultation and Coordination with Indian Tribal Governments (i.e., Mashpee Wampanoag Tribe and Wampanoag Tribe of Aquinnah) Executive Order 13175 (Applicable Regulatory Agency: Lead NEPA Agency i.e., MMS)**

The MMS works on a government-to-government basis with Native American Tribes. As a part of the government's Treaty and Trust responsibilities, the government-to-government relationship was formally recognized by the Federal government on November 6, 2000.

The MMS has formally met at the headquarters of the Wampanoag Tribe of Aquinnah on July 26th and the Mashpee Wampanoag Tribe in July 27th of 2006. MMS also met with the Mashpee Wampanoag Tribe and Wampanoag Tribe of Aquinnah on July 25th and 26th of 2007, respectively. Consultation included explanation of the proposed action and its potential impacts on tribal government and understanding of tribal concerns. Comments made by the tribal groups are addressed in this final EIS. Impacts on tribal governments are discussed under the Environmental Justice and Cultural section of this final EIS (Section 5.3.3.5). The referenced tribes were also invited to attend meetings with MMS and other agencies to discuss Section 106 concerns (see Section 106 consultation summary above).

**Consultation with NOAA (NOAA Fisheries) (Fish and Wildlife Coordination Act; 16 U.S.C. 1801-1882 - Magnuson-Stevens Fishery Conservation and Management Act of 1976; 16 U.S.C. 1531-1543; Pub. L. 93-205, as amended - Endangered Species Act of 1973; and 16 U.S.C. 1361-1421; Pub. L. 92-522, as amended; reauthorized in 1994 (Pub. L. 103-238) - Marine Mammal Protection Act of 1972**

NOAA Fisheries (formerly NMFS) is a division of the Department of Commerce and is responsible for the management, conservation and protection of living marine resources within the United States' Exclusive Economic Zone (water 3 to 200 miles [5.6 to 370.4 km] offshore). It also has regulatory review and responsibilities for the management and protection of EFH as well as responsibilities under the Endangered Species Act and the Marine Mammal Protection Act.

NOAA Fisheries is responsible for providing an assessment of the likelihood to cause adverse impacts on species or habitats under their jurisdiction. They can also provide recommendations to the Federal agency for mitigation actions to reduce or compensate for proposed action impacts, or can recommend that the Federal agency deny the permit. For the Project, NOAA Fisheries review falls into four categories: fish and wildlife species and habitats regulated under the Fish and Wildlife Coordination Act, EFH regulated under the Magnuson-Stevens Act, marine species and habitats regulated under the Endangered Species Act, and species regulated under the Marine Mammal Protection Act.

MMS initiated the EFH consultation process with NOAA-Fisheries in a letter dated January 22, 2008. NOAA-Fisheries provided its conservation recommendations in their comments on the draft EIS. MMS has been in communication with NOAA-Fisheries and has addressed their recommendations in this EIS and will incorporate these into its lease stipulations.

MMS filed a Biological Assessment in May of 2008 (see Appendix G) which initiated formal consultation under the ESA. Consultation has included individual phone calls and emails between MMS and NOAA Fisheries. NOAA has indicated that an Incidental Harassment Authorization (IHA) application will be required. The final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals, however since the authorization is only good for one year the applicant would request this authorization following issuance of the ROD. A BO was issued November 13, 2008 by NOAA Fisheries.

**Consultation with the USFWS: (Endangered Species Act, Migratory Bird Treaty Act, Fish & Wildlife Coordination Act)**

The USFWS works with landowners, private organizations, government agencies and other partners to conserve fish and wildlife resources. Through Federal action and by encouraging the establishment of state programs, the 1973 Endangered Species Act provided for the conservation of ecosystems upon which T&E species of fish, wildlife, and plants depend. The ESA authorizes the determination and listing of species as endangered and threatened; prohibits unauthorized taking, possession, sale, and transport of endangered species; provides authority to acquire land for the conservation of listed species, using land and water conservation funds; authorizes establishment of cooperative agreements and grants-in-aid to States that establish and maintain active and adequate programs for endangered and threatened wildlife and plants; authorizes the assessment of civil and criminal penalties for violating the ESA or regulations; and authorizes the payment of rewards to anyone furnishing information leading to arrest and conviction for any violation of the ESA or any regulation issued there under.

The MBTA prohibits taking any migratory bird except as permitted by regulations issued by the DOI. Another, more recent mandate regarding the conservation of migratory birds, is Executive Order (E.O.) 13186, signed January 2001, by President Clinton. This E.O. requires every Federal agency that takes action(s) likely to have a measurable negative impact on migratory birds to enter into a MOU with the USFWS, which has Federal jurisdiction over managing and conserving seabirds. The MOU should outline how an agency would promote the conservation of migratory birds. Additional obligations under E.O. 13186 include supporting other conservation efforts already underway and incorporating bird conservation into agency planning. MMS has been working with FWS to develop an MOU pursuant to this E.O. that will include mitigation measures to minimize take and promote conservation of migratory birds.

MMS began informal consultations with both the FWS (and NOAA) regarding the applicant's proposal in January 2006. This included individual phone calls and emails between MMS and USFWS/NOAA as well as the following efforts which MMS also considered part of the informal consultation and ultimately the development of the formal consultation package:

- During 2006 and 2007, MMS has regularly convened conference calls with USFWS-ESA-listed bird experts, state bird experts and private scientists (selected by the USFWS). These efforts were meant to get everyone on the same page and share expertise on: (1) information available on the proposed action as it relates to potential impacts on ESA-listed birds and (2) development of the risk assessment model and population viability analyses.
- A face-to-face meeting of these and other experts was also held on January 30, 2007 to discuss potential impacts to ESA-listed birds associated with current and conceptual offshore wind projects and identify data gaps and information needs.
- An additional face-to-face meeting was held September 13, 2007 with the same and additional individuals to discuss potential mitigation and monitoring activities that may possibly be built into the proposed action for the ESA consultation on the applicant's proposal.

MMS filed its BA in May of 2008 and has completed formal consultation under the ESA with the issuance of the final Biological Opinion on November 21, 2008. MMS has worked with USFWS to address issues of concern and to develop an avian monitoring plan and other mitigation measures.

**Consultation with United States Coast Guard (USCG) (U.S. Coast Guard Regulations at 33 CFR part 66.0, Subpart 66.01)**

Pursuant to 33 CFR part 66.0, Subpart 66.01, the USCG has jurisdiction over projects located in navigable waters of the United States. The proposed action constitutes fixed structures in navigable waters of the United States which therefore require private aids to navigation marking. A permit application to establish and operate Private Aid-to-Navigation to a Fixed Structure has not yet been filed.

All 130 WTGs and the ESP are subject to USCG review for authorization to mark and light the WTGs and ESP. The USCG has safety and regulatory jurisdiction over projects located in navigable waters of the United States. The USCG Marine Safety Office for the Port of Providence, Rhode Island, which has jurisdiction over general navigation in the proposed action area, has coordinated a Navigational Risk Assessment. This Risk Assessment was prepared at the direction of, and in consultation with, the U.S. Coast Guard Marine Safety Office at the Port of Providence in order to provide a qualitative assessment of navigational risks related to the proposed action. The analyses required by the USCG were outlined in a letter to the USACE dated February 10, 2003 (Appendix B). Subsequent to the release of the USACE draft EIS/DEIR in November of 2004, the applicant was required to revise the 2003 Navigational Risk Assessment to incorporate design changes and new information and to address topics requested by the USCG in its letter of February 14, 2005. The *Revised Navigational Risk Assessment* (Report No. 4.4.3-1) has been incorporated into this FEIS.

MMS met with the USCG, USACE, and FAA on May 8, 2008 to address water and air navigational issues. The USCG has issued their Terms and Conditions to ensure that the proposed project does not negatively impact navigation and public safety. See Appendix B.

In the fall of 2008, the USCG sponsored a radar impact study (see Appendix M) that resulted in additional consultation with the applicant and the MMS. The USCG then assessed potential impacts to marine radar from the proposed action and issued an Advanced Copy of Findings and Mitigation on December 30, 2008 (see Appendix M), presenting the USCG's assessment of mitigation requirements for moderate impacts on navigation safety resulting from the WTG impacts on radar. In addition, based on consultation between the USCG and the applicant once the radar study was completed, the applicant developed mitigation designed to offset the moderate impacts on navigation safety (see Section 9.0).

**Federal Aviation Administration (49 U.S.C. 44718, 14 CFR Part 77)**

On August 27, 2004 the applicant requested an extension on the April 9, 2003 Determination due to delays in obtaining permits to start construction. The FAA granted the extensions on October 5, 2004. The FAA initiated an appeal of the original April 9, 2003 determinations based on their receipt of two petitions requesting discretionary review of the determinations. The FAA reviewed the new information submitted and upheld the original Determination of No Hazard on August 2, 2005 which expired on February 7, 2007. As a result of the reconfiguration of the WTG's, design changes that increased rotor height from 417 ft (127 m) to 440 ft (134 m), and the release of new lighting guidelines by the FAA, the applicant has submitted a request for a new Determination of No Hazard. The revised configuration was circulated as Aeronautical Studies #2006-ANE-1078-OE through 2006-ANE-1207-OE. FAA issued a public notice on April 25, 2007 and has stated that those determinations are pending. MMS has also requested a new letter from FAA to confirm that the proposed turbine locations would not have a negative impact on aviation. FAA provided a response in late summer of 2008 to MMS indicating their evaluation is not complete (see Appendix B). MMS's construction approval would be conditioned upon receipt of the FAA final hazard determination.

# 8.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Should the proposed action be licensed and constructed, there would be some irreversible or irretrievable commitments of resources. Irreversible or irretrievable commitments are those that cannot be reversed, except perhaps in the extremely long-term. A commitment of resources involves the use or destruction of nonrenewable resources, as well as the effects that loss would have on future generations. If a species becomes extinct as a result of a proposed action, for example, that loss is permanent. If wetland is filled to build a parking lot, that habitat loss is irretrievable as long as the parking lot remains. Construction and operation of the proposed action involves the irreversible and irretrievable commitment of material resources, energy (though small), and biological resources.

Material resources used for the proposed action include building materials for new structures, cables, and other facilities. Construction would also require use of fossil fuels, a nonrenewable natural resource, by vessels transporting workers and materials to and from the site of the proposed action. Once purchased and installed, these materials would be consumed. Some components may be recycled upon decommissioning, but in the near term, these materials would not be available to others.

Construction and operation of the proposed action would result in an irreversible or irretrievable loss of some biological resources, including the irretrievable loss of approximately 11.4 acres (45,134 $m^2$) of soft bottom habitat due to the ESP and monopiles (0.67 acres [2,727 $m^2$]), scour mats (1.96 acres [7,946 $m^2$]), and rock armor (8.75 acres [35,417 $m^2$]). Vessel traffic, vehicle traffic, facility construction and monopile driving could permanently displace some fauna and flora species from favorable to unfavorable habitats. Displacement and habitat loss may result in the reduction of some local populations and become irretrievable habitat permanently maintained. However, for this proposed action the degree of displacement and amount of habitat loss should represent a transitory and negligible effect to the overall populations of species.

The presence of the monopiles and ESP would also result in a permanent loss of certain human uses of these immediate areas. For example, it would not be possible to navigate through a monopile or the ESP. However, these impacts are negligible as the size of the ESP is small relative to the area of Nantucket Sound, and the monopiles are spaced far apart from each other so that mariners would be able to safely navigate around them. Commercial fishing vessels towing mobile gear would have to avoid the monopiles and ESP, but as with general navigation, this loss of navigation space is negligible. Ultimately, after decommissioning, this restriction on use would be removed.

If required by the USCG during construction there could be temporarily but irretrievably lost area to the fishing industry due to the enforcement of the safety setbacks of small water sheet areas around the turbines under construction, the cable installation vessel, and construction vessels around the ESP. These safety areas are limited, however, and would only be enforced temporarily around the WTGs being constructed, the cable installation vessel, or the ESP under construction. In addition, given the abundance of other available area that can be fished, there should be no lost opportunity days or revenue. The creation of these safety areas around the WTGs, cable installation vessel and ESP during construction would also result in the irretrievable loss of recreation, but again this would be negligible because of the short duration and small fraction of the Horseshoe Shoal area that would be involved at any one time.

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# 9.0 MONITORING AND MITIGATION

This section provides information on monitoring and mitigation applicable to the proposed action. If the proposed action were selected, all mitigation and monitoring measures and actions described herein would become required conditions of approval for MMS' authorization of the project. Those measures and actions described in this section and adopted in the Record of Decision (ROD) would set forth the monitoring efforts the applicant would undertake during construction, operation and maintenance, and decommissioning. In addition, the ROD would contain mitigation measures for unavoidable adverse impacts that the MMS requires as a result of its consultation process with Native Americans and agencies, as well as the environmental review process occurring under NEPA. Additional mitigation measures may be implemented by the applicant as a condition of other permits and approvals that it receives.

Since neither MMS nor any other federal or state agency has past experience evaluating how projects such as the proposed action will interact with the marine environment, MMS had initially requested, and the applicant agreed to prepare and implement an EMS tailored to the proposed action. MMS has now decided that the substantive requirements for mitigation and monitoring can be met through this EIS and ROD in a substantially similar manner, along with contributions and terms and conditions that are anticipated to be attached to several forthcoming pre-construction permits required by other federal and state agencies identified in Sections 1 and 7, and therefore has decided that putting the applicant to the expense and level of detail required by a formal EMS is unnecessary for this project. However, MMS encourages the applicant (and the applicant has agreed) to implement a proactive approach for managing and implementing the mitigation and monitoring required for the proposed action.

The discussion below focuses first on an overview of an EMS, then lessons learned from existing offshore wind energy projects, followed by required monitoring and mitigation associated with the major categories of resources and includes state mitigation, mitigation included in the USCG's Terms and Conditions, mitigation associated with the FWS and NOAA Fisheries Biological Opinions and mitigation developed by MMS.

## 9.1 OVERVIEW OF ENVIRONMENTAL MANAGEMENT SYSTEMS

One widely recognized international EMS is the International Organization of Standards ISO 14001, used to systematically identify, manage, control, and monitor environmental impacts. An EMS is a system that sets up a structure for continuous improvement in the area of managing and minimizing potential environmental impacts. As a continuous improvement process, an EMS is expected to be reviewed and updated periodically to reflect changing circumstances with respect to environmental policies, construction, operation and decommissioning technologies, actual environmental impacts and their effects, and the effectiveness and viability of mitigation and monitoring programs.

An EMS requires:

1. considering policies and regulations applicable to an action;
2. planning how to undertake the action in compliance with the applicable regulations;
3. implementing the action according to a plan;
4. monitoring and measuring the effects of the action;
5. reviewing the effectiveness of the plan with respect to applicable requirements;
6. where warranted, revising plans to reflect the reality of what is occurring during the implementation of the action; and

7. documenting the applicant's environmental policy, key responsibilities, and procedures to carry out and report the results of numbers 1 - 6 above.

In the event that the applicant wishes to model its own compliance plan upon an EMS structure, the following information has been retained to explain such systems. An EMS should focus on three key commitments: complying with environmental legislation, preventing impacts to local resources, and continually striving to improve environmental performance. There are a number of resources within the proposed action location that would be impacted during construction, operation and maintenance, and decommissioning. The EMS would be designed to address each activity within each phase, and identify the approximate severity of the impacts to each resource associated with that activity. The applicant would use the EMS as a tool in ensuring that it meets its post-decision mitigation and monitoring obligations. Mitigation and monitoring commitments made in a ROD may be incorporated into the EMS, and carried through the system. The ROD states what the decision is, identifies the alternatives considered, including the environmentally preferred alternative, and discusses mitigation plans, including any enforcement and monitoring commitments (40 C.F.R. § 1505.2, [2005]).

As commitments and mitigation measures established in the ROD are implemented, tracked and monitored, the applicant would document the implementation, tracking and monitoring of commitments and mitigation measures. This documentation can facilitate their internal training, internal auditing, identification of appropriate corrective actions and communication with interested parties. The documentation should be effective and sufficient to provide details of how well the applicant conforms to its plan, information on compliance with legal standards and requirements, permits, and authorizations, results of internal audits and reviews, and details of deficiencies and corrective and preventative actions.

