Appendix E

Essential Fish Habitat Assessment

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Acronyms and Abbreviations

BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
cm	centimeter
dB	decibel
DOF	Delfin Onshore Facility
DWPA	Deepwater Port Act of 1974
EFH	Essential Fish Habitat
EIS	Environmental Impact Assessment
FAD	fish aggregating device
FERC	Federal Energy Regulatory Commission
FLNGV	floating liquefied natural gas vessel
FMP	Fishery Management Plan
GMFMC	Gulf of Mexico Fishery Management Council
GRT	gross register ton
ha	hectare
HAPC	habitat area of particular concern
HIOS	High Island Offshore System
HMS	highly migratory species
HSD	Hydro Sound Damper
Hz	hertz
LCL	lower confidence limit
LDWF	Louisiana Department of Wildlife and Fish
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
MARAD	Maritime Administration
MARPOL	International Convention for the Prevention of Pollution from Ships
µg/L	microgram per liter
µm	micrometer
µPa rms	microPascal root mean squared
Mgal	million gallons
mm	millimeter
MMtpa	metric tonnes per year
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MW	megawatt
NMS	Noise Mitigation Screen
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OD	outside diameter
P.L.	Public Law
Project	Port Delfin LNG Project
PTS	permanent threshold shift
ROI	Region of Influence

SEAMAP	Southeast Area Monitoring and Assessment Program
SEL	sound exposure level
SPCC Plan	Spill Prevention, Containment, and Countermeasures Plan
SPL	sound pressure level
TL	transmission loss
TTS	temporary threshold shift
TYMS	tower yoke mooring system
U.S.C.	United States Code
UCL	upper confidence limit on the mean
USCG	U.S. Coast Guard
UTOS	U-T Offshore System
WC	West Cameron
ZOI	Zone of Influence

1.0 INTRODUCTION

The fisheries of the United States are managed within a framework of overlapping Federal, State, interstate, and tribal authorities. The Magnuson-Stevens Fishery Conservation and Management Act (MSA), Public Law (P.L.) 104-297, 16 United States Code (U.S.C.) 1801 et seq., established eight Fishery Management Councils responsible for protecting and managing certain fisheries within specific geographic jurisdictions. The councils are required to prepare fishery management plans (FMP) to regulate commercial and recreational fishing and to identify Essential Fish Habitat (EFH) for managed species.

The MSA directs Federal agencies to consult with the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) when any Federal activity may have an adverse effect on EFH. The following effect determinations for the Proposed Action were considered:

- No adverse effect on EFH (no consultation required);
- Minimal adverse effect or less than substantial adverse effect on EFH (abbreviated consultation); or,
- Substantial adverse effect on EFH (expanded consultation).

An adverse effect is defined as “any impact which reduces the quality and/or quantity of essential fish habitat,” which includes physical, chemical, or biological effects (NMFS 2004). Effects may manifest in a number of ways, either directly or indirectly, and on any spatial scale, including areas beyond EFH. For example, changes in water quality, benthic communities, or prey availability may constitute adverse effects on EFH. Any impact that reduces the quality or quantity of EFH is an adverse effect. Effects are evaluated on a spatial scale from site-specific to habitat-wide, and on a temporal scale that includes the cumulative effects of multiple actions on EFH.

2.0 PROJECT DESCRIPTION

The Applicant submitted an application to the U.S. Coast Guard (USCG) and Maritime Administration (MARAD) seeking a Federal license under the Deepwater Port Act of 1974 (DWPA), as amended, to own, construct, and operate a deepwater port for the liquefaction and export of liquefied natural gas (LNG) in Federal waters off the coast of Cameron Parish, Louisiana. The proposed deepwater port would be the first of its kind offshore terminal operated for the purpose of exporting LNG to the global market. Natural gas would be delivered to four moored floating liquefied natural gas vessels (FLNGVs) through two existing offshore natural gas pipelines: the former U-T Offshore System (UTOS)[1] and the High Island Offshore System (HIOS).

The proposed Port Delfin LNG Project (Project) has both onshore and offshore components. The proposed Port would be located in Federal waters of the Gulf of Mexico, approximately 37.4 to 40.8 nautical miles off the coast of Cameron Parish, Louisiana, in water depths ranging from approximately 64 to 72 feet. The proposed Port would reuse and repurpose two existing offshore natural gas pipelines—the former UTOS pipeline and the HIOS pipeline—to transmit natural gas sourced from the onshore interstate pipeline grid to the offshore deepwater port. The proposed Port facilities contained in the USCG and MARAD license application would consist of:

- Four semi-permanently moored FLNGVs,
- Four disconnectable tower yoke mooring systems (TYMS),
- Four pipeline riser components, and
- Four service vessel mooring points.

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[1] The UTOS naming convention is retained for ease of reference but technically describes the “former UTOS” pipeline system that no longer exists as a legal entity and is now owned by Delfin Offshore Pipeline, LLC, a wholly owned subsidiary of Delfin LNG, LLC, “the Applicant.”

The proposed offshore pipeline facilities contained in the USCG and MARAD license application would consist of:

- Four 30-inch-diameter pipeline laterals, each approximately 6,400 feet in length; and
- One 700-foot, 42-inch-diameter bypass around existing platform West Cameron block (WC) 167 to connect the HIOS and UTOS pipelines.

The proposed Delfin Offshore Facility (DOF) would be located in Cameron Parish, Louisiana, and would be licensed by the Federal Energy Regulatory Commission (FERC) under a separate licensing process (see FERC Docket No. CP15-490-000). The proposed DOF would consist of:

- Return to FERC-jurisdictional service of approximately 1.1 miles of existing UTOS pipeline;
- Addition of 74,000 horsepower of new compression and associated metering and regulation facilities; and
- Installation of new supply header pipelines inclusive of 0.25 mile of new 42-inch pipeline connecting the former UTOS pipeline to the new metering station and 0.6 mile of new twin 30-inch pipelines between Transco Station 44 and the new compressor station site.

Detailed descriptions of the Proposed Action (proposed offshore port and pipeline facilities and DOF) are provided in Section 2.1 of the draft Environmental Impact Statement (EIS).

Each TYMS would consist of a pile jacket structure connected to a manifold deck module and turntable deck module, with an attached swivel stack. It is anticipated that each mooring structure would require the installation of four driven piles (approximately 78 inches in diameter by 300 feet in length; subject to change during detailed engineering design), one in each leg. Four new-build, custom-designed FLNGVs would be moored to each disconnectable TYMS, allowing these vessels to weathervane. Natural gas would be liquefied and stored on the FLNGVs until delivered to liquefied natural gas carriers (LNGCs) via ship-to-ship transfer through offloading arms or cryogenic hoses, which would be able to accommodate the linear and rotational relative motions between the unit and FLNGV that are induced by the environmental loads and cargo transfer. The four FLNGVs would be capable of producing a nominal capacity of 12.0 million metric tonnes per annum (MMtpa) of LNG, or 3.0 MMtpa each. Each FLNGV would include gas pretreatment and three liquefaction trains having a nominal capacity of 1.0 MMtpa each, providing the nominal capacity of 3.0 MMtpa. A single FLNGV would have an LNG storage capacity of approximately 210,000 cubic meters. The FLNGVs would receive pipeline quality gas through a flexible pipe originating from a swivel assembly located on the TYMS. The feed gas would be processed through a gas metering skid and sent for pretreatment and liquefaction. The FLNGV facility would use air cooling to support the LNG liquefaction process, generate all its required electrical power, and produce and store on board demineralized water, freshwater, and potable water for process and other requirements. Each FLNGV would include an offload mooring system to moor an LNGC side-by-side for offloading of LNG. The offloading system would be capable of accommodating LNGCs with nominal cargo capabilities ranging between 125,000 and 177,000 cubic meters.

The proposed Project would originate at the proposed DOF in Cameron Parish, Louisiana, and would use two existing and underutilized 42-inch outside-diameter (OD) pipelines to be interconnected by a new bypass to be added at WC 167 and new offshore laterals to connect the existing pipelines to the FLNGVs in the general vicinity of WC 327. The offshore portion of the proposed Project would be located in the Gulf of Mexico, south of the area of coastline between the Calcasieu River and Sabine Pass, offshore of southwest Louisiana. The existing HIOS pipeline segment planned for use by Delfin LNG transects Lease Blocks WC 314, 318, 319, 327, and 335. Proposed Project moorings #1, #2, #3, and #4 would be located in WC 319, 327, 328, and 334 blocks, respectively. Figure 1 shows the general location of the proposed Project. Section 2.1 of the final EIS provides a more detailed description of the proposed moorings, pipeline laterals, bypass, and ancillary facilities. The Region of Influence (ROI) for effects on resources described in this final EIS includes the area within and directly adjacent to the proposed Port location and proposed bypass location that could be affected by construction, operation, and decommissioning of the proposed Project.