## 9.2 LESSONS LEARNED FROM EUROPEAN WIND FARMS

In order to identify possible lessons learned from other offshore wind energy projects, MMS reviewed the monitoring results from a recent study on two demonstration wind farms in Denmark (Horns Rev and Nysted), which have been the subject of research and monitoring programs to examine the potential environmental impacts of offshore wind farm projects. Horns Rev, constructed during the summer of 2002, is sited 8.7 to 12.4 miles (14 to 20 km) off the coast of Denmark in the North Sea, and consists of 80 turbines totaling 160 MW. Nysted was constructed between 2002 and 2003 approximately 6.2 miles (10 km) offshore in the Baltic Sea, and incorporates 72 wind turbines placed in 8 rows of 9 turbines each, with a total installed capacity of 165.5 MW. The monitoring data at both sites consist of three years of baseline monitoring, monitoring during construction, and three years of monitoring during operation.

The environmental monitoring program focused primarily on the effects of construction and operation of the offshore wind farms on the infauna, epifauna, and vegetation of the benthic community; on fish, marine mammals and birds; and on peoples' attitudes towards offshore wind farms locally and nationally. Overall, the results from the Danish wind farms suggest that with proper siting and placement of turbines, offshore wind farms can be engineered and operated without significant damage to the marine environment and vulnerable species. In general, the monitoring results show that the wind farms seem to pose a low risk to birds, mammals, and fish. The studies stress that appropriate siting is an essential precondition for ensuring limited impact on nature and the environment, and that careful spatial planning is necessary to avoid damaging cumulative impacts. Important differences between the two sites were observed in the results of some studies, suggesting that environmental impacts are likely to vary by location even with careful site planning. Therefore, it is difficult to generalize the results of this monitoring program to potential environmental impacts at other offshore wind sites including the proposed action.

Research on the benthic communities at Horns Rev and Nysted focused on the effects of the introduction of hard foundation structures. Changes observed include increased abundance and biomass in the benthic community at the turbine sites associated with increased habitat heterogeneity and structural complexity, and a change in community composition. This may have a positive environmental impact if the increased biomass provides additional food resources for fish and birds. There was no clear evidence of impacts associated with changes in the hydrodynamic regime on the surrounding native benthic communities, seabed sediment structure, or established fouling communities. Many of these results are dependent on the particular benthic community and substrate types present, the level of natural scouring action, the salinity, and the species in the water column available for colonization. However, the rapid colonization and long-term establishment of a hard-surface community on turbine foundations was similar to what is observed on other artificial reefs, and may be representative of what would occur in other locations, including the proposed action.

Potential long-term impacts of offshore wind farms on fish may likewise be associated with the creation of artificial reefs and the establishment of the new hard-surface benthic communities at wind turbine sites. It was expected that fish would be attracted to these areas at the Danish wind farms, resulting in a positive effect on fish abundance and diversity, since artificial reefs may provide additional food, shelter, spawning areas, and a refuge from fishing activities that occur outside the wind farm area. To date, no effect has been observed on fish species composition, distribution and abundance at the Danish wind farm sites; however, it has been suggested that because it can take years for the full reef community to become established, sufficient time may not yet have passed to observe long-term effects on fish distribution or abundance.

The study at Nysted also looked for effects on fish and fish behavior that might be caused by the EMFs created by submarine cables during the operation phase of the wind farm. The Nysted study was not conclusive on this point, but suggests that there is no strong effect. There was some evidence of either avoidance or attraction to the magnetic fields depending on the fish species. The data, however, did not rule out the possibility that physical conditions, not EMFs, along the cables might have caused the observations. Only one species, flounder, showed a correlation between the inferred strength of the EMF and increased avoidance of the cable. It may be invalid, however, to assume that other species do not feel an effect of the EMFs; a weakness of this study was that the EMFs around the cables were not measured directly, and the strength of the fields was inferred from turbine output only, which may not be sensitive enough to produce a correlation.

Construction activity did seem to have an effect on marine mammal behavior and abundance. Other than a reaction to pile-driving and ramming activities, construction and operation of the wind farms had no noticeable effect on seals. Decreases in porpoise abundance were found at both sites during construction, only a slight decrease at Horns Rev, and a much stronger decrease at Nysted, with clear effects from the pile driving and ramming activities. At Horns Rev, there was no observed effect of wind farm operation, while at Nysted; the decrease in porpoises observed during construction has persisted during the first two years of operation, with indications of a slow recovery. The conclusions in these studies are that most effects of the wind farms on mammals are temporary and related to construction noise, but the reasons behind the slow recovery at Nysted are unclear.

Radar, infra-red video monitoring, and visual observations confirmed that at the Danish offshore wind farms most of the more numerous species of birds showed avoidance of wind farm areas, although responses were highly species specific. Birds tended to avoid the vicinity of the turbines and move along the periphery of the wind farm. Slightly extended migration distances for seasonal migrations are unlikely to have negative consequences for any species. The energetic costs of avoidance behavior could be much higher for wind farms located near nesting sites, which the Danish projects are not, if the avoidance interferes with daily foraging trips, affecting breeding success.

Post-construction studies showed an almost complete absence of loons and scoters within the Horns Rev wind farm, and reductions in long-tailed duck densities within the Nysted wind farm. This suggests displacement of these birds from feeding areas, probably due to avoidance of the turbines rather than a decrease in food resources. A few species such as cormorants and gulls may have increased their use of the wind farm areas, mostly as resting ground.

Low collision rates of migrating birds with turbines were predicted by computer simulation. Comparing model predictions for common eider to observed levels from one of the turbines using an infra-red monitoring system, collision rates for this species' migration through the Danish wind farm areas appear to be very low. It should be noted, however, that the assessments from this study were primarily focused on waterbird behavior and collision, and potential effects on other kinds of migrating birds were not addressed. This study also made no attempt to quantify the effects of weather conditions, such as areas with fog, on potential collision rates.

The final study conducted on Nysted and Horns Rev looked at the attitudes of neighboring local populations and the national population towards offshore wind farms. Results suggested the national population was favorably inclined to offshore wind farms, with this sentiment represented in the local Horns Rev population. The Nysted population was more critical of offshore wind farms, suggesting there may be substantial differences in local attitudes. Results of the study clearly showed that people expressed a willingness to pay for future wind farms to be located at distances from the shore where their visual impact is reduced. Willingness to pay to place wind farms completely out of sight was limited, but the local population at Nysted had a higher willingness to pay for this than Horns Rev or the national population.

Conclusions reached from the Danish offshore wind farms, therefore, showed generally minimal environmental impacts over the long term at these sites, but enough differences between sites to recommend caution in generalizing too much from these limited studies. New benthic habitats were colonized fairly rapidly, without strong observed effects on the surrounding soft bottom communities. The effects of the offshore wind farms were neutral with regard to fish density, species composition and abundance, showing neither positive nor negative effects. Results from the study on the potential effects of EMFs were inconclusive. Marine mammals, in general, were affected during construction temporarily, but their use of wind farm areas recovered during the operation phase, with the exception of the porpoises at Nysted, which exhibited long-term avoidance of the area. Bird studies showed general avoidance of wind farm areas for migration in most species, as well as avoidance by some species that otherwise use the area as a feeding ground. Collision rates with turbines for a large diving duck, the common eider, during migration, were predicted and observed to be very low.

## 9.3 PHYSICAL RESOURCES MITIGATION

Various types of mitigation have been developed to minimize the impacts of the proposed action. This section describes this mitigation which includes state mitigation via MEPA and EFSB requirements, mitigation required in the FWS and NOAA biological opinions, mitigation via the USCG terms and conditions, and mitigation requirements from the MMS.

### 9.3.1 State Mitigation (MEPA)

The applicant has committed to mitigation as part of the MEPA process to address concerns of regulatory agencies and to minimize impacts on the environment. This mitigation is included in the MEPA FEIR Certificate (refer to the Certificate on the Final EIR in Appendix B) but the commitments are presented below using the language of the FEIR Certificate. This State mitigation is independent of any MMS mitigation proposed.

The MEPA certificate on the FEIR requires conservation measures as part of the MEPA process (see page 5 of the MEPA Certificate on Final EIR in Appendix B). Details are presented below.

### *9.3.1.1 Bird Island*

The proponent would provide $780,000 towards the restoration of Bird Island, off the town of Marion in Buzzards Bay, with funds to be managed by the Department of Fish and Game, Natural Heritage and Endangered Species Program.

At 1.5 acres in size, Bird Island supports an average of 750 pairs of Roseate Terns, and is the second or third largest Roseate Tern colony in North America, supporting an average of 22 percent of the North American population. It is also the third largest Common Tern colony in Massachusetts, and supports an average of 1,900 pairs of Common Terns. Bird Island is conservation land owned by the Town of Marion and managed by the Harbormaster and Conservation Commission.

While Bird Island provides prime nesting habitat, the island is subject to significant and accelerating erosion. As a result, former Common Tern nesting areas adjacent to the seawall have turned into salt marsh, which is unsuitable for nesting. Common Terns have moved into interior nesting areas, forcing Roseate Terns out. The objective of the local, state, and federal partnership that is managing the restoration is to restore tern nesting habitat and protect the historic lighthouse by rebuilding the revetment to reduce erosion, fill eroded areas, and revegetate appropriate areas to provide suitable nesting habitat. Based on consultation with the Natural Heritage and Endangered Species Program, the enhancement of tern nesting habitat on Bird Island would directly benefit the same tern population that is subject to potential impacts from the WTG array. The project has a total cost of $3.775 million, the balance of which would be borne by the US Army Corps of Engineers, who is also providing planning, design, and construction services. If the proposed restoration project does not go forward, for whatever reason, the proponent shall coordinate with EOEA and state agencies and develop an alternative vehicle of equal value for offsetting avian impacts.

### *9.3.1.2 Natural Resource Preservation, Marine Habitat Restoration, and Coastal Recreation Enhancement Projects*

The proponent would provide $4.22 million in annual payments prorated over the life of the project towards natural resource preservation, marine habitat restoration, and coastal recreation enhancement projects in the area of Cape Cod, Nantucket, and Martha's Vineyard, with funds to be managed by the Coastal Zone Management Office, in consultation with state agencies and the Cape Cod Commission.

Massachusetts Office of Coastal Zone management provided details of its recommendations for allocation of the compensatory mitigation and Massachusetts's portion of the lease revenue. MA CZM's consultation with other state agencies and the Cape Cod Commission is ongoing and the recommendations may still be amended due to these consultations or public comment, but the currently the recommended allocations consist of three programs summarized below (see EOEA letter of August 1, 2008 in Appendix B for details).

### *9.3.1.3 Avifauna Program*

The Avifauna program, administered by the Department of Fish and Game's Natural Heritage and Endangered Species Program, has the goal of effective conservation of the roseate tern and piping plover and the habitat for these species. The program will include increased monitoring and protection of tern and piper populations, breeding sites, and post-breeding staging sites and migratory stopover areas. Threat to the roseate tern and piping plover by mammalian and avian predators will be assessed and selected predators will be removed from nesting sites to increase reproductive success rate and adult survival.

#### *9.3.1.4 Marine Fisheries Resources and Habitat Program*

The intent of the Marine Fisheries Resources and Habitat Program, administered by Department of Fish and Game's Division of Marine Fisheries, is the protection of valuable fisheries resources that support the commercial and recreational fishing that are an integral part of Cape Cod and the Islands' socioeconomic and cultural fabric. Under the program, a comprehensive eelgrass monitoring plan to supplement MA DEP's eelgrass mapping and inventory activities will be developed. The dynamics of fish stocks that are not currently well understood will be investigated. The program calls for a five year study of the socioeconomic impact of the proposed action on the fishermen and fisheries of Nantucket Sound. The program will also allow for the implementation of a quahog management plan.

#### *9.3.1.5 Grants Program*

The Grants Program, administered by the Office of Coastal Zone Management, will provide grants for various projects that will include conservation efforts for the habitat of threatened and endangered species, restoration of tidal and sub-tidal habitats, and improvement to public access and public education. The Grants Program may also provided funding for research in areas such as ocean planning, fishing and fisheries, habitat mapping, and renewable energy.

#### *9.3.1.6 Other Environmental Mitigation Proposed Under the MEPA FEIR Certificate*

Other mitigation the applicant would be committed to under the MEPA FEIR certificate to avoid and minimize impacts to environmental resources are described in the following subsections.

##### 9.3.1.6.1 Marine Resources

- Vessels transporting construction materials to the project site in Nantucket Sound would travel at slow speeds, usually at 10 knots or below.
- Potential vessel impacts (collisions and harassment) to marine mammals and sea turtles would be minimized by requiring that project vessels follow National Oceanic & Atmospheric Administration (NOAA) Fisheries Regional Viewing Guidelines -Northeast Region (NMFS and NOS, 2006) while in transit to and from the site so as not to disturb any individuals that may be in the area.
- The use of state-of-the-art hydraulic jet plow technology for cable installation to minimize sediment transport and suspended sediments.
- The use of monopile foundations for the WTGs.
- Implementing post-construction monitoring to document habitat disturbance and recovery. The applicant will undertake a seafloor habitat and benthic community monitoring program to measure impacts and the recovery of the benthic community levels comparable to control areas outside of the area of potential impact. A proposed plan, Seafloor Habitat/Benthic Community Monitoring, is for the area within the Massachusetts 3.5-mile (5.6 km) jurisdictional limit (3.5-mile [5.6 km] limit) and may need to be modified with a monitoring or adaptive management program for the area outside the Massachusetts 3-mile (5.6 km) jurisdictional limit.
- Potential impacts to marine mammals and sea turtles associated with underwater sound levels created by pile driving would be minimized by conducting a "soft-start" to each piling event.

- Underwater sound monitoring would be performed during initial monopile construction (the first three monopiles).
- A NMFS approved observer would be posted on-site during all pile driving activities to monitor the area during construction. If protected marine species are observed within the 500 m (1,640 ft) Safety Zone by the NMFS approved observer, the observer would ensure that work would cease until the animal is clear of the work area and safety zone.

#### 9.3.1.6.2 Fisheries

- Utilization of a state-of-the-art hydraulic jet plow for cable installation, monopile foundations for WTG towers, HDD installation at the nearshore area, and post-construction monitoring to document habitat disturbance and recovery.
- The pile driving hammer and jet plow technology that would be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum.
- The proponent has agreed to work with commercial/recreational fishing agencies and interests to ensure that the construction and operation of the project would minimize potential impacts to commercial and recreational fishing interests.
- Measures proposed to minimize or avoid potential impacts to the commercial fishing industry include: no restrictions on fishing activities within the site; marking the WTGs with USCG-approved lighting to ensure safe vessel operation; and burying the inner-array cables and two submarine cable circuits to a minimum of 6 ft (1.8 m) below the seabed to avoid the potential for conflicts with fishing vessels and gear operation.
- Notification of fishermen well in advance of mobilization as to the location and timeframe of project construction activities, as well as a daily broadcast on VHS marine channel 16 as to the construction activities for that and upcoming days.
- Cable burial depth would be inspected periodically during project operation to ensure adequate coverage is maintained so as not to interfere with fishing gear/activity or with the safe operation of the cable.
- To protect the earliest life stages of sensitive fish species such as winter flounder, the proponent has committed to avoid in-water construction in Lewis Bay between January 1 and May 31 of any year, except for the installation of the cofferdam for the HDD. This temporary cofferdam would be constructed in May and would include drive sheet piling, installation of a silt curtain and sheet piles. Most of the sediment should be contained by the silt curtain and sheet piles, thus avoiding impacts to fish and shellfish.

#### 9.3.1.6.3 Benthic and Shellfish

- Utilizing state-of-the-art hydraulic jet plow for cable installation in order to minimize seabed disturbance and sediment dispersion during cable embedment.
- Utilizing monopile foundations for WTG towers which minimize the seabed footprint and sediment disturbance while also minimizing opportunities for benthic organism colonization or fish habitat creation.
- Post construction monitoring to document habitat disturbance and recovery.
- The use of mid-line buoys on anchor lines in order to minimize the impacts from anchor line sweep.

- The duration and sequencing of construction has been designed to minimize the period of disturbance.
- Impacts to benthos and benthic habitat in Lewis Bay within 200 ft (61 m) of shore would be minimized by using HDD methodology to transition the submarine cable system to the shore.
- The proponent has committed to working with the Town Shellfish Constable to appropriately avoid or minimize impacts to designated shellfish areas from installation of the submarine cable. The proponent would provide the Town of Yarmouth with funds to mitigate for the direct area of impact within the Town's designated recreational shellfish bed in accordance with the Town's mitigation policies.

#### 9.3.1.6.4 Aquatic Vegetation

- The proponent would not anchor vessels or perform cable installation work in the area near Egg Island where eelgrass beds are located.
- A dive survey would be conducted to confirm the limits of the eelgrass bed near Egg Island (verifying the limits of submerged aquatic vegetation [SAV] previously surveyed in July 2003) prior to the commencement of cable installation in the same calendar year preceding construction, and divers would also be used to confirm correct placement of work vessel anchors.
- If during installation of the submarine cable the eelgrass beds are disturbed, the proponent has committed to replanting eelgrass.
- Pre and post-construction monitoring of the eelgrass bed would be performed and if it is determined that eelgrass has been lost as a result of project activities, replanting would occur.
- The proponent has committed to aerially photograph the entrance to Lewis Bay in the month of July immediately prior to jet-plowing, under conditions conducive to documenting the extent of eelgrass beds, to use the photographs in finalizing the exact location of jet-plowing, and to provide such photographs to the Energy Facilities Siting Board.
- The proponent would denote the edge of the eelgrass bed at the water surface with buoys near Egg Island. In addition, the proponent would implement a No Wake Zone for its construction vessels at a distance of 200 ft (61 m) from the edge of the eelgrass bed.
- An eelgrass survey would be performed for the two consecutive years following construction to document any changes in density and would be coordinated with the appropriate state and federal agencies.

#### 9.3.1.6.5 Visual

- The proponent has removed daytime FAA lighting on the WTGs, formerly proposed in the DEIR.
- Potential nighttime visual impacts have been lessened by the reduction in FAA nighttime lighting (from the originally proposed 260 lights down to 57).
- Revisions to the layout have narrowed the breadth of the visual impact as seen from certain areas around the Sound.
- The WTGs would be an off-white color, to reduce contrast with the sea and sky.

- The upland transmission route would be located entirely below ground within paved roads and existing utility ROWs to avoid visual impacts and impacts to potential unidentified archaeological resources.
- If MMS determines there would be an adverse effect (due to visual impacts) MMS would direct a formal consultation process under the requirements of the NHPA, to develop measures to help mitigate these impacts on historic properties. (This process has already begun as part of the Section 106 consultations – Refer to discussion in Section 7).
- The proponent and MMS would continue to consult with MHC, the Wampanoag Tribe of Gay Head Aquinnah (WTGHA), the Mashpee Wampanoag and other consulting parties to address and resolve issues concerning potential visual effects of the project on historic properties.

#### 9.3.1.6.6 Historical/Archaeological

- All submerged potentially archaeologically sensitive areas identified during marine archaeological investigations have been avoided, including relocation of eight WTGs and associated cable arrays.
- The interpreted limits of three submerged potential historic resources on the seafloor within the site would be extended by a 100 ft (30.5 m) perimeter that would constitute a no-activity buffer zone. Compliance would be overseen by an environmental inspector.
- In addition, Procedures Guiding the Unanticipated Discovery of Cultural Resources and Human Remains would be provided to construction contractors, outlining measures to be taken in the event that previously unidentified submerged and upland historic/archaeological resources are discovered during Project construction. Compliance with the procedures would be overseen by an environmental inspector.
- The proponent has reduced lighting on the WTGs and revised the layout such that the breadth of visual impact of the array as seen from certain areas is reduced. If the MMS determines that the offshore above water components of the project would result in adverse effects to certain onshore aboveground historic properties due to visual impacts, then the MMS would direct a formal consultation process under the National Historic Preservation Act (NHPA) to develop mitigation measures that would be detailed in a Programmatic Agreement.

#### 9.3.1.6.7 Noise

- The proponent has selected state-of-the-art, very low noise wind turbines.
- Construction noise impacts would be temporary, unavoidable, and are primarily associated with the laying of the Onshore Transmission Line from the transition vault at the shore of Lewis Bay along existing roadways to the Barnstable Switching Station using standard roadway construction equipment. Noise mitigation for this onshore activity would consist of scheduling activities during normal working hours and ensuring that all equipment has properly functioning noise mufflers.
- Onshore construction activities (which include the HDD at the landfall), would be temporary, lasting 4 to 6 weeks, and would be audible to persons near the cable corridor. Sound levels would be similar to roadway construction equipment. Noise barrier walls would be constructed at the edge of the HDD pit to shield nearby residences at 32 and 49 New Hampshire Avenue.

#### 9.3.1.6.8 Benthic Physical Environment

- Scour mats and or rock armoring (rip-rap) would be placed at the foundation of each WTG and each support pile of the ESP to minimize sediment scour.
- The use of state-of-the-art hydraulic jet plow for offshore cable embedment that minimizes sediment disturbance.
- Restoration of the dredged cofferdam area using originally dredged material supplemented with imported clean sandy backfill material if necessary to restore preconstruction contours.

#### 9.3.1.6.9 Wetlands and Drainage Operations

- The proposed submarine and onshore transmission cable route would be designed to fully comply with all applicable local, state and federal wetland performance standards.
- Direct wetland impacts would be minimized through the use of hydraulic jet plowing, HDD, and installation of the upland transmission line within existing paved roadways or disturbed electric ROWs.
- The proponent has committed to coordinate with the Yarmouth and Barnstable Conservation Commissions, the DEP, and Natural Heritage Endangered Species Program (NHESP) to prevent impacts to state-listed species as part of the project.
- The project would use best management practices for sedimentation and erosion control and stormwater management.
- A pre-construction survey would be performed to document the occurrence of state-listed rare species along the NSTAR Electric ROW route. If a state-listed species is located within the proposed transmission line route, a Conservation Permit under Massachusetts Endangered Species Act (MESA) would be obtained and efforts would be made to eliminate, minimize, or mitigate for any potential impacts.
- Post-construction monitoring would document habitat disturbance and recovery.
- The upland transmission line system has been sited below grade within existing roadways and maintained ROW.
- Sediment and erosion controls would be installed prior to construction, and would be inspected and maintained throughout the construction activities.
- A Dewatering Plan would be prepared to address the procedures for handling of any water encountered during excavation.
- The transmission line would not contain any fluids, petroleums, oils, or lubricants.
- The project would not result in any direct discharge of untreated stormwater into wetlands and waterbodies. Once installed, the paved areas would be restored to preconstruction conditions and the NSTAR Electric ROW would be restored to pre-construction contours and revegetated using a suitable upland seed mixture. The existing stormwater collections and management systems for these roadways would remain intact.

#### 9.3.1.6.10 Water Quality

- An Oil Spill Response Plan (OSRP) (Appendix D) would be in place and a Stormwater Pollution Prevention Plan (SWPPP) (Appendix C) and an Operation & Maintenance (O&M) Plan (ESS, 2007-Appendix 2.0-B) would be implemented during project construction/decommissioning and operation to prevent potential impacts to water quality from spills and erosion/sedimentation.

- The proponent would work with the Yarmouth Shellfish Constable to mitigate for any short-term impacts to shel1fish productivity and would provide the Town with funds to mitigate for the direct area of impact.
- To minimize the release of bentonite drilling fluid into Lewis Bay during HDD, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavation pit.
- Scour protection, in the form of scour control mats and/or rock armor, would be installed around monopiles and ESP piles in order to prevent scouring.

#### 9.3.1.6.11 Construction

- Use of state-of-the-art low-impact hydraulic jet plow installation for the marine cables.
- Use of HDD cable installation techniques at the landfall to avoid impacts to the intertidal zone and shoreline in Lewis Bay.
- A temporary cofferdam would be used during construction to minimize sediment resuspension at the interface between the HDD conduit and submarine cable system.
- Use of hollow monopile foundations for WTG towers.
- Installation of scour protection mats and/or rock armor to reduce scour potential near the WTGs.
- Post-construction monitoring including regular visual inspection of inner array cable routes in areas of migrating sand waves, to ensure the cables remain properly buried.

#### 9.3.1.6.12 Navigation and Transportation

- Direct communication would be established between Coast Guard Sector Southeastern New England command center personnel and the proponent's operation center (manned 24/7) in order to facilitate rapid remote WTG shut down, at the request of the USCG.
- The proponent would implement procedures outlined by the USCG to deconflict the areas around ongoing construction activities.
- The proponent has designed the WTG monopiles to withstand the forces of up to 6 inch (15 cm) thick ice floes impacting the monopile.
- The proponent has committed to initiate manual shutdown of WTG(s) experiencing icing conditions if conditions warrant such a shutdown.
- The proponent would use either Seabed Scour Control Mats or rock armor for scour protection to limit changes to bottom contours in the vicinity of the WTGs.
- The proponent would provide private aids-to-navigation (ATONs) (lights and sound signals) within the site to assist mariners.
- The proponent would mark each WTG with its alphanumeric designation to serve as a point of reference for mariners.
- The proponent would provide the USCG; other local, state, and federal agencies and commercial sailors with a plan showing the designations of each WTG.

- The proponent has committed to continue coordinating with the USCG and NOAA regarding inclusion of the project site on NOAA nautical charts covering the area.
- The proponent has committed to immediately shutting down all or a portion of the WTGs upon notification from the USCG.
- The proponent would work with the USCG to develop information that could be used to provide mariners to educate them regarding the potential effects of the WTGs on marine radar.
- The submarine cable system would be buried 6 feet below the present sea bottom. Installation of the upland cable system will occur outside of the height of the summer tourist season to minimize any vehicular disruption.
- Trenchless technologies would be used at major intersections and railroad crossings in order keep traffic disruptions to a minimum.
- Impacts to land-based transportation would be limited and temporary in nature. A Construction Traffic Management Plan would be prepared in consultation with local and state officials to ensure that safe access is maintained for vehicular traffic during onshore cable system installation, once the final route has been determined.

#### 9.3.1.6.13 Telecommunication

- The potential does exist for interference to vessel mounted radar operating within or in close proximity to the proposed project site. The proponent would work with the USCG to develop information and training opportunities that could be provided to local mariners in order to raise awareness if interference does occur.

#### 9.3.1.6.14 Details on Roseate Tern and Piping Plover Conservation Measures

In accordance with requirements in the Massachusetts Environmental Policy Act (MEPA) Certificate, issued by the State of Massachusetts (via MassWildlife) on March 29, 2007, a $10M fund was established to compensate for unavoidable impacts to affected wildlife and habitat. On March 20, 2008, the MassWildlife provided MMS with a listing of the roseate tern and piping plover projects that would be implemented through this state run fund. Details of these projects are described below:

- *Bird Island Restoration:* Under the Bird Island Restoration Project, funded in large part and carried out by the Army Corp of Engineers, approximately 2.2 acres of suitable roseate tern nesting habitat will be created or stabilized. This habitat restoration project will stabilize the shorefront and attenuate wave energy, provide new sand to renourish the eroded and scoured areas of the island, further protect the island from all but extreme storm waves and significantly reduce the rate of erosion. Ultimately, the project will create suitable nesting habitat for common tern thereby reducing the encroachment of this species into roseate tern nesting habitat. The restoration plan also provides mitigation for construction impacts to just over one-half acre of existing salt marsh resources on the island. The applicant, through the state administered fund, has committed to provide $780,000 toward the overall project cost.
- *Predator Management:* MassWildlife plans to assign portions of the fund for contracts with the USDA-Wildlife Services to assess mammalian and avian predators at a carefully selected subset of priority piping plover nesting sites and at the three island-nesting colonies of Roseate and Common Terns in Buzzards Bay and to remove selected predators from those sites during winter and spring in order to

improve plover and tern reproductive success and adult survival. Predator removal at priority plover nesting sites would likely benefit Least Terns as well. Predator removal work would be conducted pursuant to depredation permits issued by MassWildlife, and would occur only at sites where MassWildlife and USDA-Wildlife Services have secured permission from the landowner(s).

- *Population Monitoring, Site Protection, and Management (Breeding Season):* Funding would be used to sustain and augment current statewide efforts to monitor the abundance, distribution, and reproductive success of piping plovers and terns in Massachusetts and to protect the birds, their nests, unfledged chicks, and habitat from human recreational activities, dune-building and beach stabilization activities. Funding may be used to hire seasonal shorebird monitors directly through MassWildlife, or to contract with municipal or private conservation organizations (NGOs) to continue or augment current monitoring and protection activities as coordinated by MassWildlife and USFWS. Monitors will be expected to follow monitoring and management protocols as directed by MassWildlife, including reporting of abundance, reproductive success, and limiting factors using standard census forms; protection of nests, nesting habitat, and chick refuge areas with warning signs and string fencing; and protection of nests with wire predator exclosures. Priority locations where additional monitoring and protection for piping plovers is needed, and number of additional seasonal staff needed (in parentheses), are: Outer Cape (2), Upper Cape (1), Upper Cape / South Shore (1), Martha's Vineyard (1), Nantucket/Tuckernuck/Muskeget (1). Priority locations where additional tern monitoring and protection is needed, and number of additional seasonal staff needed (in parentheses), are: Buzzards Bay (1), Lower Cape (1).

- *Identification and Protection of Tern and Piping Plover Post-Breeding Staging and Migration Areas (e.g., Signage, Patrolling, Education):* Funding would be used to identify post-breeding staging and migratory stopover areas for terns and piping plovers, identify management needs, and then provide annual site management to protect the birds from human disturbance (purchase and install signage, patrol key staging sites, educate beach-goers, work with landowners and beach managers to reduce disturbance from dogs). An estimated four seasonal staff persons are needed to manage key sites statewide.

- *Coastal Waterbird Conservation Assistant:* Time dedicated to piping plover and tern conservation efforts by MassWildlife staff (now primarily the Senior Zoologist and Buzzards Bay Tern Restoration Coordinator) has actually declined over the past 6 years, at the same time that conservation needs have increased. Funding will be used to develop a new, year-round Costal Waterbird Conservation Assistant to oversee the scope and effectiveness of the statewide conservation efforts for piping plovers and terns.

### 9.3.2 State Mitigation (Massachusetts Energy Facility Siting Board)

In addition to the State mitigation required under MEPA, the Massachusetts Energy Facility Siting Board decision on the electric transmission cable has the following conditions related to mitigation.

- The applicant would not anchor vessels or perform cable installation work in the area near Egg Island where eelgrass beds are located.

- A dive survey would be conducted to confirm the limits of the eelgrass bed near Egg Island (verifying the limits of SAV previously surveyed in July 2003) prior to the commencement of cable installation in the same calendar year preceding construction, and divers would also be used to confirm correct placement of work vessel anchors.

- If during installation of the submarine cable the eelgrass beds are disturbed, the applicant has committed to replanting eelgrass.
- The applicant has committed to aerially photograph the entrance to Lewis Bay in the month of July immediately prior to jet-plowing, under conditions conducive to documenting the extent of eelgrass beds, to use the photographs in finalizing the exact location of jet-plowing, and to provide such photographs to the EFSB.
- The applicant would denote the edge of the eelgrass bed at the water surface with buoys near Egg Island. In addition, the applicant would implement a No Wake Zone for its construction vessels at a distance of 200 ft (61 m) from the edge of the eelgrass bed.
- The scope of work to perform the dive survey at the eelgrass bed within Lewis Bay would be coordinated with the appropriate state and Federal agencies.
- Development of a BACI Plan for Eelgrass.
- Pre and post-construction monitoring of the eelgrass bed would be performed; if it is determined that eelgrass has been lost as a result of project activities, replanting would occur. The post-construction monitoring plan would be developed to document potential indirect impacts from cable embedment and subsequent habitat recovery. Habitat recovery would be considered successful, if it is found that SAV has migrated back to the site of disturbance. Should the habitat not recover naturally, the disturbance would be mitigated by replanting.
- An eelgrass survey would be performed, in the same timeframe as the pre-construction surveys, for the 2 consecutive years following construction to document the change in density.