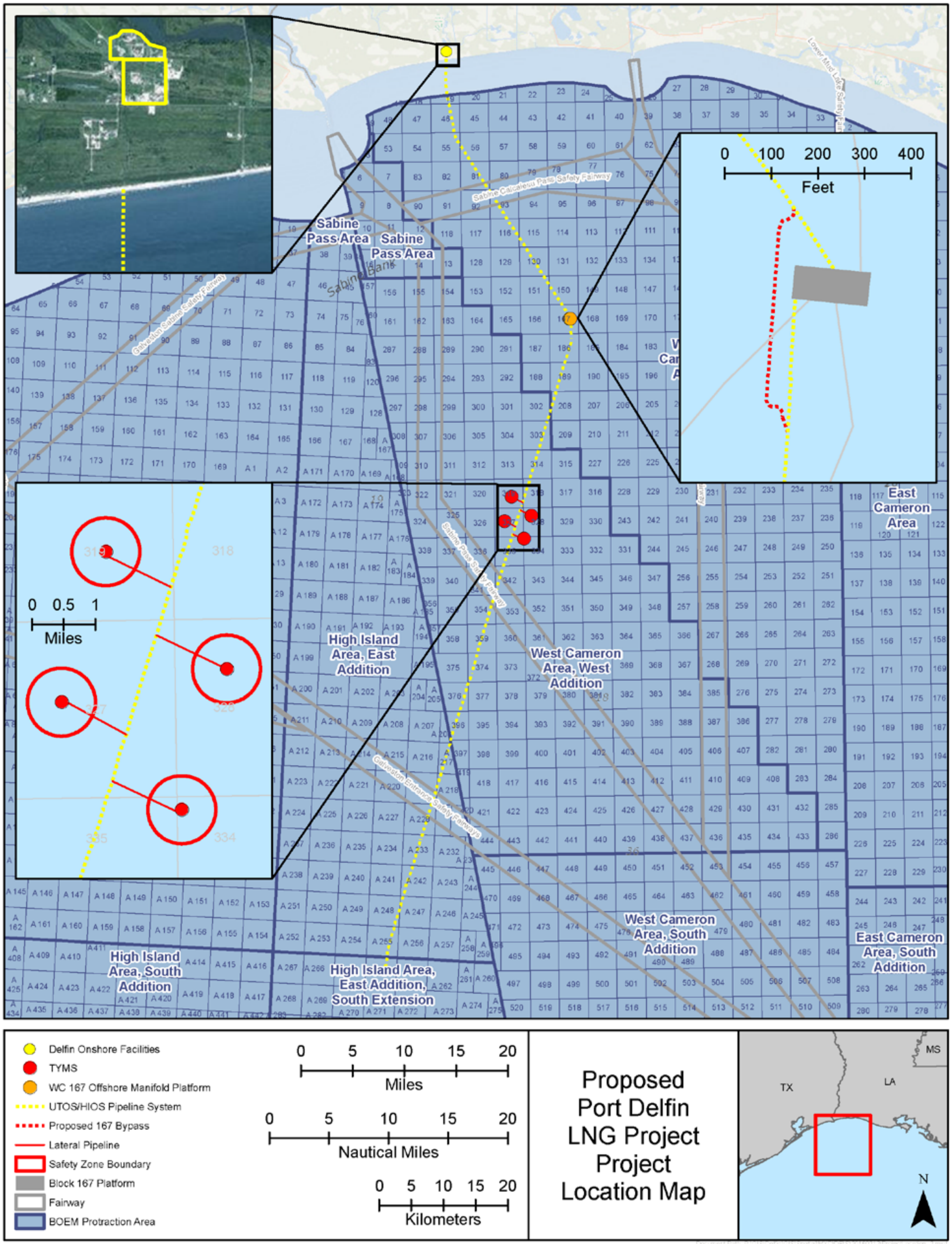


Figure 1. **Proposed Project General Location**

3.0 FEDERALLY MANAGED SPECIES AND ESSENTIAL FISH HABITAT

3.1 Managed Fisheries

Marine fisheries in the proposed Project area are under primary jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC), established under authority of the MSA. The GMFMC works together with NOAA Fisheries to manage commercially and recreationally important marine fish stocks and to prepare FMPs for target species. The GMFMC manages fisheries within the Federal waters surrounding the proposed Port site. Marine recreational and commercial fishing in Louisiana State waters (within 9 nautical miles [10.4 statute-miles]) of the coastline are the responsibility of the Louisiana Department of Wildlife and Fisheries (LDWF).

NOAA Fisheries' Highly Migratory Species Division is responsible for tunas, sharks, swordfish, and billfish in the Gulf of Mexico (NMFS 2009). Species in the ROI are managed under the following FMPs:

- Shrimp Fishery of the Gulf of Mexico, U.S. Waters;
- Red Drum Fishery of the Gulf of Mexico;
- Reef Fish of the Gulf of Mexico;
- Coastal Migratory Pelagic Resources in the Gulf of Mexico; and
- Stone Crab Fishery of the Gulf of Mexico and South Atlantic

3.2 Essential Fish Habitat

In 50 Code of Federal Regulations (CFR) 600.10, EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and specifically includes the "physical, chemical, and biological properties" of those waters. The term "fish" includes finfish, mollusks, crustaceans, and all other marine animal and plant life except birds, sea turtles, and mammals.

The GMFMC and NOAA Fisheries have identified waters and substrate necessary to fish for spawning, breeding, feeding, and growing to maturity as EFH. The FMPs provide details on EFH and other management issues for commercially, recreationally, and ecologically important resources, including corals and coral reefs, shrimp, stone crab, spiny lobster, reef fishes, coastal migratory pelagic fishes, and red drum. Virtually the entire northern coast of the Gulf of Mexico to a depth of about 600 feet (183 meters) has been identified as EFH for at least one species. EFH for corals and coral reefs includes shallow topographic features in the Central and Western Planning Areas.

Habitat areas of particular concern (HAPC) are localized areas of EFH that are ecologically important, sensitive, stressed, and/or a rare area. For example, portions of the Flower Garden Banks are designated HAPCs for corals (BOEM 2012) and a large deep open water area is considered HAPC for Atlantic bluefin tuna (*Thunnus thynnus*) (Figure 2).

3.3 Categories of EFH

The GMFMC classifies EFH for managed species in terms of five life stages: eggs, larvae, juveniles, adult, and spawning adult. Eggs are the fertilized product of individuals that have spawned; they depend completely on their yolk-sac for nutrition in this unhatched phase. Larvae are individuals that have hatched and can capture prey. Juveniles are individuals that are not sexually mature but that have fully formed organ systems, similar to those of adults. Adults are sexually mature individuals that are not necessarily in spawning condition, and spawning adults are those individuals capable of producing offspring.