### 9.3.3 Reasonable and Prudent Measures Required by NOAA and FWS

An outcome of the formal consultation under the ESA has been the issuance of Biological Opinions, containing reasonable and prudent measures.

#### *9.3.3.1 NOAA*

MMS initiated formal consultation under Section 7 of the ESA with NOAA Fisheries on May 20, 2008. NOAA Fisheries issued its Biological Opinion on November 13, 2008 (see Appendix J) which concluded that the proposed action would not jeopardize the continued existence of any threatened or endangered species. In particular, the NOAA Fisheries' Biological Opinion analyzed the proposed action construction activities and found that the hawksbill turtle and the sperm, blue and sei whales do not occur in the action area and needed no further analysis, yielding a determination that the proposed action will not affect these species. For the right, humpback and fin whales, NOAA Fisheries concluded that since "all effects to whales from the proposed project are likely to be insignificant or discountable, this action is not likely to adversely affect listed whales in the action area," and, therefore, is not likely to jeopardize the continued existence of these whale species. NOAA Fisheries concluded that the proposed action (e.g., pile driving noise, and potential for vessel strikes) may adversely affect but is not likely to jeopardize the continued existence of the loggerhead, Kemp's ridley, leatherback or green sea turtles. Lastly, because no critical habitat is designated in the action area, none will be affected by the proposed action.

The Reasonable and Prudent Measures designed to minimize impacts to sea turtles required by NOAA Fisheries are as follows:

- MMS must ensure that any endangered species monitors contracted by Cape Wind are approved by NMFS.
- During the conduct of pile driving activities related to turbine monopile and Electrical Service Platform (ESP) installation, the 750 meter exclusion zone must be monitored by a NMFS-approved endangered species monitor for at least 60 minutes prior to pile driving.
- During the conduct of the high resolution geophysical survey, the 500 meter exclusion zone must be monitored by a NMFS-approved endangered species monitor for at least 60 minutes prior to the survey.
- Acoustic measurement of the first pile being driven must be conducted to confirm the sound levels modeled by MMS and reported in the BA.
- Prior to decommissioning, MMS must provide to NMFS a complete plan for decommissioning activities.

In addition to these measures, the NOAA Fisheries BO contained specific terms and conditions for implementation of the reasonable and prudent measures, which can be found in the Appendix J BO.

#### *9.3.3.2 FWS*

MMS initiated formal consultation under Section 7 of the ESA with the FWS on May 20, 2008. The consultation ultimately covered the following endangered and threatened FWS trust species: (1) threatened Atlantic Coast piping plover (*Charadrius melodus*) population, (2) endangered northeastern population of the roseate tern (*Sterna dougallii dougallii*), and (3) threatened northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*). There is no habitat designated as critical pursuant to Section 4 of the ESA within the Horseshoe Shoal marine environment or elsewhere within the area of the proposed action for these species. Similarly, there are no species currently proposed for ESA listing as threatened or endangered that may be present in the area of the proposed action. Consultation with the FWS was completed on September 19, 2008, and the final BO was issued on November 21, 2008 by the FWS. See Appendix J.

The Reasonable and Prudent Measures designed to minimize impacts to the Atlantic Coast piping plover (*Charadrius melodus*) and the roseate tern (*Sterna dougallii dougallii*) are as follows:

1. Pre- and post-construction monitoring to assess the effects and incidental take of the Cape Wind Project.

   The MMS and CWA Monitoring Framework is a preliminary framework of methodologies for pre- and post-construction monitoring of the potential impacts of the Cape Wind Project on roseate terns and piping plovers. MMS, CWA and the Service will coordinate in the development of more detailed protocols to determine the extent of roseate tern and piping plover presence in the project area, the effects of the WTGs on roseate tern foraging and other use of Horseshoe Shoal and/or the level of incidental take as a result of the project.

2. Oil Spill Response Plan

   Although MMS requires an oil spill response plan in the event of a spill related to the Cape Wind Project, specific response measures shall be identified for roseate tern and piping plover habitat in order to avoid or minimize take. Some adverse effects and possible take (primarily in the form of harm or harassment) may be unavoidable during an emergency response. These effects will be addressed in a post-spill emergency consultation as described in the BO.

3. Review of pre- and post-construction monitoring activities, perching deterrents and operational adjustments.

   The Service, MMS and CWA will review the efficiency and efficacy of pre- and postconstruction monitoring activities, and the implementation of perching deterrents to determine their effectiveness and/or make adjustments as needed, in order to continue or enhance avoidance and minimization of take.

4. Reporting requirements

   Post-construction monitoring may not be able to sufficiently document take of roseate terns and piping plovers resulting from collisions with WTGs or the ESP. Nevertheless, MMA and CWA must report roseate tern and piping plover injury or mortality associated with the Cape Wind Project to the Service within 24 hours.

In addition to these measures, the FWS BO contained specific terms and conditions for implementation of the reasonable and prudent measures, which can be found in the Appendix J BO.

### 9.3.4 USCG Conditions

The USCG has provided Terms and Conditions requiring that the design and construction of the proposed action shall not impede navigation and that the applicant shall ensure that maritime navigation safety is maintained. The Terms and Conditions require the WTGs and ESP to be marked with private aids to navigation such as clearly visible, unique, alpha-numeric identification characters, in accordance with guidelines set by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA); and safety lines, mooring attachments and access ladders must be placed on each WTG and a plan for placement and design must be approved by the USCG. The Terms and Conditions also require the applicant to submit a research analysis before the start of construction, concerning whether or not the WTGs as designed would interfere with marine communication or navigation systems or produce any adverse impacts to navigational safety. In addition, the applicant is required under the Terms and Conditions to provide status reports to the USCG monthly throughout the construction activities, including information regarding the current status, any changes to the construction schedule, a description of any complaints received during construction, and copies of any correspondence between the applicant and federal, state, and local agencies. The full Terms and Conditions are provided in Appendix B.

In addition, as mentioned earlier in Section 5, the USCG 2008 Radar Impact Study (see Appendix M) identified sufficient radar interference caused by the WTGs that navigation safety within the wind turbine array was moderately impacted under certain conditions. To address these issues, the applicant in consultation with the USCG has proposed the mitigation measures described below to address navigation safety issues related to radar impacts.

A. *Aids-to-Navigation Measures:* the applicant will install Private Aids to Navigation (PATON) lighting and signals as proposed in Figure 4-17 of the Revised Navigation Risk Assessment dated November 16, 2006. Other ATON measures may be required by the Coast Guard, after consultation with the Southeastern Massachusetts Port Safety and Security Forum, including but not limited to:

1. Day beacons
2. Signs/Signals/Lights at the perimeters of the wind farm
3. Sound signals

B. *Traffic Management Measures:* The applicant will adopt traffic management measures that may be prescribed by the Coast Guard, after consultation with the Southeastern Massachusetts Port Safety and Security Forum, including but not limited to:

1. Specially marked traffic lanes
2. Recommended vessel routes
3. Adoption of applicable specific navigation rules consistent with Collision Regulations (COLREGS) for vessel operations within the wind farm

C. *Operational Measures:* The applicant will establish a control center as required by the Coast Guard Terms and Conditions. The control center will include the following items sufficient to maintain Coast Guard-required monitoring capability:

1. Staffing
2. Equipment
3. Doctrine, to include Standard Operating Procedures (SOPs) and contingency plans consistent with local doctrine.

D. *Education Measures:* The applicant will work with the USCG, NOAA, the Southeastern Massachusetts Port Safety and Security Forum, and other appropriate entities to educate mariners on navigation safety issues related to the wind farm.

The USCG assessed potential impacts to marine radar from the proposed action and issued an Advanced Copy of Findings and Mitigation on December 30, 2008 (see Appendix M), presenting the USCG's assessment of mitigation requirements for the moderate impacts on navigation safety resulting from the WTG impacts on radar. The full presentation of mitigation measures can be found in Section 8 of the December 30th document. An underlying theme within the mitigation discussion is that an adaptive management approach needs to be followed, since there are user groups that may still need to be included in mitigation discussions, and until the proposed action is constructed and proposed mitigation implemented, effectiveness cannot be fully assessed. If proposed mitigation is found to be inadequate or insufficient, the USCG retains the ability to seek revised or additional mitigation measures to ensure that navigation safety is acceptable.

### 9.3.5 MMS Mitigation

#### *9.3.5.1 Water Quality*

MMS requires a draft O&M Plan that details standard operating and maintenance protocols to ensure proper operation of offshore facilities. The draft O&M Plan (ESS, 2007-Appendix 2.0-B) specifies operating guidelines, maintenance schedules, and materials approved for maintenance activities. The maintenance program would include preventive and emergency maintenance functions including shore-based predictive maintenance analysis of the WTGs and ESP. The applicant would be responsible for developing and implementing an OSRP (Appendix D) and a stormwater pollution prevention plan

(SWPPP) (Appendix C) covering all phases of the proposed action. The OSRP will cover all phases of the proposed action, and the SWPPP will cover on land components of the proposed action.

In the event of a release of oil to the ocean, the applicant's employees, its contractors, and its responders would refer to the OSRP to ensure that the appropriate spill response actions are taken in a timely manner to minimize impacts to sensitive receptors and the environment.

#### *9.3.5.2 Emergency Response Plan*

The applicant has prepared an Emergency Response Plan (ERP) (ESS, 2007-Appendix 2.0-D). The purpose of this ERP is to describe procedures to be followed by the applicant's personnel in responding to emergencies, including those involving releases of hazardous substances (see Section 5.2.2.1), fires, medical emergencies, severe weather, etc. Impacts to humans and the environment would be reduced through application of this plan. This facility would be subject to MMS and Occupational Safety and Health Administration (OSHA) regulations with respect to emergency response.

#### *9.3.5.3 Electro Magnetic Fields*

The proposed action design incorporates economically viable and prudent measures to reduce EMF. The use of three-conductor cables – rather than a flat arrangement of single conductor cables in separate trenches – minimizes the spacing between phases, which in turn, reduces the magnetic flux density. The cable is proposed to be buried at a depth of 6 ft (1.8 m) to reduce the magnetic flux density on the sea floor. Since all of the proposed transmission cables contain grounded metallic shields, no or minimal electric fields should exist beyond the cable itself.

#### *9.3.5.4 Avifauna and Bats (ESA-listed and Non-Listed)*

MMS, in cooperation with the applicant and the FWS, has developed a "Framework for the Avian and Bat Monitoring Plan for the Cape Wind Proposed Offshore Wind Facility" (see Appendix N) which identifies technology and methods for assessing impacts of the proposed action and then using monitoring results to drive changes in mitigation requirements and readjustments to monitoring as needed. The following information provides highlights of the main mitigation and monitoring requirements from this plan. The full plan can be viewed in Appendix N.

**Pre-Construction (Post-Lease) Surveys**

MMS will require that a minimum of one full year of data be collected, analyzed and reported to MMS prior to commencing construction activities, unless a change is agreed to in advance by MMS in consultation with the FWS. Data will be collected through the methods outlined below.

***Radio Tracking***

Twenty-five common terns, as surrogates for roseate terns, will be captured, tagged with radio transmitters, and located at least 12 times between July 1 and August 31 to determine their movements and proximity to Horseshoe Shoal during the staging period at Monomoy Island prior to fall migration in late August, and to determine if they pass over Horseshoe Shoal when leaving Monomoy Island in large numbers at the initiation of fall migration. Any radio tagging of Common Terns will require implementation by and approval from agencies such as United States Fish and Wildlife Service (USFWS) and Massachusetts Natural Heritage and Endangered Species Program (NHESP). The goal of a pre-construction telemetry study would be to assess tern movements in/around the project area. A pre-construction assessment would be compared with a post-construction assessment to evaluate any changes in tern use of the project area. Similarly, 25 semi-palmated plovers, as surrogates for the piping plover, would be tagged to determine their locations at least twice weekly in August. Telemetry tracking will occur from ground, boats, and aircraft and there would also be experimenting with up to three yagi antennas with operators on the ground, in boats, and with an antenna attached to an aircraft. Data collected during the surveys could be analyzed using GIS and Ranges (www.anatrack.com), a software program specifically created to identify habitat use, home ranges, dispersal and other metrics related to species distribution.

***Avian Acoustic Monitoring***

An acoustic microphone(s) will be attached to the meteorological tower and data recorded automatically for later analysis from May through October and at least three days/month from November through April. Another microphone will be placed in/near the breeding area for roseate terns and piping plovers to verify the effectiveness of acoustic microphones for detection of these species and discrimination among tern species. Playbacks may also be used to test equipment effectiveness.

***Anti-Perching Monitoring***

Section 5.1 of the Biological Assessment prepared for the Cape Wind proposed (see Appendix G) action outlines the specific proposal by CWA for installation of anti-perching structures on the MET tower, ESP and wind turbines (post construction) and monitoring the effectiveness of these perch deterrents. Pre-construction, remotely operated video cameras or still photo camera with motion detectors would be used to collect observations on bird perching rates and the effectiveness of the proposed perching deterrents on the MET tower. The cameras would have motion-detecting capabilities so that observations are only recorded when they are triggered by a target passing within the field of view (See More Wildlife Systems, 2008). The cameras will also be fitted with anti-perching deterrents if necessary. If cameras fail to work, observers would monitor the effectiveness of anti-perching devices. Based on the results of this monitoring, MMS and CWA, in coordination with the FWS, would determine whether any changes in anti-perching structures would be required prior to construction.

The level of monitoring will be determined by the selection of the best available and economically feasible camera technology. If the camera cannot be downloaded remotely the camera will need to be actively managed to retrieve the data. The cameras will function for a length of time that provides sufficient data on anti-perching devices. Selection of the camera and level of monitoring effort will be determined by CWA and MMS in coordination with the FWS.

***Bat Surveys***

To develop a more thorough characterization of existing bat use of the project area, Cape Wind will deploy bat detection equipment on the MET tower from April to October. The proposed detection equipment includes an Anabat SD1 Bat Detector with built-in data storage and associated software. Further investigation will be needed to determine whether Anabat detectors will function as effectively with ambient ocean background noise. Multiple detectors may be set up on the MET tower at varying elevations to maximize the area surveyed. The detection equipment is used to identify bat species by detecting, recording and displaying bat ultrasonic echolocation calls (Titley Electronics, 2006). The detection equipment converts ultrasonic bat calls into a signal that is audible to humans. In addition, this audible signal is converted to a visual form through a sound analysis. Following the completion of a survey, these data are reviewed and analyzed to determine bat species.

If determined to be feasible, a long-term, passive monitoring station will be established on the MET tower for data collection. The station will include the Anabat SD1 Bat Detector unit, long-term power source such as a solar panel, and weather protection equipment. Unlike active monitoring, there will be no observer present on the tower to record visual observations, which for logistical reasons, is not feasible. The monitoring station will serve as a long-term data logger of bat activity in the area. The station would operate all night for an extended period of time which allows for a greater sampling effort than active monitoring. The range at which a bat call is detected varies depending on a number of factors including air temperature, pressure, humidity and the bat call frequency. On land, calls of bats which pass within roughly 100 to 200 feet (30 to 60 meters) of the detector unit are recorded and stored for future analysis (Titley Electronics, 2006). The effective detection range of the detector on the ocean will be determined based on further consultation with Titley Electronics. The use of bat detectors will permit the collection of a continuous set of data which can be used to gain insights into the temporal aspects of bat occurrence within the project area monopile platforms.

**Post-Construction Surveys**

The following monitoring techniques, which employ recent technology, will be implemented for the purpose of documenting movements and locations of avian and bat species, especially the roseate tern and piping plover, around and over Nantucket Sound. MMS will require that a minimum of four full years of data be collected, analyzed and reported to MMS subsequent to commencement of construction activities, unless a change is agreed to in advance by MMS in consultation with the FWS. At least three years of that monitoring must be after construction is complete and the facility is operating. According to the reporting structure provided in the MMS BA, MMS will regularly evaluate the results of the monitoring in coordination with the FWS and make adjustments to the monitoring plan where appropriate and needed.

***Anti-Perching Monitoring***

Each WTG and the ESP will be equipped with an avian deterrent system to discourage terns and other avian species from perching on the railings and deck areas. Based on the effectiveness of using cameras on the met tower during pre-construction, cameras may be used on some turbines to monitor the effectiveness of the anti-perching devices. Video cameras would be set up on up to six turbine monopoles selected from throughout the wind farm (one at each corner, and two internal turbines) to monitor the effectiveness of the existing perching deterrents. Any changes to the perching deterrent system in use will be made based on the results of the video monitoring.

On the ESP, a camera would be installed so that the structure could be remotely viewed from the Cape Wind Control Station. The structure would be observed first thing every morning and for five minutes at the top of each hour when the Control Station is manned during daylight hours (up to one year). Results of monitoring the ESP and turbine deterrent systems will be reported initially to MMS in bimonthly reports during the first year of project operation. Frequency of reporting will then change to annual cycle unless MMS determines data indicate a need for more frequent reporting.

If perching remains an issue based on the monitoring, Cape Wind will screen and evaluate additional anti-perching/roosting devices and mechanisms for potential use on both the WTG and the ESP. For each device or mechanism that advances through the screening process, Cape Wind will provide a visual detailing of the proposal and a narrative describing its expected action. To enable efficient testing, these devices may be tested in an appropriate environment where terns are more consistently present.

In addition to monitoring for tern presence in the project area, field biologists will also monitor for avoidance or attraction behaviors at the ESP and select WTGs. Avoidance or attraction behaviors of terns will be made from a vantage point on the ESP. Cape Wind will deploy field biologists during the breeding season from mid-May to late July and the staging season from mid-August to late September to observe tern behavior around the ESP and adjacent WTGs. Observers will collect 32 hours of observations (staggered during day light hours) in field journals and photo document birds where possible. Observers will monitor tern behavior for avoidance or attraction to the WTGs or ESP for two years.

***Abundance and Spatial Distribution Surveys***

Cape Wind will conduct aerial surveys using the same methodology employed during the studies conducted for the DEIR and FEIR to document avian species abundance, and spatial distribution within the project area and Nantucket Sound. This will allow comparisons with pre-construction data to see if/how bird use of the area has changed due to the presence of the wind energy facility. Flight paths during the tern breeding and staging period will shift to include a transect near Monomoy Island. Cape Wind will fly five aerial surveys from May to late July (tern breeding period), four aerial surveys during the tern fall staging period from mid-August to late September, and ten surveys during the winter (mid October to mid-April) to monitor sea ducks and waterbirds.

Cape Wind will fly surveys at an altitude of 250 ft (76 m), which was chosen as the lowest possible altitude in order to observe individuals clearly down to sea level with minimal disturbance to bird behavior. The surveys will be flown in a floatplane (or equivalent) which will maintain an air speed of approximately 90 knots, or the slowest speed the aircraft can safely fly. The 76-meter altitude corresponds approximately to the rotor hub height 257.5 ft (78.5 m) of the proposed wind turbines. The flight lines will be slightly adjusted from pre-construction flight paths so that they are in between turbine strings.

Birds will be counted and identified along 16 transects spaced approximately 7,500 ft (2,286 meters) apart. Surveys will be flown at different times of the day, at different tides, and in somewhat varying weather conditions, but only when visibility is either good or excellent to ensure that birds can be seen. No observations will be made when sea states are greater than three to ensure birds on the water can be seen. Flights will not take place during inclement weather when the safety of the pilot and survey crew would be compromised.

The survey team will consist of the pilot, a data recorder, and two observers. The pilot will maintain the plane on transect, at the correct altitude and speed, and at the proper wing level attitude. Two observers will be seated on either side of the plane. An aluminum rod will be attached perpendicular to the wing strut on each side of the plane to delineate the transect boundaries. A clinometer will be used to measure the calculated angle for the placement of these aluminum rods. The distances between the plane’s float and the aluminum rods will be initially verified by flying over the airport at 250 ft (76 m) using pre-measured 656 ft (200 m) markers on the ground. The area visible between the float on the plane and the aluminum rod will provide each observer with a 656 ft (200 m) transect width within which all birds shall be counted. The observers will not be able to see the area directly below the airplane.

The data recorder and observers will maintain direct communication using aviation headsets. The observers will identify species, number of species, activity of bird (i.e., foraging or flying), and time of sighting. The data recorder will be responsible for entering the data identified by the observers and record a Global Positioning System (GPS) point of the location at the beginning and end of each transect in addition to a GPS point every minute during each transect. Each observer’s sightings shall be independently recorded on an audiotape linked directly to each headset.

Results of the surveys will be transferred to a geographic information systems map to show abundance and spatial distribution of key bird species during specific times of year (tern breeding season, tern fall staging, winter sea ducks, and winter waterbirds). Sea duck species include Common Eider, Long-tailed Duck, Surf Scoter, Black Scoter, and White-winged Scoter. Winter waterbird species include loon, grebe, Northern Gannet, American Black Duck, American Goldeneye, mergansers, Alcids, Dovekie, and Razorbill. The results of the post construction monitoring will be compared with pre-construction aerial surveys.

***Avian Acoustic Monitoring***

Acoustic microphones will be placed on 10 monopiles or the ESP, one on each of the 4 corners of the project, one in the approximate middle of the western and northern sides, and 4 placed at random in the interior of the project array. These will record flight calls of birds over/near the project 24/7 from May through October and during three 24-hour intervals per month from November through April, weather permitting, to determine bird presence/absence in the airspace in/around the proposed project site.

***Telemetry Surveys***

If the first year radio tracking of common terns and semipalmated plovers proves to be effective and safe for the birds, then radio transmitters will be attached each year to 25 adult roseate terns and 25 adult piping plovers exactly as described for pre-construction radio tracking of common terns and semipalmated plovers and as approved in any permits from the FWS and other regulatory agencies. CWA will also test the effectiveness of using the turbines and/or ESP as receiving stations. Attempts will be made to locate tagged birds at least 12 times between July 1 and August 31. One consideration in the selection of test subjects is the geographic source of the population. For example, plovers captured around Nantucket Sound may not be as vulnerable to collision with turbines as plovers which nested farther north and are migrating down the Atlantic Coast. Such plovers conceivably could be less familiar with the area and with wind turbines and could during migration be further offshore.

***Monitoring Collision — Thermal Animal Detection Systems (TADS)***

CWA will install a Thermal Animal Detection System (TADS) or similar system. Thermal imaging cameras will be positioned near the base of the wind turbine monopole. The camera model, lens type and set-up will be refined after further consultation with experts. The cameras and weather-proof housing will be mounted on pan/tilt heads which will enable a change in field of view. To reduce impacts of vibration from the turbine operation on the camera, rubber vibration absorbers will be placed between the housing and the base plate of the mount and between the mounting and the turbine. The number of cameras and the orientation necessary to monitor the turbine will be designed depending on the system used. In addition, the nacelles proposed for the Cape Wind project, to which the rotor and blades are attached, can rotate 360 degrees. Movement of the nacelles will then need to be considered in the design of the monitoring for optimized viewing of the rotor swept zone.

It is anticipated that each thermal imaging camera would be connected to a data logging device at the turbine. To limit data collection to just those times when a target passes within the camera's field of view, the computers would be loaded with thermal trigger software with operator defined settings. Typically, video sequences from the thermal camera would be downloaded and stored on the data logger when at least one pixel in the field of view exceeds the operator-defined threshold temperature. The threshold would be tested and adjusted to help to eliminate non-avian targets.

**Reporting**

Cape Wind will submit a monitoring report at the end of construction and then annually by December 15 that contains the following information.

- A summary of results from the previous year's studies, including information that specifically addresses the research objectives outlined in this ABMP and an evaluation of the effectiveness of these monitoring techniques in achieving these objectives.

- Details of research plans and objectives for the coming year and how these will logically advance the research objectives outlined in this ABMP as well as address any refinements needed to increase effectiveness of techniques for the coming year.

For the first year of operation of the project, MMS will require bimonthly reports on the results of the anti-perching monitoring when listed avian species are potentially present in the action area (April-October). Frequency of monitoring for the second year will depend on the level of perching that was detected in the first year and will be determined by MMS in coordination with the FWS.

In addition, all collisions (with vessels, aircraft, turbines or structures) involving bird and bat species listed under federal or state endangered species laws, will be documented and reported within 24 hours to MMS (Jill Lewandowski, 703-787-1703) and FWS (Michael Amaral, 603-223-2541). With respect to state-only listed species, the applicant will be required to notify an appropriate contact (to be determined) at the Massachusetts Division of Fisheries and Wildlife. For these species, and to the extent necessary, the responsible agencies will coordinate with their respective law enforcement offices to arrange for the proper chain of custody, handling and disposition of any injured or dead specimens. Fatalities of non-listed species would be reported at least annually to MMS and the FWS, or as otherwise stipulated or conditioned by any subsequently issued salvage, collection or scientific permits. In addition to any information that may be required under other permits, minimum data collection includes standard data collected during bird and bat fatality studies at wind plants including: name of person who found carcass or witnessed incident, species, date/time, location, weather, identification of the vessel, aircraft, turbine (turbine number), or structure involved and its operational status when the strike occurred, and known or suspected cause of death (if possible) and status of carcass (complete, incomplete, scavenged, time since death [approximate], etc.). Bird/carcass photographs should also be provided when necessary to document species identification or other relevant attributes. Carcasses of non-listed species shall be retained (for examination and documentation) in a freezer in zip-lock or similar bags with the above listed information included on non-degradable paper. For any banded or marked birds, record the presence and nature of the band (number on band should be recorded) or marking and include in reports. In addition for Federal or research bands and marking, information (band or other identification number) must be reported to the USGS Bird Banding Laboratory
(see http://www.pwrc.usgs.gov/BBL/homepage/call800.htm).

Finally, all raw data will be stored according to accepted archiving practices. In addition, all reports submitted to MMS and the FWS will be made publicly available.

#### 9.3.5.5 Subtidal Offshore Resources

The applicant has proposed the use of midline buoys on anchor cables to reduce the amount of area that would be impacted by anchor cable sweep; and use of a cofferdam when constructing the HDD to minimize the dispersal of disturbed sediments and any released drilling fluid. A drilling fluid fracture or overburden breakout monitoring program would be part of the overall HHD operation in Lewis Bay. This monitoring program would serve to minimize the potential for significant impacts associated with a drilling fluid breakout in Lewis Bay since a breakout would be detected and measures taken to minimize the release of drilling fluid.

#### 9.3.5.6 Marine Mammals and Sea Turtles

This section outlines the specific mitigation, monitoring and reporting measures built into the proposed action, as part of MMS or other federal or state required conservation measures, to minimize or eliminate potential impacts to ESA-listed as well as non-ESA species of marine mammals and sea turtles.

These measures are divided into the five sections: (1) those required during all phases of the project; (2) those required during pre-construction site assessment: (3) those required during construction; (4) those required during operation/maintenance; and (5) those required during decommissioning.

**Requirements for All Phases of Project**

The following specific measures are meant to reduce the potential for vessel harassments or collisions with listed whales or sea turtles during all phases of the project:

- All vessels and aircraft associated with the construction, operation/maintenance and/or decommissioning of the project will be required to abide by the: (1) NOAA Fisheries Northeast Regional Viewing Guidelines, as updated through the life of the project (http://www.nmfs.noaa.gov/pr/pdfs/education/viewing_northeast.pdf); and (2) MMS Gulf of Mexico Region's Notice to Lessee (NTL) No. 2007-G04 (http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g04.pdf).

- All vessel and aircraft operators must undergo training to ensure they are familiar with the above requirements. These training requirements must be written into any contractor agreements.

- All vessel operators, employees and contractors actively engaged in offshore operations must be briefed on marine trash and debris awareness elimination as described in the MMS Gulf of Mexico Region's NTL No. 2007-G03 (http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g03.pdf). MMS will not require the applicant to undergo formal training or post placards, as described under this NTL. The applicant will be required to ensure that its employees and contractors are made aware of the environmental and socioeconomic impacts associated with marine trash and debris and their responsibilities for ensuring that trash and debris are not intentionally or accidentally discharged into the marine environment. The above referenced NTL provides information the applicant may use for this awareness training.

**Requirements during Pre-Construction Site Assessment Geophysical Surveys**

The following mitigation, monitoring and reporting requirements will be implemented during the conduct of all high-resolution seismic surveying work proposed by the applicant. Additional detail on how these measures will be implemented is described in the MMS Gulf of Mexico (GOM) Notice to Lessee (NTL) No. 2007-G02 (see http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2007NTLs/07-g02.pdf). Although this NTL focuses on seismic surveying with air guns in the GOM, the methodologies described in the NTL for exclusion zone monitoring, ramp up and shut down are the same as those that will be required under this proposed action.

- *Establishment of Exclusion Zone*: A 1640 ft (500 m) radius exclusion zone for listed whales and sea turtles will be established around the seismic survey source vessel in order to reduce the potential for serious injury or mortality of these species.

- *Visual Monitoring of Exclusion Zone*: The exclusion zone around the seismic survey source vessel must be monitored for the presence of listed whales or sea turtles before, during and after any pile driving activity. The exclusion zone will be monitored for 30 minutes prior to the ramp up (if applicable) of the seismic survey sound source. If the exclusion zone is obscured by fog or poor lighting conditions, surveying will not be initiated until the entire exclusion zone is visible for the 30 minute period. If listed whales or sea turtles are observed within the zone during the 30 minute period and before the ramp up begins, surveying will be delayed until they move out of the area and until at least an additional 30 minutes have passed without a listed whale or sea turtle sighting. Monitoring of the zone will continue for 30 minutes following completion of the seismic surveying. Monitoring of the zones will be conducted by one qualified NMFS approved observer. Visual observations will be made using binoculars or other suitable equipment during daylight hours. Data on all observations will be recorded based on standard marine mammal observer collection data. This will include: dates and locations of construction operations; time of observation, location and weather; details of marine mammal sightings (e.g., species, numbers, behavior); and details of any observed taking (behavioral disturbances or injury/mortality). Any significant observations concerning impacts on listed whales or sea turtles will be transmitted to NMFS and MMS within 48 hours. Any observed takes of listed whales or sea turtles resulting in injury or mortality will be immediately reported to NMFS and MMS.

- *Implementation of Ramp Up*: A "ramp up" (if allowable depending on specific sound source) will be required at the beginning of each seismic survey in order to by allowing them to vacate the area prior to the commencement of activities. Seismic surveys may not commence (i.e., ramp up) at night time or when the exclusion zone cannot be effectively monitored (i.e., reduced visibility).

- *Shut Down*: Continuous (day and night) seismic survey operations will be allowed. However, if a listed whale or sea turtle is spotted within or transiting towards the exclusion zone surrounding the sub-bottom profiler and the survey vessel, an immediate shutdown of the equipment will be required. Subsequent restart of the profiler will only be allowed following clearance of the exclusion zone and the implementation of ramp up procedures (if applicable).

- *Compliance with Equipment Noise Standards*: All seismic surveying equipment will comply as much as possible with applicable equipment noise standards of the U.S.

- *Reporting for Seismic Surveys Activities*: The following reports must be submitted during the conduct of seismic surveys: (1) A report will be provided to MMS and NMFS within 90 days of the commencement of seismic survey activities that includes a summary of the seismic surveying and monitoring activities and an estimate of the number of listed whales and sea turtles that may have been taken as a result of seismic survey activities. The report will include information, such as: dates and locations of operations, details of listed whale or sea turtle sightings (dates, times, locations, activities, associated seismic activities), and estimates of the amount and nature of listed whale or sea turtle takings; and (2) Any observed injury or mortality to a listed whale or sea turtle must be reported to NMFS and MMS within 24 hours of observation. Any significant observations concerning impacts on listed whales or sea turtles will be transmitted to NMFS and MMS within 48 hours.