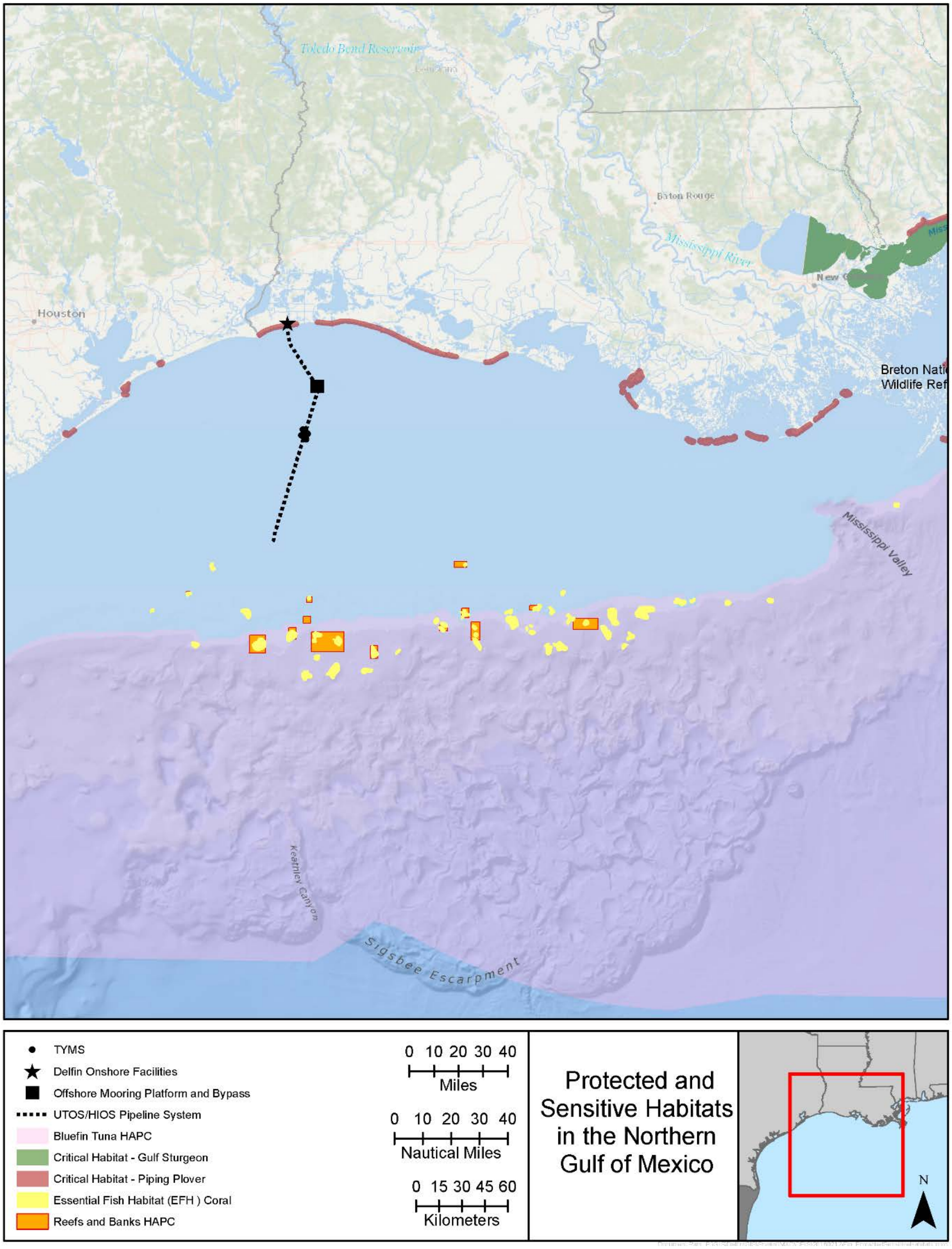


Figure 2. **Protected and Sensitive Habitats in the Northern Gulf of Mexico**

Life stages of highly migratory species are grouped in three categories based on common habitat usage: (1) spawning adult, egg, and larva; (2) juvenile and subadult or juvenile; and (3) adult. Subadults are individuals just reaching sexual maturity. The juvenile and subadult category combines all life stages between age 1 year and maturity. Adults are sexually mature fish. Young-of-the-year are individuals born within the past year. Additionally, EFH life stage categories for sharks are defined as neonate (primarily includes newborns and only small young-of-the-year), juvenile (includes all immature sharks from young to older and late juveniles), and adult (sexually mature sharks—largest size class). For most managed species, EFH is designated separately for each life stage according to its particular habitat needs. The proposed Project is expected to overlap with two categories of EFH, as shown in Table 1.

Table 1. Project Overlap with Categories of Essential Fish Habitat

EFH Category	Representative Habitats	Project Overlap
Benthic – Soft Bottom	May include the seafloor substrate on the continental shelf and slope that consists of soft or unconsolidated sediments such as gravel, cobbles, pebbles, sand, clay, mud, silt, and shell fragments	Yes
Water Column and Currents	All waters from the surface to the ocean floor (but not including the ocean bottom), including bays, estuaries, and rivers; floating *Sargassum*	Yes
Hard Bottom / Live Bottom	Consolidated sediments such as rock; areas of vertical relief such as crevices, overhangs, and vertical walls	No
Submerged Vegetation	Seagrass, kelp, macroalgae	No
Shoreline Vegetation	Salt marsh, mangrove	No
Biogenic Reefs	Scallop beds, mussel beds, oyster reefs; coral reefs; some deepwater coral	No
Deepwater Corals	Non-reef forming corals on continental shelves, slopes, canyons, and seamounts	No

Soft-bottom benthic habitat refers to any seafloor habitats, except for hard bottom, as well as the water-sediment interface used by many invertebrates (for example, members of the shrimp management unit). Soft-bottom unconsolidated bottom habitats include loose rocks, gravel, cobble, pebbles, sand, clay, mud, silt, and shell fragments. A variety of species use these unconsolidated bottom habitats for spawning and nesting, development, dispersal, and feeding (NMFS 2000).

Soft-bottom sediments range in size from gravel (larger than 2.0 millimeters [mm]) to sand (0.05 to 2.0 mm), silt (0.002 to 0.05 mm), and clay (less than 0.002 mm). Sediment deposited on the continental shelf is mostly delivered by rivers, but also by local and regional currents and wind (Wren and Leonard 2005). Sediment quality is influenced by its physical, chemical, and biological components; where it is deposited; the properties of seawater; contaminants; and other factors. Because all these factors interact to some degree, sediments tend to be dynamic and are not easily generalized. Benthic fauna and infauna often rework sediments in the process of feeding and burrowing. In this way, marine organisms can influence the structure, texture, and composition of sediments as well as the horizontal and vertical distribution of substances in the sediment (Boudreau 1998).

The water column itself, apart from associated benthic or structural features, provides EFH for many species. Neritic and coastal waters occur above the continental shelf and roughly encompass the top 600 feet (200 meters) of the ocean known as the photic zone, where sunlight can penetrate and photosynthesis can occur. All waters from the surface to the ocean floor (but not including the ocean bottom) are part of the marine water column. The water column is particularly important for planktonic life stages (eggs and larvae) and all life stages of planktivorous species (NMFS 2000, 2009). The Loop Current in the Gulf of Mexico provides critical transport of larvae and floating *Sargassum*, connecting populations in the Gulf of Mexico, the Caribbean Sea, and the Atlantic Ocean (BOEM 2012).

4.0 CONDITION OF ESSENTIAL FISH HABITAT IN THE PROPOSED PROJECT AREA

4.1 Soft-bottom Benthic EFH

Benthic organisms serve as trophic links between plankton and higher-order consumers because they feed on plankton and detritus and are preyed upon by fishes and larger invertebrates. In addition, benthic organisms provide physical substrate that adds complexity to soft bottom habitat. The soft, muddy bottom in the ROI supports two dominant groups of benthic fauna: (1) infauna (animals that live in the substrate, such as burrowing worms, crustaceans, and mollusks) and (2) epifauna (animals closely associated with the substrate, such as crustaceans, echinoderms, mollusks, hydroids, sponges, and soft and hard corals).

Benthic habitats are highly productive in the subtidal Gulf of Mexico. The offshore food chain is sustained by phytoplankton, notably diatoms, dinoflagellates, and other unicellular algae. Infaunal suspension feeders such as bivalve mollusks consume either plankton, sediment, or both. The numerically dominant polychaetes, or soft-bodied segmented worms, are represented by species that feed by ingesting sediment, pursuing prey, scavenging, or selectively collecting detritus. In turn, this wide variety of infaunal organisms are eaten by predatory gastropods (the familiar “sea shells”), starfish, decapod crustaceans (shrimp and crabs), and fish (Britton and Morton 1989).

4.2 Water Column EFH

By far the most abundant organisms in the open waters of the Gulf of Mexico are phytoplankton, zooplankton, and ichthyoplankton (fish and invertebrate eggs and larvae). The plankton community consists of both permanent members and transient larval forms of fishes and invertebrates (Johnson and Allen 2005). Plankton and marine invertebrates in the open waters of the Gulf of Mexico are the basis of the food web that supports fish, birds, sea turtles, and marine mammals and provides recreation and economic benefits to people. The composition of the planktonic community in any given location and depth changes over time in response to physical factors such as wind, currents, turbidity, nutrient availability, and light (Hernandez et al. 2010). Ecological processes such as predation and competition also influence the abundance and distribution of planktonic organisms. Lower trophic level communities are characterized by mixed species assemblages of phytoplankton, zooplankton, and ichthyoplankton, as well as pelagic invertebrates. These organisms are predominately moved passively within water masses, although some have limited swimming abilities.

Although most plankton are tiny, they range in size from microscopic bacteria and plants to larger animals, such as jellyfish. Zooplankton are categorized by size as the barely visible microzooplankton (20 micrometers [µm] to 0.2 mm) and mesozooplankton (0.2–20 mm), and the more familiar macrozooplankton (20 mm–20 centimeters [cm]), which includes ctenophores (comb jellyfish), shrimp, amphipods, euphausiids, and larval fish. The megazooplankton (20 cm–2 meters) are the true jellyfish. Plankton are also grouped by residency in the plankton. Holoplankton remain in the plankton throughout their lives; meroplankton are temporarily planktonic during certain life stages (especially larval) and are more seasonally occurring (Britton and Morton 1989).

Phytoplankton and zooplankton provide the nutritional support for essentially all of the important species in the Gulf of Mexico. Some important fish species, such as Gulf menhaden and bay anchovy, rely on plankton food their entire lives (Patillo et al. 1997). Larval stages of virtually all of the important finfish and shellfish species consume vast amounts of plankton. Many fish that are piscivorous as adults, such as spotted seatrout and Atlantic croaker, rely on zooplankton during early life stages then shift to larger prey as they grow (Akin and Winemiller 2006). Immature stages of species that are harvested as adults, such as blue crab, are well-represented in the plankton (Lochmann et al. 1995).