**Requirements during Construction**

MMS has included the following specific measures as part of the proposed action and are meant to reduce or eliminate the potential for adverse impacts on listed whales or sea turtles during the construction phase of the project:

- *Pre-Construction Briefing*: Prior to the start of construction, a briefing will be held between the construction supervisors and crews, the marine mammal and sea turtle visual and acoustic observer(s) (see further below), and Cape Wind Associates. The purpose of the briefing will be to establish responsibilities of each party, define the chains of command, discuss communication procedures, provide an overview of monitoring purposes, and review operational procedures. The Resident Engineer will have the authority to stop or delay any construction activity, if deemed necessary. New personnel will be briefed as they join the work in progress.

- *Requirements for Pile Driving*: The following measures will be implemented during the conduct of pile driving activities related to turbine monopile and Electrical Service Platform (ESP) installation:

  - Establishment of Exclusion Zone: A preliminary 2,461 ft (750 m) radius exclusion zone for listed whales and sea turtles will be established around each pile driving site in order to reduce the potential for serious injury or mortality of these species. Once pile driving begins, the actual generated sound levels will be measured (see requirements below for *Field Verification of Zone*) and a new exclusion zone will be established based on the results of these field-verified measurements. This new exclusion zone will be based on the field inputs calculating the actual distance from the pile driving source where underwater sound levels are anticipated to equal or exceed 180 dB re 1 microPa rms (impulse). Based on the outcome of the field-verified sound levels and the calculated or measured distances as noted above, the applicant can either: (1) retain the 750 m zone or (2) establish a new zone based on field-verified measurements demonstrating the distance from the pile driving source where underwater SPLs are anticipated to equal or exceed the received the 180 dB re 1 microPa rms (impulse). Any new exclusion zone radius must be based on the most conservative measurement (i.e., the largest safety zone configuration), include an additional 'buffer' area extending out of the 180 dB zone and be approved by MMS and NMFS before implementing. Once approved, this zone will be used for all subsequent pile driving and will be periodically re-evaluated based on the regular sound monitoring described in the *Field Verification of Exclusion Zone* section described below.

  - Field Verification of Exclusion Zone: Field verification of the exclusion zone will take during pile driving of the first three piles. The results of the measurements from the first three piles can then be used to establish a new exclusion zone which is greater than or less than the 2460 ft (750 m) depending on the results of the field tests. Acoustic measurements will take place during the driving of the last half (deepest pile segment) for any given open-water pile. One reference location will be established at a distance of 328 ft (100 m) from the pile driving. Sound measurements will be taken at the reference location at two depths (a depth near the mid-water column and a depth near the bottom of the water column but at least 3 ft [1 m] above the bottom) during the driving of the last half (deepest pile segment) for any given pile. Two additional in-water spot measurements will be conducted at appropriate depths (near mid water column), generally 1,640 ft (500 m) and 2,461 ft (750 m) in two directions either west, east, south or north of the pile driving site. These will be conducted at the same two depths as the reference location measurements. In cases where such measurements cannot be obtained due to obstruction by land mass, structures or navigational hazards, measurements will be conducted at alternate spot measurement locations. Measurements will be made at other locations either nearer or farther as necessary to establish the approximate distance for the zones. Each measuring system shall consist of a hydrophone with an appropriate signal conditioning connected to a sound level meter and an instrument grade digital audiotape recorder (DAT). Overall SPLs shall be measured and reported in the field in dB re 1 micro-Pa rms (impulse). An infrared range finder will be used to determine distance from the monitoring location to the pile. The recorded data will be analyzed to determine the amplitude, time history and frequency content of the impulse.

- Visual Monitoring of Exclusion Zone: Visual monitoring of the exclusion zone will be conducted during driving of all piles. Monitoring of the zones will be conducted by one qualified NMFS approved observer. Multiple monitors will be required if pile driving is occurring at multiple locations at the same time. Observer(s) will begin monitoring at least 30 minutes prior to soft start of the pile driving. Pile driving will not begin until the zone is clear of all listed whales and sea turtles for at least 60 minutes. Monitoring will continue through the pile driving period and end approximately 30 minutes after pile driving is completed. Visual observations will be made using binoculars or other suitable equipment during daylight hours. Data on all observations will be recorded based on standard marine mammal observer collection data. This will include: dates and locations of construction operations; time of observation, location and weather; details of marine mammal sightings (e.g., species, numbers, behavior); and details of any observed taking (behavioral disturbances or injury/mortality). Any significant observations concerning impacts on listed whales or sea turtles will be transmitted to NMFS and MMS within 48 hours. Any observed takes of listed whales or sea turtles resulting in injury or mortality will be immediately reported to NMFS and MMS.

- Required Mitigation Should Listed Whales or Sea Turtles Enter the Exclusion Zone: The exclusion zone around the pile driving activity must be monitored for the presence of listed whales or sea turtles before, during and after any pile driving activity. The exclusion zone will be monitored for 60 minutes prior to the soft start of pile driving. If the safety radius is obscured by fog or poor lighting conditions, pile driving will not be initiated until the entire safety radius is visible for the 60 minute period. If listed whales or sea turtles are observed within the zone during the 60 minute period and before the soft start begins, pile driving of the segment will be delayed until they move out of the area and until at least an additional 30 minutes have passed without a listed whale or sea turtle sighting. Monitoring of the zone will continue for 30 minutes following completion of the pile driving activity. MMS recognizes that once the pile driving of a segment begins it cannot be stopped until that segment has reached its predetermined depth due to the nature of the sediments underlying the Sound. If pile driving stops and then resumes, it would potentially have to occur for a longer time and at increased energy levels. In sum, this would simply amplify impacts to listed whales and sea turtles, as they would endure potentially higher SPLs for longer periods of time. Pile segment lengths and wall thickness have been specially designed so that when work is stopped between segments (but not during a single segment), the pile tip is never resting in highly resistant sediment layers. Therefore, because of this operational situation, if listed whales or sea turtles enter the zone after pile driving of a segment has begun, pile driving will continue and observers will monitor and record listed whale and sea turtle numbers and behavior. However, if pile driving of a segment ceases for 30 minutes or more and a listed whale or sea turtle is sighted within the designated zone prior to commencement of pile driving, the observer(s) must notify the Resident Engineer (or other authorized individual) that an additional 30 minute visual and acoustic observation period will be completed, as described above, before restarting pile driving activities. In addition, pile driving may not be started during night hours or when the safety radius can not be adequately monitored (i.e., obscured by fog, inclement weather, poor lighting conditions) unless the applicant implements an alternative monitoring method that is agreed to by MMS and NMFS. However, if a soft start has been initiated before dark or the onset of inclement weather, the pile driving of that segment may continue through these periods. Once that pile has been driven, the pile driving of the next segment cannot begin until the exclusion zone can be visually or otherwise monitored.

- Implementation of Soft Start: A “soft start” will be required at the beginning of each pile installation in order to provide additional protection to listed whales and sea turtles near the project area by allowing them to vacate the area prior to the commencement of pile driving activities. The soft start requires an initial set of 3 strikes from the impact hammer at 40 percent energy with a one minute waiting period between subsequent 3-strike sets. If listed whales or sea turtles are sighted within the exclusion zone prior to pile driving, or during the soft start, the Resident Engineer (or other authorized individual) will delay pile-driving until the animal has moved outside the exclusion zone.

- Compliance with Equipment Noise Standards: All construction equipment will comply as much as possible with applicable equipment noise standards of the U.S. Environmental Protection Agency, and all construction equipment will have noise control devices no less effective than those provided on the original equipment.

• *Reporting for Construction Activities*: The following reports must be submitted during construction:

  - Prior to any re-establishment of the exclusion zone, a report must be provided to MMS and NMFS detailing the field verification measurements and proposal for the new exclusion zone. This includes information, such as: a fuller account of the levels, durations, and spectral characteristics of the impact and vibratory pile driving sounds; and the peak, rms, and energy levels of the sound pulses and their durations as a function of distance, water depth, and tidal cycle. Any new zone may not be implemented until MMS and NMFS have reviewed and approved any changes.

- Weekly status reports will be provided to MMS and NMFS that include a summary of the previous week's monitoring activities and an estimate of the number of listed whales and sea turtles that may have been taken as a result of pile driving activities. These reports will include information, such as: dates and locations of construction operations, details of listed whale or sea turtle sightings (dates, times, locations, activities, associated construction activities), and estimates of the amount and nature of listed whale or sea turtle takings. NMFS and MMS may reduce or increase the frequency of this reporting throughout the time period of pile driving activities dependent upon the outcome of these initial weekly reports.

- Any observed injury or mortality to a listed whale or sea turtle must be reported to NMFS and MMS within 24 hours of observation. Any significant observations concerning impacts on listed whales or sea turtles will be transmitted to NMFS and MMS within 48 hours.

- A final technical report within 120 days after completion of the pile driving and construction activities will be provided to MMS and NMFS that provides full documentation of methods and monitoring protocols, summarizes the data recorded during monitoring, estimates the number of listed whales and sea turtles that may have been taken during construction activities, and provides an interpretation of the results and effectiveness of all monitoring tasks.

• *Requirements for Cable Laying*: The following measures will be implemented during the conduct of cable laying activities:

  - The applicant must contact NMFS and MMS within 24-hours of the commencement of jet plowing activities and again within 24-hours of the completion of the activity.

  - All interactions with listed whales or sea turtles during cable laying activities must be reported to NMFS and MMS within 24 hours.

  - A final report must be submitted to NMFS and MMS within 60 days of completing cable laying activities which summarizes the results and any takes of listed species.

**Requirements during Operation/Maintenance**

Nedwell et al. (In press) measured and assessed the underwater noise and potential impacts to marine life during the construction and operations/maintenance phases of four offshore wind parks located in U.K. waters. For the operations/maintenance phase, they concluded that in general the level of underwater noise from the operation of a wind facility was very low and not above ambient levels even in close proximity to the turbines. Therefore, the underwater noise from the operation of offshore wind farms was unlikely to result in any behavioral response for the marine mammals and fish assessed in this study.

Given these results, the main mitigation required for the operations/maintenance phase of the proposed project will include the vessel and aircraft measures outlined previously. A yearly status report will also be provided to MMS that includes a summary of the year's operation and maintenance activities. In addition, any observed injury or mortality to a listed whale or sea turtle must be reported to NMFS and

MMS within 24 hours of observation. Any significant observations concerning impacts on listed whales or sea turtles will be transmitted to NMFS and MMS within 48 hours.

**Requirements during Decommissioning**

The applicant would be required to remove all project components once operations have ceased and must provide a financial instrument or other assurances which secure this obligation. As discussed in Section 2.5 the applicant is required to submit a decommissioning plan to MMS for approval which satisfactorily demonstrates the removal and recycling of equipment and associated materials thereby returning the area to pre-existing conditions. MMS will consult with NOAA Fisheries prior to approval of this plan to ensure the plan's components are covered under any ESA biological opinion issued on this project and that any additional mitigation and monitoring measures are identified and implemented.

**Authorization under the Marine Mammal Protection Act**

The applicant has informed MMS that it intends to seek authorization from NOAA Fisheries under the Marine Mammal Protection Act (MMPA). Therefore, MMS will require that the MMPA authorization be completed and a copy provided to MMS before activities are allowed to commence under any MMS issued lease or other authority that may result in the taking of marine mammals. This also includes any amended ESA incidental take statement, if issued, to include marine mammals. Any measures contained within any MMPA authorization, if issued, that are more conservative than those measures built into this proposed action will take precedence.

### *9.3.5.7 Port Facilities*

The applicant has proposed mitigation measures specific to navigation including the notification of registered fishermen regarding the timeframe and location of construction activities in advance of mobilization; and daily broadcasted updates providing information on marine channel 16 to provide current information on construction activities as well as information for following days; the lighting of monopoles and construction vessels; and the spacing and placement of monopoles to allow for safe navigation. Since jurisdiction over navigation and port safety as well as rules and regulations for navigation of vessels in U.S. waters lies with the USCG, ultimate decisions about the adequacy of these measures, the ability to implement them, or the requirement for different procedures or design features lies with the USCG, not MMS. Refer also to USCG Terms and Conditions in Appendix B.

### *9.3.5.8 Communications: Electromagnetic Fields, Signals and Beacons*

The applicant proposes the following mitigation to minimize impacts to communications: construction crews would be required to avoid the frequencies listed in Table 5.3.4-1. VHF radios used for construction should be tested for output to ensure that they are not inadvertently tuned to any of these frequencies, and to ensure that they have no spurious emission within +/-50 KHz.

As a precaution, watercraft would be advised by the applicant or its contractors to respect a two-wavelength distance from the cranes at the lowest frequency of interest, which would be approximately 4,000 ft (1,219.5 m) on 500 KHz.

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# 12.0 GLOSSARY

**Acoustic backscatter device:** Instrument that uses sound waves to collect measurement data to generate images (e.g., of the seafloor).

**Airgun:** A device that releases compressed air into the water column, creating an acoustical energy pulse with the purpose of penetrating the seafloor.

**Air quality:** Assessment of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances. Air quality standards are the prescribed levels of substances in the outside air that cannot be exceeded during a specific time in a specified area.

**Alternating current (AC):** A flow of electrical current that increases to a maximum in one direction, decreases to zero, and then reverses direction and reaches maximum in the other direction. The cycle is repeated continuously. The number of such cycles per second is equal to the frequency, measured in Hertz (Hz). U.S. commercial power is 60 Hz.

**Alternative energy:** For the purposes of this EIS, alternative energy is defined as energy derived on the OCS from other than what are generally considered conventional sources of energy (e.g., nuclear, fossil fuels). Possible sources include wind, solar, biomass, wave, ocean current, hydrogen, and tidal energy. The term is often used interchangeably with *renewable energy*.

**Ambient noise level:** Environmental background noise composed of contributions from various sources at both near and far distances.

**Ambient ocean noise:** The sound profile within the ocean composed of both far and near sound sources of both natural and anthropogenic origin. Ambient ocean noise is also referred to as *environmental background noise*.

**Amplitude:** The maximum absolute value of a periodic curve measured along its vertical axis. For sound waves, it is the maximum amount that the wave's pressure differs from ambient pressure in the medium through which the sound wave is propagating.

**Anadromous:** Pertaining to fish that spawn in freshwater after spending most of their lives in saltwater.

**Anthropogenic:** Human made; produced as a result of human activities.

**Anticline:** A fold in layers of rock caused by deformation. The older strata are found toward the center of the fold.

**Anticyclone:** Clockwise-rotating eddies in oceans of the northern hemisphere. Anticyclones generally migrate westward and transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern Gulf.

**Aquaculture:** Farming of organisms, such as fish, shellfish, and algae that live in water.

**Areas of Special Concern:** Areas managed by the Bureau of Land Management (BLM) and defined by the Federal Land Policy and Management Act of 1976 as having significant historical, cultural, and scenic values; habitat for fish and wildlife; and other public land resources, as identified through the BLM's land-use planning process.

**Array:** The layout or arrangement of objects in a specific pattern, often in rows and columns.

**Attenuation:** Reduction; in this document, reduction of the level or intensity of sound.

**Attenuator:** Wave energy conversion device with a long, multisegment floating structure oriented parallel to the direction of the waves. The differing heights of waves along the length of the device causes flexing where the segments connect, and this flexing is connected to hydraulic pumps or other converters.

**Bathymetry:** Topography of the ocean floor indicated by depth contours drawn at regular intervals.

**Bathypelagic:** Pertaining to the subzone of the pelagic zone that generally includes waters deeper than 1,000 m (3,300 ft). At this depth, there is little to no light, and photosynthesis is not possible. Consequently, there are no living plants, and most animals survive by consuming detritus falling from the pelagic zones above or by preying on other animals.

**Benthic:** Of, relating to, or occurring at the bottom of a body of water.

**Biota:** The combined flora and fauna of a region.

**Bureau of Land Management (BLM):** An agency of the U.S. Department of the Interior responsible for managing public lands.

**Bycatch:** Nontarget organisms caught in fishing or other harvest operations and usually discarded.

**Candidate species:** Plants and animals for which the U.S. Fish and Wildlife Service has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act, but for which development of a listing regulation is precluded by other higher-priority listing activities.

**Capacity factor:** The actual energy output of an electricity-generating device divided by the energy output that would be produced if it operated at its rated power output for the entire year.