Floating *Sargassum* carries a variety of attached organisms, including hydroids and barnacles. In addition to the sessile community, many motile animals are strongly associated with floating *Sargassum*; a typical assemblage includes fish, crabs, gastropods, polychaetes, bryozoans, anemones, and sea spiders (Britton and Morton 1989). Juvenile fishes are the dominant vertebrate inhabitants of pelagic *Sargassum* mats, but adults of highly migratory pelagic species (for example, crevalle jacks, mackerel scad, dolphinfish, and billfishes) also aggregate around *Sargassum* mats (GMFMC 2010). The Loop Current in the Gulf of Mexico provides critical transport of larvae and floating *Sargassum*, connecting populations in the Gulf of Mexico, the Caribbean Sea, and the Atlantic Ocean (BOEM 2012).

4.3 Fisheries with Essential Fish Habitat in the Proposed Project Area

EFH has been designated for several groups of managed fishes in the Gulf of Mexico that occur within the ROI, including shrimp, stone crab, coastal migratory pelagics, reef fish, and highly migratory species (HMS) (Table 2).

Table 2. Fisheries with Essential Fish Habitat in the Proposed Project Area

Coastal Migratory Pelagics Fishery Management Plan	
In the Management Unit	
King mackerel	*Scomberomorus cavalla*
Spanish mackerel	*Scomberomorus maculatus*
Cobia	*Rachycentron canadum*
In Fishery but not in the Management Unit	
Cero	*Scomberomorus regalis*
Little tunny	*Euthynnus alletteratus*
Dolphin	*Coryphaena hippurus*
Bluefish (Gulf of Mexico only)	*Pomatomus saltatrix*
Reef Fish Fishery Management Plan	
Snappers: Family Lutjanidae	
Queen snapper	*Etelis oculatus*
Mutton snapper	*Lutjanus analis*
Blackfin snapper	*Lutjanus buccanella*
Red snapper	*Lutjanus campechanus*
Cubera snapper	*Lutjanus cyanopterus*
Gray (mangrove) snapper	*Lutjanus griseus*
Lane snapper	*Lutjanus synagris*
Silk snapper	*Lutjanus vivanus*
Yellowtail snapper	*Ocyurus chrysurus*
Wenchman	*Pristipomoides aquilonaris*
Vermilion snapper	*Rhomboplites aurorubens*
Groupers: Family Serranidae	
Speckled hind	*Epinephelus drummondhayi*
Yellowedge grouper	*Epinephelus flavolimbatus*
Goliath grouper	*Epinephelus itajara*
Red grouper	*Epinephelus morio*
Warsaw grouper	*Epinephelus nigritus*
Snowy grouper	*Epinephelus niveatus*
Black grouper	*Mycteroperca bonaci*

Table 2. Fisheries with Essential Fish Habitat in the Proposed Project Area (continued)

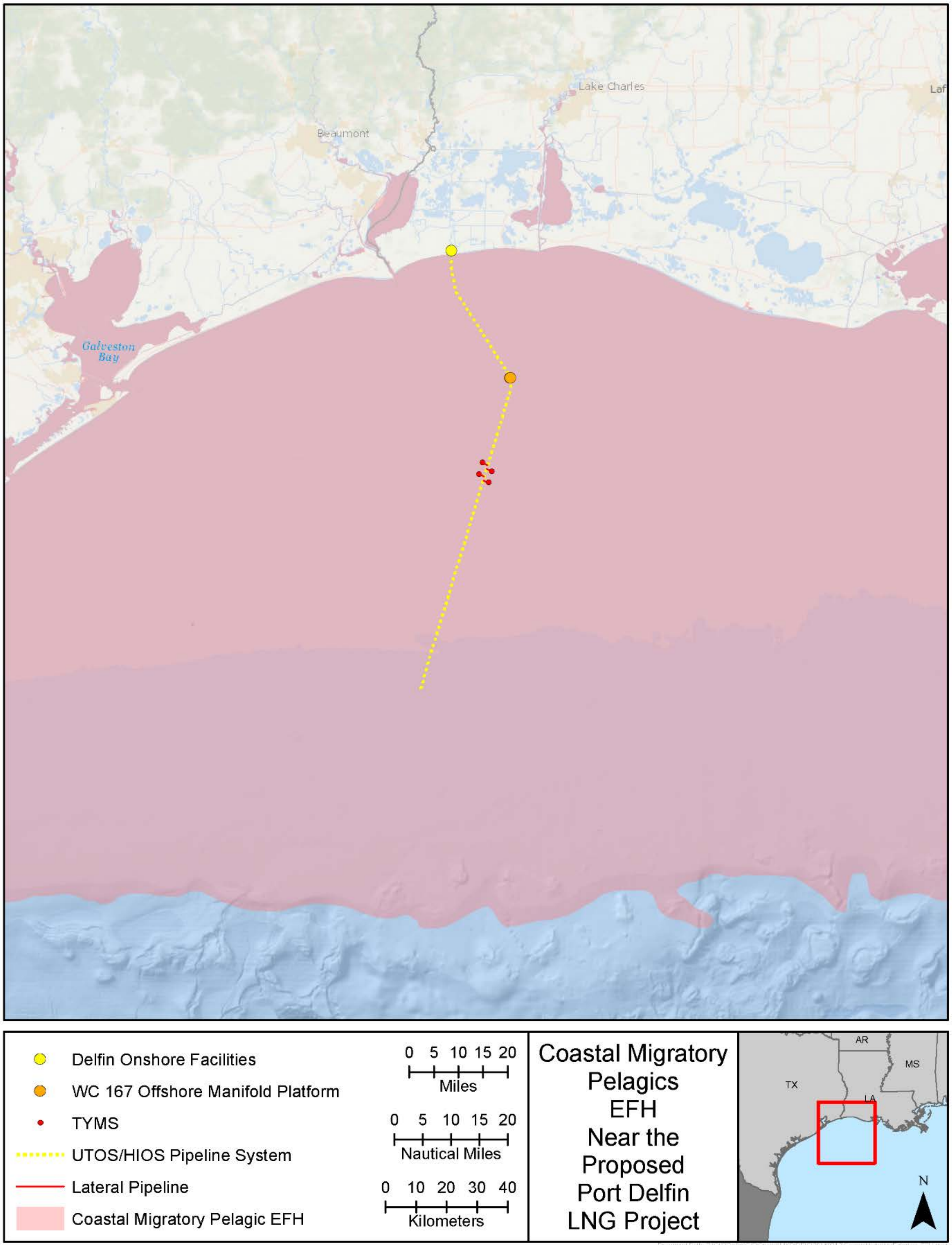
Coastal Migratory Pelagics Fishery Management Plan	
Yellowmouth grouper	*Mycteroperca interstitialis*
Gag	*Mycteroperca microlepis*
Scamp	*Mycteroperca phenax*
Yellowfin grouper	*Mycteroperca venenosa*
Tilefishes: Family Malacanthidae	
Goldface tilefish	*Caulolatilus chrysops*
Blueline tilefish	*Caulolatilus microps*
Tilefish	*Lopholatilus chamaeleonticeps*
Jacks: Family Carangidae	
Greater amberjack	*Seriola dumerili*
Lesser amberjack	*Seriola fasciata*
Almaco jack	*Seriola rivoliana*
Banded rudderfish	*Seriola zonata*
Triggerfishes: Family Balistidae	
Gray triggerfish	*Balistes capriscus*
Wrasses: Family Labridae	
Hogfish	*Lachnolaimus maximus*
Shrimp Fishery Management Plan	
Brown shrimp	*Farfantepenaeus aztecus*
White shrimp	*Litopenaeus setiferus*
Pink shrimp	*Farfantepenaeus duorarum*
Royal red shrimp	*Pleoticus robustus*
Stone Crab Fishery Management Plan	
Stone crab	*Menippe mercenaria*
Highly Migratory Species Fishery Management Plan	
Atlantic bluefin tuna	*Thunnus thynnus*
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*

4.3.1 Coastal Migratory Pelagics

King mackerel, Spanish mackerel, and cobia are managed within the group of coastal migratory pelagics, species that typically migrate throughout the Gulf and South Atlantic. Adults of these commercially and recreationally valuable species occur in nearshore waters, but eggs hatch and larvae are reared in open waters farther offshore (Table 3). Designated EFH for coastal migratory pelagic species ranges across the northern Gulf of Mexico from the shoreline out to the continental shelf (Figure 3).

Table 3. Coastal Migratory Pelagics Essential Fish Habitat

Species	Eggs	Larvae	Juveniles	Adults
King mackerel	Pelagic; offshore in spring and summer	Mid to outer continental shelf (25-180 m; 82-590 ft) in October; feed on larval fishes	Inshore waters on the inner shelf; feed on estuarine- dependent fish	Pelagic; coastal to offshore waters; feed on nekton; spawn from May to October on the outer continental shelf
Spanish mackerel	Pelagic; on the continental inner shelf (<50 m; 164 ft) in spring and summer	Continental inner shelf from spring to fall; feed on larval fishes	Estuarine and coastal waters with a wide salinity range; feed on fishes	Inshore and coastal waters; feed on estuarine-dependent fishes; spawn on the inner shelf from May to September
Cobia	Pelagic; top meter of the water column	Offshore waters	Coastal waters and offshore on the shelf in the upper water column in summer; feed on nekton	Shallow coastal waters and offshore shelf waters (1-70 m; 3-229 ft) from March to October; spawn in the shelf waters spring and summer
Source: BOEM (2012) Volume 3				



Source: NMFS (2015)

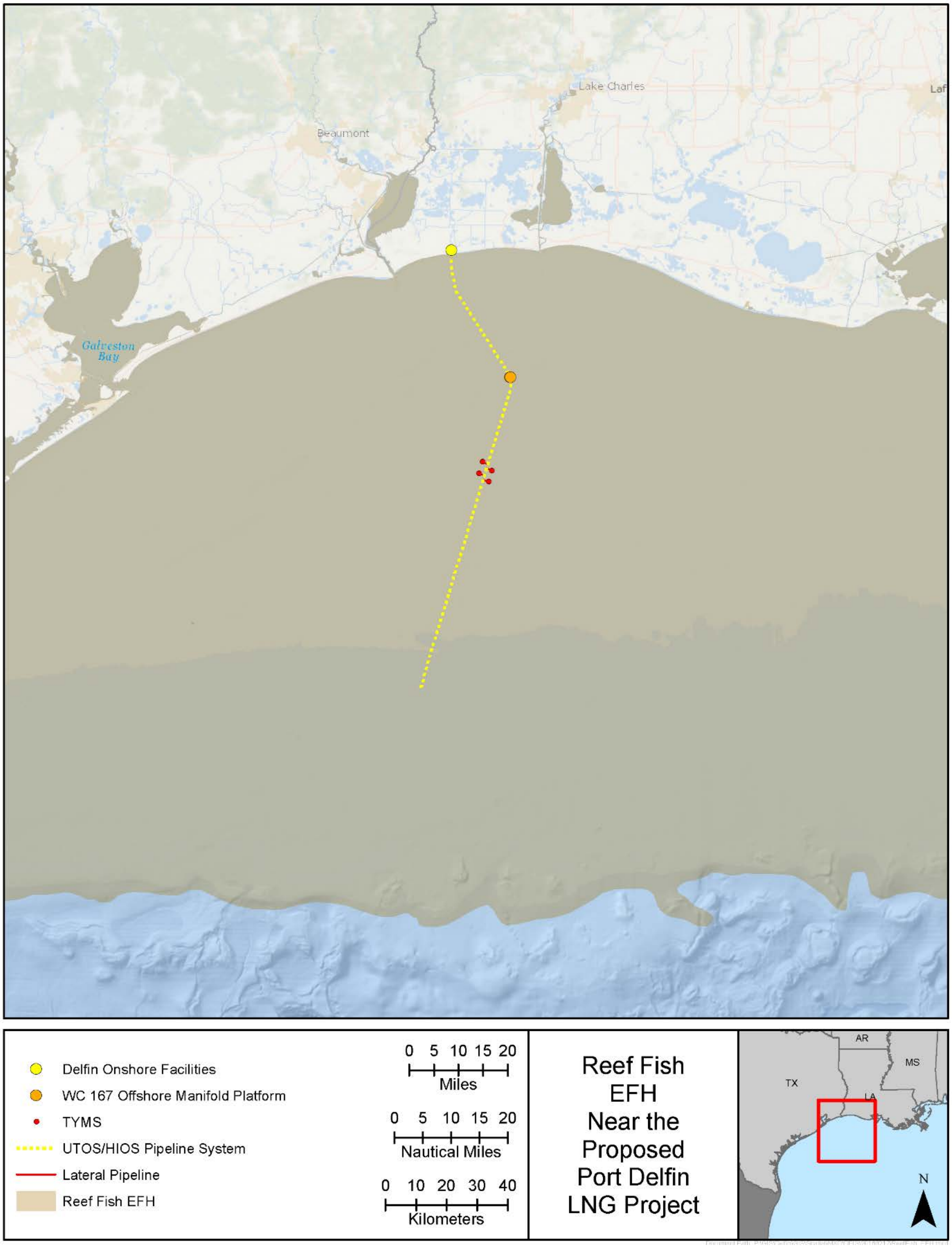
Figure 3. Coastal Migratory Pelagics Gulf of Mexico Essential Fish Habitat

4.3.2 Reef Fish

The reef fish FMP includes fishes associated with natural and artificial reefs and other hard-bottom habitats, such as snappers, groupers, amberjack, bass, triggerfish, hogfish, porgies, and tilefish. Most of these species are recreationally and commercially valuable. Despite the common association with hard-bottom habitat, species managed as reef fish have diverse life history characteristics; note the use of artificial structures by various life stages of the selected examples in Table 4. Designated EFH for reef fish ranges across the entire nearshore zone in the northern Gulf of Mexico (Figure 4).

Table 4. Essential Fish Habitat for Various Life States of Selected Reef Fishes

Species Name	Eggs	Larvae	Post Larvae	Juveniles	Adults
Grey trigger	Sand bottoms near reef habitats in spring and summer	None	Upper water column in spring and summer	Upper water column associated with *Sargassum*; eat from *Sargassum*	Continental shelf waters (>10 meters [33 feet]) and reefs in late spring and summer; eat invertebrates
Greater amberjack	Gulfwide	Gulfwide	Offshore in summer	Gulfwide with *Sargassum* and other floating structures in late summer and fall; feed on invertebrates	Gulfwide near structured habitat; eat invertebrates and fishes; spawn in spring and summer offshore
Red snapper	Offshore in summer and fall	Continental shelf waters in summer and fall; eat rotifers and algae	None	Continental shelf associated with structures and *Sargassum* feed on zooplankton and shrimp	Hard and irregular bottoms; eat nekton; spawn offshore away from coral reefs in sand bottoms with low relief in summer and fall
Gray snapper	High salinity continental shelf waters near coral reefs in summer	High salinity continental shelf waters near coral reefs in summer; eat zooplankton	Move to vegetated estuaries; eat copepods and amphipods	Feed on crustaceans	Onshore and offshore; eat nekton; spawn offshore near reefs in summer
Yellowtail snapper	February and October	Shallow water with vegetation and structure; feed on zooplankton	None	Nearshore with vegetation; move to shallow coral reefs with age	Semipelagic; use deeper coral reefs (50 meters [164 feet]); feed on nekton; spawn away from shore with peaks in February-April and September-October
Source: BOEM (2012) Volume 3					



Source: NMFS (2015)