**Cape (spit):** A type of sand bar or beach that is built out from the shore by deposition of sediment (typically sand) carried in the longshore current; these landforms have a characteristic "hook" shape when viewed from above (e.g., Cape Cod).

**Carbon monoxide (CO):** A colorless, odorless gas formed when carbon in fuel is not burned completely. Motor vehicle exhaust is a major contributor to nationwide CO emissions, followed by nonroad engines and vehicles. CO interferes with the blood's ability to carry oxygen to the body's tissues and results in numerous adverse health effects. CO is listed as a criteria air pollutant under Title I of the Clean Air Act.

**Catadromous:** Term used to describe fishes that spend most of their adult lives in freshwater but migrate to the marine environment to spawn.

**Cavitation:** The sudden formation and subsequent collapse of low-pressure bubbles of air in fluids that are moving as a result of applied mechanical forces. The phenomenon of cavitation is the single largest contributor to underwater sound from ship propellers.

**Cetacean:** Any of various aquatic, chiefly marine mammals of the order Cetacea, including the whales, dolphins, and porpoises, which are characterized by a nearly hairless body, anterior limbs modified into broad flippers, vestigial posterior limbs, and a flat notched tail.

**Clastic:** Sediments composed of pieces of pre-existing rock.

**Clathrate:** Layer of frozen gas hydrate on the seafloor.

**Clean Air Act (CAA):** An act that establishes National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: sulfur oxides ($SO_X$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), ozone ($O_3$), particulate matter ($PM_{10}$ and $PM_{2.5}$), and lead (Pb). Collectively, the criteria pollutants are indicative of the quality of the ambient air. The Act requires facilities to comply with emission limits or reduction limits stipulated in State Implementation Plans (SIPs). Under this Act, construction and operating permits, as well as reviews of new stationary sources and major modifications to existing sources, are required. The Act also prohibits the Federal Government from approving actions that do not conform to SIPs.

**Clean Water Act (CWA):** An act that requires National Pollutant Discharge Elimination System permits for discharges of effluents to surface waters, permits for stormwater discharges related to industrial activity, and notification of oil discharges to navigable waters of the United States.

**Coastal:** An imprecise area of land and water located at the interface between the shore and the ocean, where physical, chemical, and biological processes occur as interactions between these two ecosystems or because of their proximity to each other.

**Coastal State:** A State bordering the Atlantic or Pacific Oceans, or the Gulf of Mexico.

**Coastal Zone Management Act (CZMA):** 16 USC 1451 et seq. The CZMA regulates development in coastal areas to protect their unique resources.

**Coastal Zone Management Act Consistency Determination:** A finding that an activity that affects land or water uses or natural resources in a State's coastal zone is in compliance with that State's Federally approved Coastal Zone Management Act Program. Federal Agencies must be consistent to the maximum extent practicable.

**Code of Federal Regulations (CFR):** A compilation of the general and permanent rules published in the *Federal Register* by the executive departments and agencies of the United States. Each volume of the CFR is updated once each calendar year and is issued quarterly.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):** The Federal law that guides cleanup of hazardous waste sites. Also known as Superfund.

**Continental margin:** A collective term referring to the continental shelf and continental slope.

**Continental rise:** A broad, gently dipping depositional plain that extends from the base of the continental slope from a depth of about 2,000 m (6,600 ft) to more than 5,000 (16,400 ft).

**Continental shelf:** The shallow, gradually sloping seabed around a continental margin, usually no deeper than 200 m (660 ft) and formed by the submergence of part of a continent.

**Continental slope:** Region of the outer edge of a continent between the generally shallow continental shelf and the deep ocean floor, usually demarcated by the 200-m (660-ft) isobath (the line on a map or chart that connects all points having the same depth below the surface of a body of water).

**Criteria air pollutant:** A group of very common air pollutants whose presence in the environment is regulated by the U.S. Environmental Protection Agency (EPA) on the basis of certain criteria (information on health and/or environmental effects of pollution). Criteria air pollutants are widely distributed all over the United States.

**Critical habitat:** The specific area within the geographical area occupied by a species at the time it is listed as an endangered or threatened species. The area in which physical or biological features essential to the conservation of the species is found. These areas may require special management or protection.

**Cumulative impacts:** In an environmental impact statement, cumulative impacts are impacts that result from incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or nonfederal), private industry, or individual undertakes these actions. They are impacts that can result from individually minor but collectively significant actions over a period of time.

**Decibel (dB):** A standard unit for the measure of the relative loudness or intensity of sound. The relative intensity is the ratio of the intensity of a sound wave to a reference intensity. In general, a sound doubles in loudness with every increase of 10 dB. By convention, the intensity level of sound at the threshold of hearing for a young healthy individual is 0 dB.

**Decibel A-weighted:** A sound measurement scale biased toward sounds with frequencies within the average auditory range of humans.

**Decibel B-weighted:** A sound measurement scale biased toward loud high and middle frequency sound.

**Decibel C-weighted:** A sound measurement scale biased toward very loud frequency sound.

**Decibel D-weighted:** A sound measurement scale biased toward very loud sounds particularly associated with aircraft.

**Decommissioning:** The activities necessary to take out of service and dispose of a facility after its useful life.

**Delta:** An area formed from the deposition of sediments at the mouth of a river.

**Demersal fishes:** Those fishes that spend at least the adult portion of their life cycle in association with the ocean bottom.

**Dendritic drowned river valleys:** River valleys, currently under water, that have a multibranching, tree-like form when viewed from above (e.g., Chesapeake Bay).

**Depauperate fauna:** A fauna, especially common on islands, lacking many species found in similar habitats elsewhere.

**Deposition:** The laying down of matter by a natural process (e.g., the settling of particulate matter out of air or water onto soil or sediment surfaces).

**Detritus:** Dead, decaying plant material.

**Dewater:** To remove or drain water from an area.

**Diadromous fishes:** Those fishes that spend a portion of their life cycle in freshwater and a portion in saltwater.

**Diapir:** Intrusion of fluid rock (e.g., molten rock, salt, or mud) caused by the difference in buoyancy and pressure between it and the overlying rock.

**Direct current (DC):** Electric current that flows in one direction only.

**Dissolved oxygen concentration:** The concentration of oxygen in a water sample.

**Distinct Population Segment (DPS):** "Population" or "distinct population segment" are terms with specific meaning under the Endangered Species Act when used for listing, delisting, and reclassification purposes to describe a discrete vertebrate stock that may be added or deleted from the list of threatened and endangered species.

**Diurnal:** Having a daily cycle or occurring every day.

**Domestic:** Produced in or indigenous to a particular country.

**Earthquake:** A sudden ground motion or vibration produced by a rapid release of stored energy; may occur on land or on the seafloor (submarine).

**Easement:** Authorization for the use, for a specified purpose, of land that is not owned by the user. For the OCS, a right of use and easement usually refer to the authorization by the Minerals Management Service (MMS) to an operator for the construction and maintenance of a structure or structures on OCS lands not subject to a lease granted to the operator.

**Echolocation:** The use of reflected sound waves by some animals to gather critical information such as the location of obstructions, predators, or food, or for purposes of reproduction.

**Ecoregion:** A geographically distinct area of land that is characterized by a distinctive climate, ecological features, and plant and animal communities.

**Ecosystem:** A group of organisms and their physical environment interacting as an ecological unit.

**Eolian sediments:** Sediments or structures (sand dunes) deposited by wind.

Electrical Service Platform (ESP): A stationary structure located approximately in the center of the wind farm. It is the common electrical interconnection point for all of the turbines in the array. The ESP provides electrical protection and voltage step-up transformers

**Electromagnetic field (EMF):** The field of energy resulting from the movement of alternating electric current (AC) along the path of a conductor, composed of both electrical and magnetic components and existing in the immediate vicinity of, and surrounding, the electric conductor. Electromagnetic fields exist in both high-voltage electric transmission power lines and in low-voltage electric conductors in homes and appliances.

**Embayment:** A small bay or any small semi-enclosed coastal water body in which the opening to a larger body of water is restricted.

**Endangered Species Act of 1973 (ESA):** An act that requires consultation with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service to determine if endangered or threatened species or their habitats would be affected by a proposed activity and what, if any, mitigation measures are needed to address the impacts.

**Endangered species:** Any species, plant or animal, that is in danger of extinction throughout all or a significant part of its range. Requirements for declaring a species endangered are found in the Endangered Species Act.

**En-echelon fold:** The steplike configuration of folded rock units at the continental margin formed by compressional tectonic forces.

**Energy Policy Act of 2005:** A bill passed in August 2005 that includes new authority (Section 388) for the MMS to regulate alternative energy resources on the Outer Continental Shelf.

**Energy:** The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy) or heat.

**Environmental Impact Statement (EIS):** A document required of Federal agencies by the National Environmental Policy Act for major proposals or legislation that would or could significantly affect the environment.

**Environmental Justice:** The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

**Epibenthic:** Living on the bottom surface of lakes or the ocean.

**Epifaunal:** A community of marine organisms that live attached to hard substrates or move around and live on hard substrates

**Epipelagic:** Pertaining to a subzone of the pelagic zone where there is enough light for photosynthesis. Generally includes waters from the surface to approximately 200 m (660 ft) in depth.

**Essential Fish Habitat (EFH):** Waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. The term is specifically associated with the Magnuson-Stevens Fishery Conservation and Management Act.

**Estuary:** A transitional zone along the coastline where ocean saltwater mixes with freshwater from the land. Two prominent estuaries in the mid-Atlantic region are the Chesapeake and Delaware Bays.

**Eutrophication:** A condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae (e.g., phytoplankton). Algal decomposition may lower dissolved oxygen concentrations. Although eutrophication is a natural process in the aging of lakes and some estuaries, it can be accelerated by both point and nonpoint sources of nutrients.

**Evaporite:** A sedimentary rock formed when a saline solution evaporates. Evaporites are typically formed when a saline lake dries up or evaporation occurs in tidal marshes in hot, arid climates.

**Executive Order 12898:** An executive order, signed in 1994, establishing environmental justice as a Federal Government priority and directing all Federal agencies to make environmental justice part of their mission. Environmental justice calls for fair distribution of environmental hazards.

**Executive Order 13158:** An executive order, signed in 2000, establishing the National Marine Protected Areas Initiative.

**Extralimital:** Known on the basis of only a few records that probably resulted from unusual wanderings of animals into the region.

**Fault:** A fracture in the earth's crust accompanied by displacement of one side of the fracture with respect to the other and in a direction parallel to the fracture.

**Fluvial:** Pertaining to rivers. Fluvial sediments are deposited by rivers.

**Fouling:** A generic term for the invertebrate community that grows attached to hard substrates, including such organisms as sponges, tunicates, hydroids, bryozoans, serpulid worms, etc.

**Frequency (pitch):** For sound waves, frequency is the rate at which the source-producing sound wave is vibrating or the rate at which the sound-producing body completes one vibration cycle. Frequency is expressed in units of Hertz (Hz), where one Hz is equal to one complete vibration cycle per second.

**Gas hydrates:** Gas molecules (e.g., methane) trapped in water-ice "cages" in subsea deposits.

**Gauss:** Unit of magnetic induction; pronounced "gows," abbreviated "G."

**Geology:** The study of the materials, processes, environments, and history of the earth, including rocks and their formation and structure.

**Gulf Stream:** The powerful, warm, and swift Atlantic Ocean current that is the western boundary current of the North Atlantic subtropical gyre (the clockwise circulation pattern produced by the earth's rotation). After passing Cape Hatteras, the Gulf Stream flows northeast toward Europe.

**Habitat:** The place where a plant or animal lives.

**Haulout:** An area where marine mammals such as seals regularly come out of the water to rest. These typically occur on beaches, offshore rocks, and islands. In urban areas, structures such as docks may be used. Once established, haulouts may be used on a seasonal or year-round basis by up to several thousand individuals, depending on the species.

**Hazardous materials:** Materials, including nonwaste substances, that, because of their quantity, concentration, or physical, chemical, or infectious characteristics, may present substantial danger to public health or welfare or the environment if they are improperly managed or released into the environment. Such materials may be transported to and from, stored at, and/or used at alternative energy and alternate use project sites approved on the OCS.

**Hummock-and-hollow microtopography:** A feature of tidal swamp habitats where areas above the highest tide level provide stable substrates for the establishment of trees and microhabitats for forest herbs adapted to moderately moist environments.

**Hydrocarbon:** Any compound or mix of compounds—solid, liquid, or gas—composed of carbon and hydrogen (e.g., coal, crude oil, and natural gas).

**Hypoxia:** The condition of having low dissolved oxygen concentration; in water, it is caused by excessive nutrients and other oxygen-demanding contaminants.

**Infrasound:** Low-frequency sound, including frequencies below the lower limit of human auditory response; by convention, sound with frequencies of less than 16 Hz.

**Intensity:** For sound, intensity is the measure of the amount of energy that is transported over a given area per unit of time. Sound intensity is expressed in units of $W/m^2$.

**Intertidal zone:** The area of the foreshore and seabed that is exposed at low tide and submerged at high tide (i.e., the area between tide marks).

**Invertebrate:** An organism lacking a backbone or spinal column. Any animal other than a fish, amphibian, reptile, bird, or mammal.

**Inverse Square Law:** The mathematical expression describing the decrease in the mean square pressure level of a sound wave over distance. Under ideal conditions, sound pressure levels decrease by 6 dB for every doubling of distance from the sound source.

**Jacketed Structure:** Steel framed tubular structure attached to the seafloor with piles that are driven into the seafloor.

**Jetting:** The process of injecting high pressure water into sediments to loosen and liquefy them as a means of creating seafloor conditions that allow a cable or pipeline to sink below the bottom as an alternative to dredging a trench.

**Lacustrine:** Pertaining to the sedimentary environment of a lake.

**Lead (Pb):** A gray-white metal that is listed as a criteria air pollutant. Health effects from exposure to lead include brain and kidney damage and learning disabilities.

**Lease:** A legal document executed between a landowner, as lessor, and a company or individual (as lessee) that conveys the right to exploit the premises for minerals or other resources for a specified period of time over a given area.

**Liquefaction:** Process by which wet sediments are transformed into an unstable, dense fluid during an earthquake.

**Littoral:** Of or pertaining to the shore, especially of the sea; coastal.

**Localized:** In close proximity to where work is being conducted.

**Logarithmic:** A mathematical term for the ratio of values expressed by the base 10 or e. If the base is 10, the logarithm is called *common*. If the base is e, the logarithm is called *natural*. Human perception of the amplitude or "loudness" of sound follows a logarithmic, rather than a linear, relationship. For every increase in sound loudness perceived as a simple additive quantity, the loudness or amplitude actually increases as a multiplier of the initial amplitude.

**Longitudinal wave:** A wave in which the deformation of the medium through which the wave is passing involves motion of individual particles comprising the medium only in the direction in which energy wave is moving. Sound propagates through liquids and gases primarily as longitudinal waves.

**Longshore (littoral) current:** A current generated by waves intersecting the coastline at an oblique angle. It travels along the coastline.

**Longshore (littoral) drift:** Material (e.g., gravel, sand, and shell fragments) that is moved along the shore by a littoral current.

**Loop Current:** The principal current in the Gulf of Mexico.

**Marine Protected Area (MPA):** A marine area established as protected under Executive Order 13158.

**Marine transgression:** The influx of seawater over previously exposed land.

**Mass movement:** The geomorphic process by which soil or rock move down slope under the force of gravity; examples include slumping or landslides.

**Meander:** To wander between two points; to not follow a straight line.

**Megawatt:** A unit of power equal to 1,000 watts.

**Meiofauna:** A nontaxonomic term for invertebrates larger than microfauna but smaller than macrofauna. Generally defined as organisms that can pass through a 1-mm mesh sieve but would be retained by a 45-µm mesh, interstitial meiofauna are those invertebrates that live between (i.e., within the interstices of) sediment particles.

**Mesoscale variability:** Variability that occurs within a time frame of one to two months, with a horizontal scale of a few hundred kilometers.

**Meteorological tower:** A tower containing equipment designed to measure wind speeds and determine whether a site is suitable for a wind turbine.