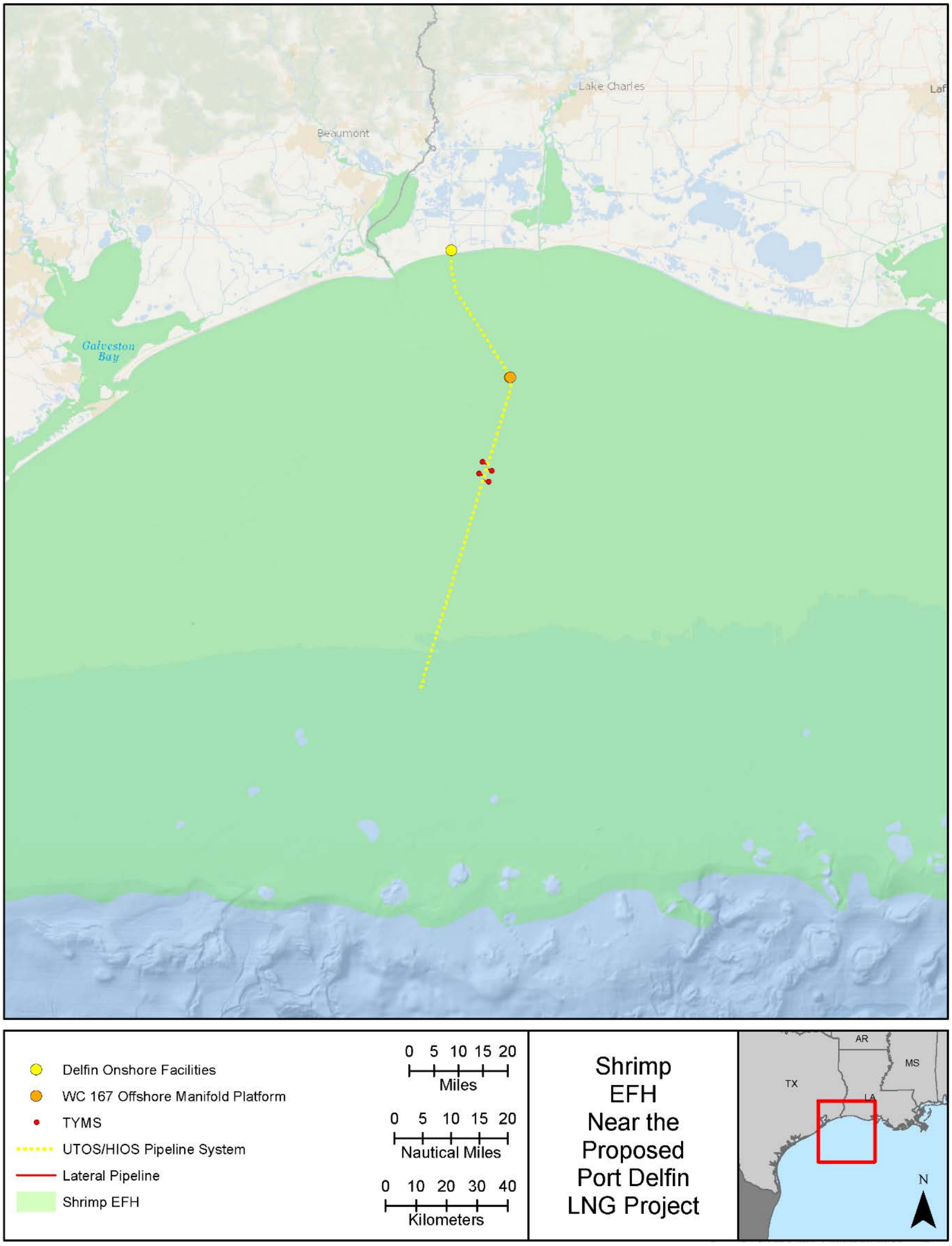
Figure 4. **Reef Fish Essential Fish Habitat within the Gulf of Mexico**

4.3.3 Shrimp

Adult brown and white shrimp are most common in the proposed Project's ROI, where the soft-bottom substrate is designated as EFH (Table 5 and Figure 5).

Table 5. Essential Fish Habitat for Brown and White Shrimp

Species	Eggs	Larvae	Post larvae	Juveniles	Adult
Brown shrimp	None	None	Migrate to estuaries in early spring	Associated with vegetation and mud bottoms; sub-adults use bays and shelf in transit from estuaries to offshore waters	Spawn in deep waters (>18 meters [59 feet]) over the continental shelf generally in spring
White shrimp	Spring and fall	None	None	Associated with soft bottoms with detritus and vegetation	Nearshore soft bottoms; spawn at <27 meters (88 feet) from spring to fall; vertical diurnal migration

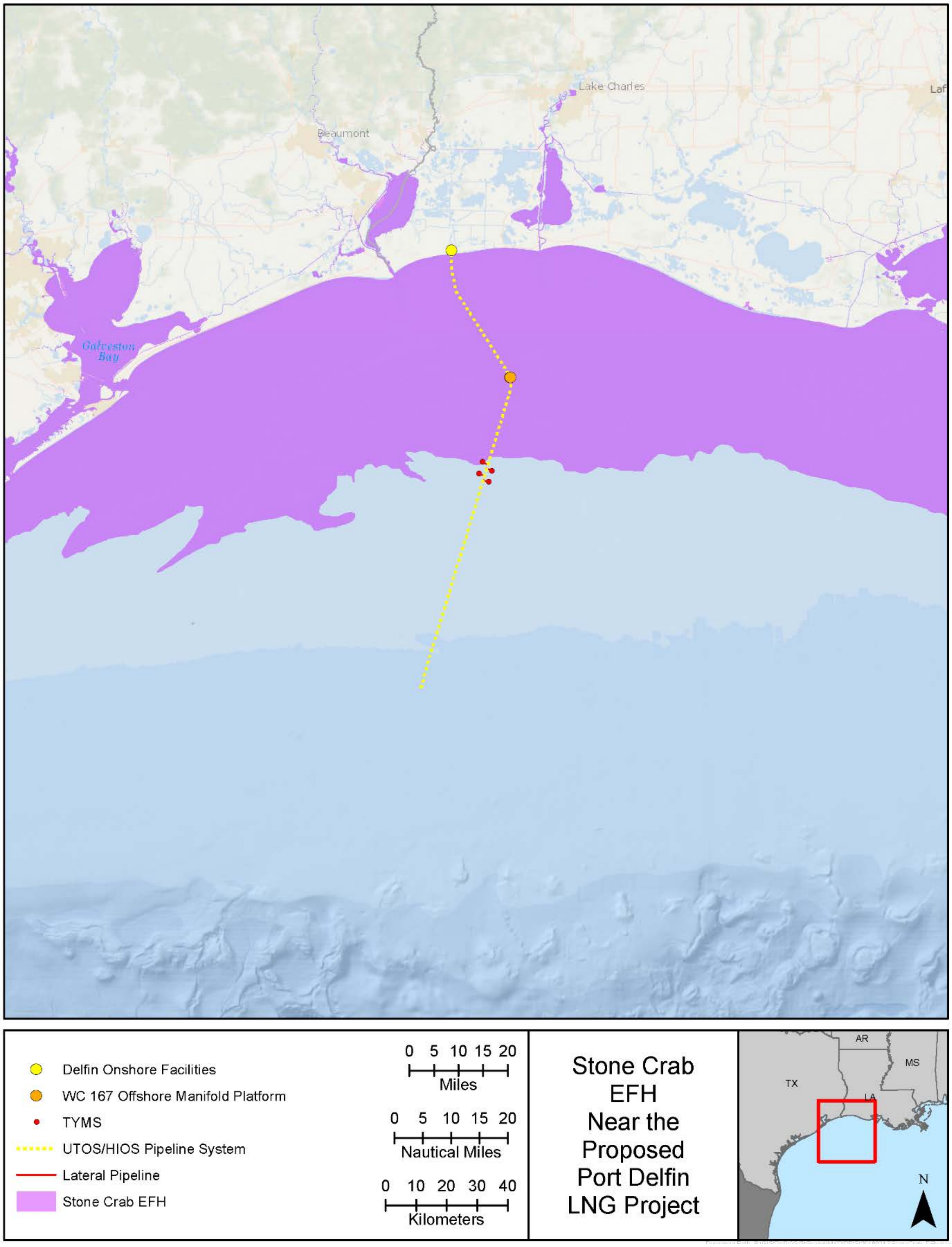


Source: NMFS (2015)

Figure 5. **Shrimp Essential Fish Habitat within the Gulf of Mexico**

4.3.4 Stone Crab

The stone crab *Menippe adina* occurs throughout the Gulf of Mexico, although the greatest fishery harvest is in Florida (Florida Fish and Wildlife Conservation Commission 2010). The GMFMC FMP identifies estuarine waters out to depths of 10 fathoms as EFH for stone crab. Depths at the proposed Project area are within stone crab EFH (Figure 6).



Source: Northern Gulf Institute (2013)

Figure 6. **Stone Crab Essential Fish Habitat within the Gulf of Mexico**

4.3.5 Highly Migratory Species

Highly migratory species are not generally closely associated with fixed habitat features such as substrate type or the presence of biogenic habitats. Most HMS occur predominately in open water far offshore where EFH is characterized by dynamic features of water masses, including oceanic fronts, river plumes, current boundaries, shelf edges, sea mounts, and temperature discontinuities. Characteristics of the water column that affect survival, growth, and reproductive success of HMS include temperature, salinity, or oxygen levels. Distribution and abundance of various life stages of HMS are influenced by the properties of the water masses in which they live, which in turn are affected by daily, annual, and decadal weather cycles. For these reasons, EFH for HMS is broad and somewhat vaguely defined, as the precise location of suitable habitat for a given HMS varies seasonally, annually, and over longer periods.

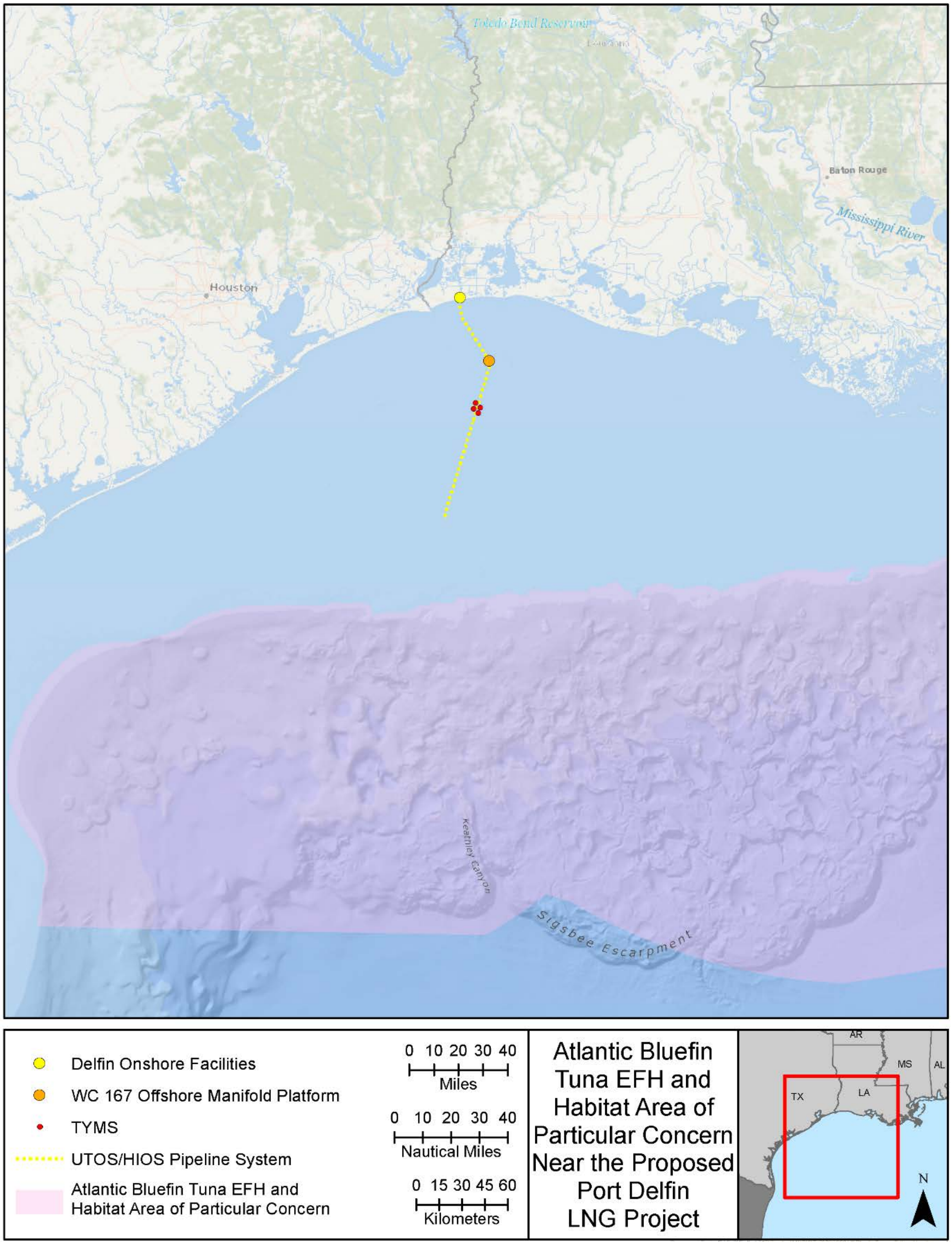
Of the many HMS with EFH in the Gulf of Mexico, the Atlantic bluefin tuna (Table 6 and Figure 7) and Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) (Table 7 and Figure 8) are most likely to overlap with the proposed Project area. Additionally, the bonnethead shark *(Sphyrna tiburo*) may occur in the ROI, although no EFH for this species is designated in the proposed Project area, according to one of the HMS FMP (NMFS 2009). However, once the proposed Port is constructed, it may attract HMS species, many of which are known to aggregate around artificial structures in open water.

Table 6. Atlantic Bluefin Tuna Essential Fish Habitat in Gulf of Mexico

Species	Spawning Adult	Eggs	Larvae	Juveniles	Adults
Atlantic bluefin tuna	Gulf of Mexico from the 100-meter depth contour to the EEZ	Gulf of Mexico from the 100-meter depth contour to the EEZ	Gulf of Mexico from the 100-meter depth contour to the EEZ	Not in Gulf of Mexico	In pelagic waters of the central Gulf of Mexico

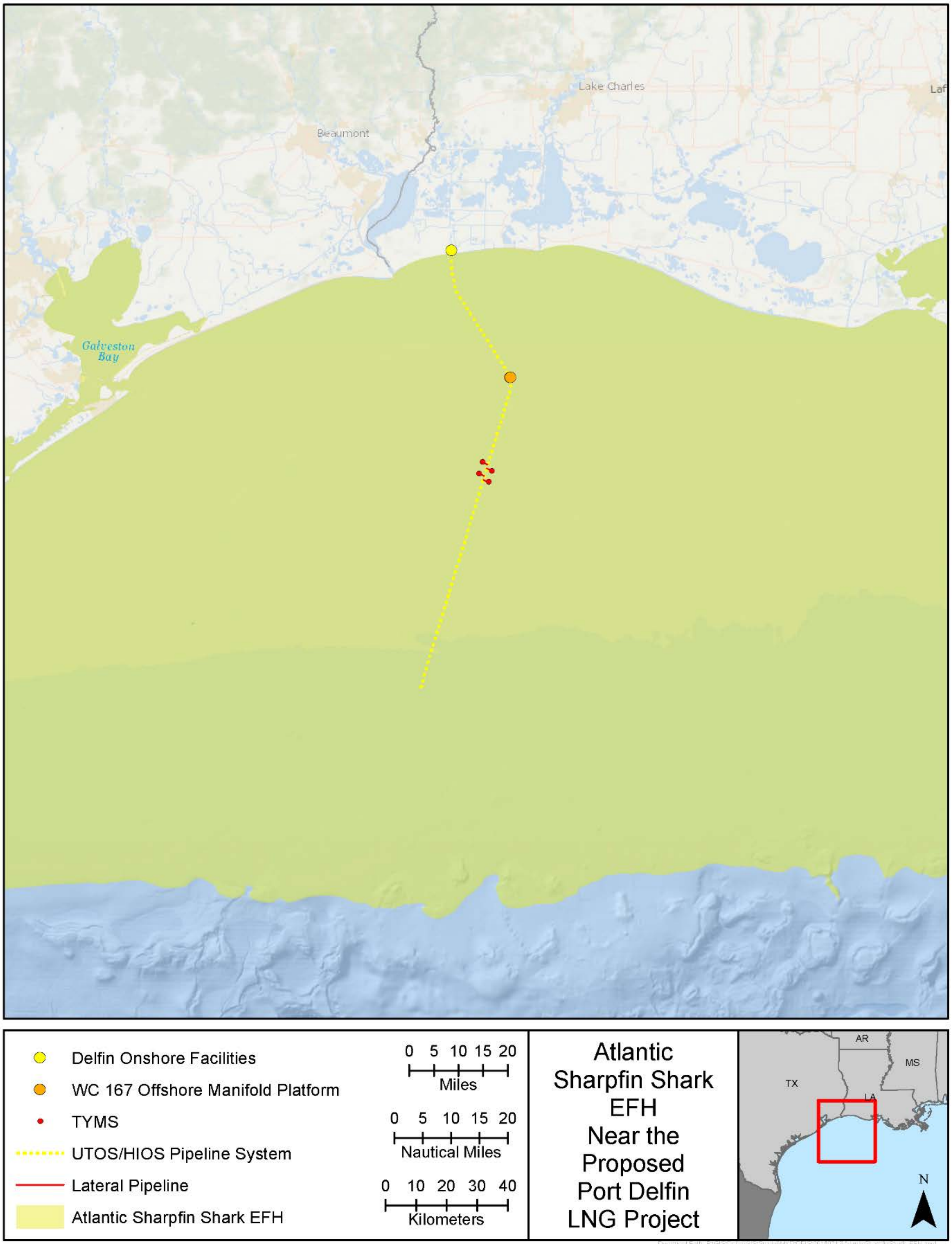
Table 7. Atlantic Sharpnose Shark Essential Fish Habitat in Gulf of Mexico

Species Name	Neonate/YOY	Juveniles	Adults
Atlantic sharpnose shark	Gulf of Mexico coastal areas from Texas to Florida Keys	Gulf of Mexico coastal areas from Texas to Florida Keys	Gulf of Mexico coastal areas from Texas to Florida Keys to a depth of 200 meters.