**Monopile:** A long, hollow, steel tube driven into the seabed to support a wind turbine or current generator.

**Moratorium:** Delay; a period during which certain proceedings or obligations are suspended.

**Mysticetes:** The suborder of whales that includes baleen whales.

**Nacelle:** The housing of a wind turbine that protects the major components (e.g., generator and gear box).

**National Ambient Air Quality Standards (NAAQS):** Air quality standards established by the Clean Air Act, as amended. The primary NAAQS specify maximum outdoor air concentrations of criteria pollutants to protect public health within an adequate margin of safety. The secondary NAAQS specify maximum concentrations that would protect the public welfare from any known or anticipated adverse effects of a pollutant.

**National Environmental Policy Act of 1969 (NEPA):** An act requiring Federal agencies to prepare a detailed statement on the environmental impacts of proposed major actions significantly affecting the quality of the environment.

**National Historic Preservation Act:** A Federal statute that established a Federal program to further the efforts of private agencies and individuals in preserving the nation's historic and cultural foundations.

**National Marine Fisheries Service (NMFS):** A Federal agency that is a part of the U.S. National Oceanic and Atmospheric Administration, or NOAA. NMFS is responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. NMFS is currently referred to as NOAA Fisheries.

**National Oceanic and Atmospheric Administration (NOAA):** A Federal agency that manages commercial and recreational fisheries within Federal waters and designates Essential Fish Habitat to help conserve Gulf fishery resources.

**Nitrogen dioxide ($NO_2$):** A reddish-brown gas that is a strong oxidizing agent, produced by combustion (as of fossil fuels). The reactive oxides of nitrogen in the atmosphere are largely NO and $NO_2$, known together as $NO_X$. During the day, there exists a rapid interconversion of NO and $NO_2$ (see "Nitrogen oxides [$NO_X$]"). $NO_2$ is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

**Nitrogen oxides ($NO_X$):** Nitrogen oxides include various nitrogen compounds, primarily nitric oxide (NO) and nitrogen dioxide ($NO_2$). They form when fossil fuels are burned at high temperatures and react with volatile organic compounds to form ozone, the main component of urban smog. They are also precursor pollutants that contribute to the formation of acid rain and to impairment of visibility.

**Noise:** Unwanted sound; a subjective term reflective of societal values regarding what constitutes unwanted or undesirable intrusions of sound.

**Nonattainment area:** The EPA's designation for an air quality control region (or portion thereof) in which ambient air concentrations of one or more criteria pollutants exceed National Ambient Air Quality Standards.

**Nonhazardous waste:** Routinely generated waste, including general facility refuse such as paper, cardboard, glass, wood, plastics, scrap, metal containers, dirt, and rubble. Nonhazardous waste is segregated and recycled whenever possible.

**Nonlisted species:** Species that are not listed as threatened or endangered by State or Federal agencies.

**Ocean current:** Continuous forward movement of ocean water driven by wind and solar heating of the waters near the equator, although some ocean currents result instead from variations in water density and salinity.

**Outer Continental Shelf (OCS):** The part of the continental shelf beyond the line that marks State ownership; that part of the offshore lands under Federal jurisdiction.

**Outer Continental Shelf (OCS) lands:** Offshore lands located outside of State coastal waters. Generally, OCS lands begin approximately 3.3 geographical mi offshore with respect to coastal States, except in the cases of Texas and the west coast of Florida, where OCS lands begin approximately 10.2 geographical mi offshore.

**Outer Continental Shelf Lands Act (OCSLA), as amended:** An act authorizing the U.S. Department of the Interior to regulate activities related to the development of mineral resources on the OCS.

**Outfall:** Structure (e.g., pipe) that discharges wastewater to a natural water body.

**Overtopping device:** A wave energy conversion device with reservoirs that are filled by incoming waves to levels above the average surrounding ocean. The water is then released, and gravity causes it to fall back toward the ocean surface. The energy of the falling water is used to turn hydroturbines.

**Ozone ($O_3$):** A strong-smelling, reactive gas consisting of molecules composed of three oxygen atoms. It is formed in the atmosphere by chemical reactions involving nitrogen oxides and volatile organic compounds in sunlight. A major constituent of smog, it can impair the respiratory system and damage plants and ecosystems. Ozone is a criteria air pollutant under the Clean Air Act.

**Pascal (Pa):** A unit of pressure equivalent to one newton of force applied evenly over 1 $m^2$. The unit is named after Blaise Pascal, the eminent French mathematician, physicist, and philosopher.

**Pelagic:** Living or growing near the surface of the ocean.

**Pelagic fishes:** Fish that spend most of their lives swimming in the water column, as opposed to on or near the bottom.

**Pelagic muds:** Marine sediments derived from floating organic matter (e.g., plankton) that accumulates on the seafloor.

**Photovoltaic:** The process of converting sunlight into electricity.

**Physical oceanography:** The scientific study of ocean physics, including ocean currents, waves, and tides.

**Physiographic:** Pertaining to the physical features of the land, in particular its slope and elevation.

**Pinnipeds**: An order of carnivorous marine mammals, including harbor seals, sea lions, walruses, and elephant seals.

**Pitch:** A property of sound; sound wave frequency as perceived by the receptor. In music, two tones whose frequencies make a 2:1 ratio are said to be separated by an octave interval; a frequency ratio of 5:4 ratio defines a third; a frequency ratio of 4:3 defines a fourth; a frequency ratio of 3:2 defines a fifth.

**Pitch Regulated:** A cross flow wind turbine comprising a rotor mounted for rotation about a vertical axis and a plurality of blade assemblies mounted on the rotor.

**$PM_{10}$:** Particles with an aerodynamic diameter of less than or equal to 10 micrometers (0.0004 in.). These can be inhaled through the upper airways and deposited in the lower airways and gas-exchange tissues in the lung. $PM_{10}$ is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

**$PM_{2.5}$:** Particles with an aerodynamic diameter of less than or equal to 2.5 micrometers (0.0001 in.). A greater fraction of particles in this size range can penetrate and be deposited deep in the lungs, and smaller portions of $PM_{2.5}$ (e.g., < 0.1 micrometer) can enter the bloodstream. $PM_{2.5}$ is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

**Pneumatic:** Operated by pressurizing air.

**Point absorber:** A wave energy conversion device with a floating structure and components that move relative to each other because of wave action (e.g., a floating buoy inside a fixed cylinder). The relative motion is used to drive electromechanical or hydraulic energy converters.

**Polychlorinated biphenyls (PCBs):** A class of chemical substances formerly manufactured as an insulating fluid in electrical equipment. PCBs are highly toxic to aquatic life and, in the environment, exhibit many of the characteristics of dichloro-diphenyl-trichloroethane (DDT). PCBs persist in the environment for a long time and accumulate in animals.

**Polynuclear aromatic hydrocarbons (PAHs):** A group of organic compounds, some of which are known to be potent human carcinogens.

**Population:** A group of individuals of the same species occupying a defined locality during a given time that exhibit reproductive continuity from generation to generation.

**Prevention of Significant Deterioration (PSD):** An EPA program, specified in the Clean Air Act and required by State and/or Federal permits. The goal of the program is to prevent air quality from deteriorating significantly by restricting emissions from new or modified sources of pollutants in areas that are presently meeting the ambient air quality standards.

**Pro Forma:** An economic analysis that captures the revenues and the expenditures associated with an undertaking to determine the level of profitability.

**Raptor:** Bird of prey, such as an eagle, owl, or hawk.

**Rebound:** The rise of a land mass that was depressed by the weight of ice sheets during the last glacial period.

**Red tides:** Blooms of single-cell algae that produce potent toxins harmful to marine organisms and humans and are a natural phenomenon in the Gulf of Mexico, occurring primarily off southwestern Florida and Mexico.

**Region:** In this document, geographic areas on the OCS off the coast of the United States where the MMS has jurisdiction to regulate actions, including oil and gas development and development of mineral resources.

**Relict:** A remnant or fragment of the vegetation of an area that remains from a period when the vegetation was more widely distributed.

**Renewable energy:** Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydrological, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

**Rift zone:** A long, narrow trough bounded by normal faults, often associated with volcanism.

**Rifting:** A geologic process involving the pulling apart (extension) of the earth’s crust, which creates a linear series of faults along which the central portion is dropped relative to either side (forming a rift valley).

**Right-of-Way (ROW):** In property law, an easement to use another’s land for passage. For the OCS, a right-of-way is most commonly used for pipelines that cross lands that the operator does not control entirely by lease.

**Rigs-to-Reef Program:** A program under which obsolete gas and oil structures are converted to artificial reefs. The owners of the structures may make financial donations to the States from any savings related to avoided disposal costs.

**Riverine:** Relating to or associated with a river or other flowing freshwater body.

**Rock armor:** Pieces of rock, sized according to the anticipated erosional force, placed around a structure to prevent erosion of looser sediments.

**Rugosity:** Roughness or three dimensional relief of a surface

**Salinity:** A measure of the salt content of water, usually expressed in parts per thousand (ppt).

**Salt diapirism:** The phenomenon of salt intrusion into rock caused by the difference in buoyancy and pressure between the salt and overlying rock.

**Salt marshes:** Intertidal wetlands that occur on the margins of estuaries, protected bays, and the landward side of barrier islands.

**Sand Wave:** A sediment formation that forms underwater ridges and troughs because currents are sufficient to physically cause sediments to move in a consistent manner. The size can range from a few inches to many feet tall.

**Scouring:** The rapid erosion of sediment caused by the movement of water.

**Scour mats:** Typically square or rectangular sheets of an artificial material with vertical relief features intended to trap sediments when anchored on the seafloor, in an attempt to prevent scour.

**Sediment:** Materials that sink to the bottom of a body of water, or materials that are deposited by wind, water, or glaciers.

**Sedimentary basin:** A geologically (but not necessarily topographically) depressed area with thick sediments (sedimentary rocks) in the interior and thinner sediments at the edges.

**Seeps:** Natural releases of material from the sediment to the water column, often in discrete locations.

**Seismic:** Of, subject to, or caused by an earthquake or earth vibration.

**Shoal:** The sandy elevation of the bottom of a body of water, constituting a hazard to navigation; a sandbank or sandbar.

**Short-term:** Lasting for a limited time (not permanent).

**Solid wastes:** In this document, wastes classified as either hazardous or nonhazardous under the Resource Conservation and Recovery Act (RCRA) that may be generated by technology testing, site characterization, construction, operation, and decommissioning activities associated with alternative energy or alternate use projects likely to be proposed on the OCS.

**Sound power level (SPL):** The level of a sound wave's power relative to a reference value, expressed in decibels and averaged over time. The SPL represents the total sound power emitted by a source in all directions. Sound power is measured in watts, and SPLs are traditionally given in decibels with 1 dB of sound power equaling one picowatt (represented as: 1 dB re 1 *p*W). Whereas the sound pressure level represents the pressure of the sound wave reaching a receptor at a specific distance and in one direction from the sound source, the SPL represents all of the sound emanating from the source in all directions. To avoid confusion between the two terms, SPLs are often expressed in "bels" rather than decibels where one bel = 10 dB.

**Sound pressure level:** The relative magnitude of a sound wave's pressure compared to a reference pressure value. The pressure of the sound wave is proportional to the square of the sound's intensity and is measured in decibels.

**Species of (Special) Concern:** A species that may have a declining population, limited occurrence, or low numbers for any of a variety of reasons.

**Stratification:** The formation, accumulation, or deposition of materials in layers, such as layers of fresh water overlying higher salinity water (saltwater) in estuaries.

**Submarine bank (shoal):** A shallow place in a body of water.

**Subtidal**: That portion of the ocean that occurs below the low tide elevation, and therefore is continuously under water.

**Sulfur dioxide ($SO_2$):** A pungent, colorless gas formed when a fossil fuel containing sulfur, such as coal and oil, is burned. Of $SO_X$, only $SO_2$ is found at appreciable levels in the ambient gas phase (see also "sulfur oxides [$SO_X$]").

**Sulfur oxides ($SO_X$):** A collective term for oxides of sulfur, of which the principal air pollutants are sulfur dioxide ($SO_2$), sulfur trioxide ($SO_3$), and sulfur mist generated by the combination of the sulfur oxides with water in the air. These gases are formed primarily by fossil fuel combustion. $SO_X$ contributes to respiratory illness, particularly in children and the elderly, and aggravates existing heart and lung diseases. It also contributes to the formation of acid rain and to visibility impairments. $SO_X$ is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

**Surficial:** Pertaining to or lying on the surface of the earth.

**Syncline:** A fold in the layers of rock caused by deformation of the earth's crust; younger strata are found toward the center of the fold.

**Talus:** Small, broken rock found on mountain slopes and at the base of cliffs as a result of mass movement (e.g., a landslide).

**Tectonic:** Pertaining to forces within the earth that cause the earth's plates to move relative to one another; these include extension (when plates move apart), subduction (when plates converge and one plate is pushed below the other, and transverse movement (when plates move past each other, as along the San Andreas Fault).

**Temporary:** Lasting for a limited time (not permanent).

**Terminator:** A wave energy conversion device that extends perpendicular to the direction of wave travel and captures or reflects the power of the wave. These devices are typically installed onshore or near shore; however, floating versions have been designed for offshore applications. The oscillating water column is a form of terminator in which water enters through a subsurface opening into a chamber with air trapped above it. The wave action causes the captured water column to move up and down like a piston to force the air though an opening connected to a turbine.

**Terrace:** A flat, wave-cut platform of various unconsolidated sedimentary deposits.

**Terrestrial biota:** Plant, animal, or other life living in or on land.

**Terrigenous:** Pertaining to sediments derived from land sources.

**Terrigenous clastic sediments:** Sediments derived from pre-existing, land-derived sources, delivered to the ocean by rivers and streams.

**Threatened species:** Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Requirements for declaring a species threatened are contained in the Endangered Species Act.

**Topography:** The elevation or slope of the land surface.

**Transverse wave:** Wave in which the deformation of the medium through which an energy wave is passing involves motion of individual particles composing the medium in directions that are perpendicular to the direction in which energy wave is moving. Sound propagates in solids as transverse waves.

**Tsunami:** An ocean wave generated when an earthquake displaces the seafloor.

**Turbine:** A device in which a stream of water or gas turns a bladed wheel, converting the kinetic energy of the flow into mechanical energy available from the turbine shaft. Turbines are considered the most economical means of turning large electrical generators. They are typically driven by steam, fuel vapor, water, or wind.

**U.S. Environmental Protection Agency (EPA):** The independent Federal agency, established in 1970, that regulates Federal environmental matters and oversees the implementation of Federal environmental laws.

**Upwelling:** The process by which warm, less-dense surface water is drawn away from a shoreline by offshore currents and replaced by cold, denser water brought up from the subsurface.

**Velocity:** For acoustics, the speed at which a sound wave (a longitudinal wave) travels through a medium. Velocity is measured in units of distance/time. The velocity or speed of a sound wave in any medium is dependent on both the inertial and elastic properties of the medium. In air, the speed of sound is dependent on the air’s pressure (a measure of its inertial property of density) and its temperature (a measure of the air’s elastic property of deformation in response to an applied force—in this case, the sound wave). At one atmosphere of pressure and a temperature of 20°C (68°F), the speed of sound is approximately 343 m/s (750 mph).

**Vibratory:** Operated by causing rapid, small movement in a back and forth manner.

**Visual impact:** The creation of an intrusion or perceptible contrast that affects the scenic quality of a landscape.

**Water quality:** The condition of water with respect to the amount of impurities in it.

**Watt:** An International System unit of power equal to one joule per second.

**Wavelength:** The distance from any point in the wave to the corresponding point in the next cycle of the wave. Longer wavelengths are perceived by the human ear as low tones, shorter wavelengths as high tones.

**Wetlands:** Areas that are soaked or flooded by surface or groundwater frequently enough or long enough to support certain species of plants, birds, animals, and aquatic life. Wetlands generally include swamps, marshes, bogs, estuaries, and other inland and coastal areas and are Federally protected.

**Yaw:** The wind turbine yaw mechanism is used to turn the wind turbine rotor against the wind.

**Zonation:** Distribution of plants or animals arranged in zones or bands, caused by gradations of biotic (living) and/or abiotic (e.g., physical and chemical) factors.

## The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

## The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.