Source: NMFS (2009)

Figure 7. **Atlantic Bluefin Tuna Essential Fish Habitat in the Gulf of Mexico**



Source: NMFS (2009)

Figure 8. **Atlantic Sharpfin Shark Essential Fish Habitat in the Gulf of Mexico**

4.4 Ichthyoplankton of Managed Species in the Proposed Project Area

Ichthyoplankton (fish and invertebrate eggs and larvae) make up a substantial portion of the zooplankton community, as most fishes in the Gulf of Mexico have pelagic larval stages that last between 10 and 100 days, depending on the species. The distribution of fish larvae depends on spawning behavior of adults, hydrographic structure and transport at a variety of scales, duration of the pelagic period, behavior of larvae, and larval mortality and growth (BOEM 2012). For most of the year in the north-central Gulf of Mexico, density of ichthyoplankton is greater at the surface and decreases with depth (Shaw et al. 2002). Some larvae undergo diurnal vertical migrations in response to daylight (Shaw et al. 2002). Larval fishes are highly dependent on zooplankton until they can feed on larger prey. The composition of larval fish assemblages varies with season, mediated by temperature, day length, nutrient supply, and other factors (BOEM 2012). In general, larval densities are lowest during winter, increase during the spring, peak during the summer, and decline during the fall, as shown in Table 8. Many of the managed fish and invertebrates are in the ROI in the spring, late spring, and early fall. From May through October, king and Spanish mackerel and many of the snappers are present.

Distribution and abundance of ichthyoplankton in the Gulf of Mexico is a function of adult movement, spawning season, currents, and other physical and biological parameters that vary spatially and temporally. Seasonal patterns of ichthyoplankton composition in nearshore waters are strongly influenced by the spawning cycles of coastal fish species, while further offshore composition is influenced by the spawning cycles of pelagic and migratory species. The Mississippi River discharge plume and the Loop Current have widespread influence over patterns of ichthyoplankton abundance throughout the Gulf of Mexico (BOEM 2012).

Table 8. Peak Seasonal Occurrence of Larval Fishes in the Northern Gulf of Mexico

Common Name	Scientific Name	Month											
		J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Groupers	*Epinephelus* spp.	X	X			X	X	X	X	X	X	X	
	Myctoperca spp.				X								
	Serranus spp.	X	X		X	X	X	X	X	X	X	X	X
Cobia	*Rachycentron canadum*				X	X	X	X	X	X			
Amberjacks	*Seriola* spp.	X	X	X	X	X	X	X	X	X	X	X	X
Triggerfish	*Balistes* sp.							X	X				
Wenchman	*Pristipomoides aquilonaris*		X			X	X	X	X	X	X		
Vermillion snapper	*Rhomboplites aurorubens*	X				X	X	X	X	X	X	X	
Queen snapper	*Etelis oculatus*							X	X	X	X	X	
Red snapper	*Lutjanus campechanus*				X	X	*	*	*	X	X	X	
Gray snapper	*Lutjanus griseus*				X	X	*	*	*	X	X	X	
Lane	*Lutjanus synagris*				X	X	*	*	*	X	X	X	
Little tunny	*Euthynnus alletteratus*				X	*	*	*	*	*	X	X	
King mackerel	*Scomberomorus cavalla*					X	X	X	*	*	X	X	
Spanish mackerel	*Scomberomorus maculatus*				X	X	X	X	*	*	X		
Bluefin tuna	*Thunnus thynnus*				X	X	X						

X = Seasonality (meaning "presence")
* = Peak Seasonal Occurrence
Source: Ditty et al. (1988)

Spring and fall plankton surveys have been conducted in the Gulf of Mexico since 1982 as part of NOAA's Southeast Area Monitoring and Assessment Program (SEAMAP). Plankton were collected using neuston nets and bongo nets. Ichthyoplankton abundance in the ROI was estimated using samples from a 30- by 30-nautical mile (34.5- by 34.5-statute mile; 55.5- by 55.5-kilometer) coverage of SEAMAP sampling stations near the proposed Port location (Figure 9) (see Appendix I for more detail). The mean larval fish density within the ROI was 0.274 larvae/cubic meter (m^3), or about 1,037 larvae per million gallons (Mgal) of seawater. Mean density of fish eggs was 4.6 eggs/m^3 (17,484 eggs per Mgal).

Samples collected during the Gulf-wide SEAMAP survey were used to identify ichthyoplankton expected to occur within the ROI of the offshore facilities. More than 1,200 taxonomic categories, including unidentified specimens, were identified in plankton samples collected in the proposed Project area. Samples were collected from June through November over 29 years (1983 to 2012). As noted above, the distribution and abundance of ichthyoplankton was highly variable on temporal and spatial scales. More than one dozen managed species and numerous forage species were represented in the samples. However, none of the 20 most abundant taxa identified in samples from the proposed Project area were managed species.

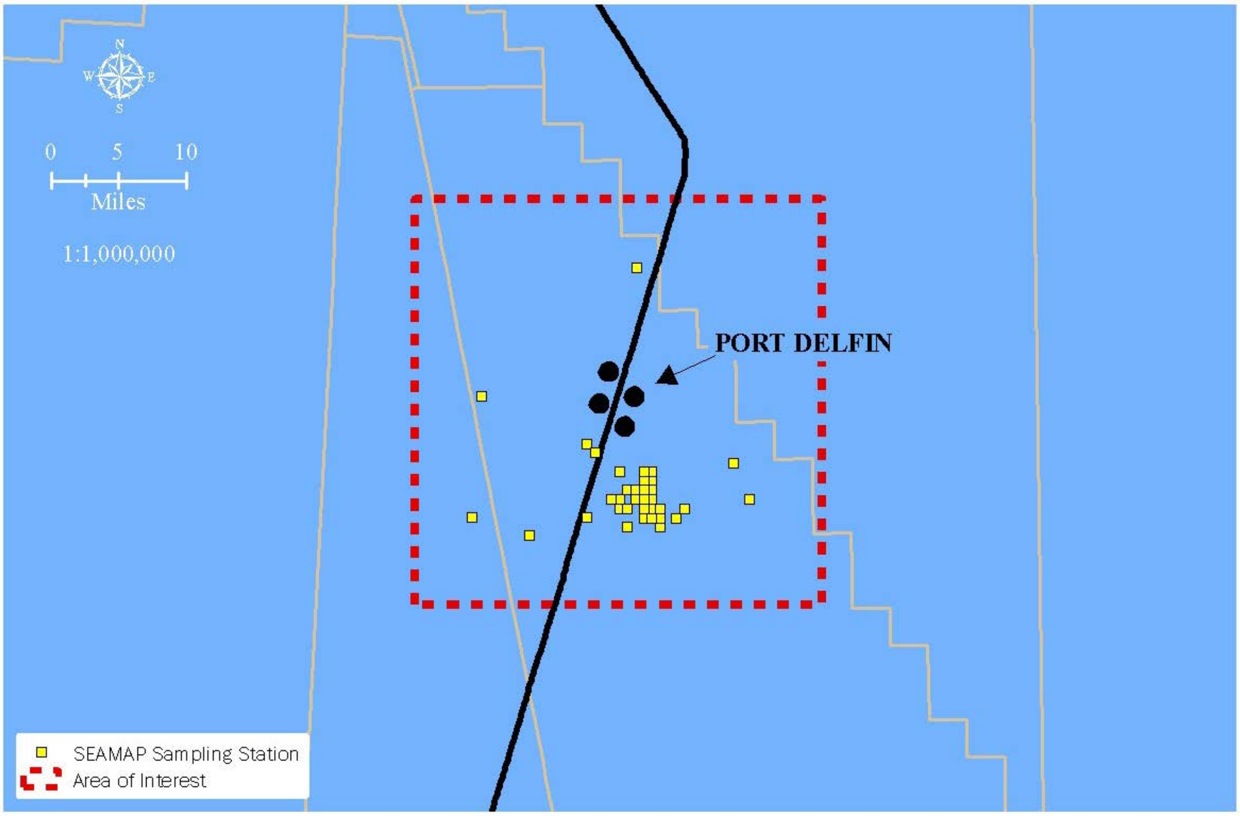


Figure 9. **SEAMAP Stations within the Proposed Project's Region of Influence**

5.0 EFFECTS ON ESSENTIAL FISH HABITAT

Effects on EFH were evaluated based on reported effects of similar offshore marine projects, primarily associated with deepwater ports or other energy-related infrastructure. The proposed Project would have minimal adverse effect on EFH, requiring an abbreviated consultation with NOAA Fisheries.

FMPs prepared in accordance with 50 CFR part 600 (Subpart J) include an evaluation of non-fishing impacts on EFH. Under this directive, NOAA and the FMCs have evaluated effects of non-fishing activities on the quality and quantity of EFH in various regions of the country, including the Gulf of

Mexico (GMFMC 2010). The reports are in general agreement that primary threats to EFH include the following: dredging, filling, mining, impounding waters, diverting waters, thermal discharges, non-point source pollution and sedimentation, introduction of hazardous materials or exotic species, and modifying/converting aquatic habitat. Events occurring over a larger spatial scale, such as severe weather and climate change, often exacerbate the local effects to EFH caused by specific human activities. Effects of the Proposed Action on the quantity and quality of EFH are evaluated within the context of these identified non-fishing threats.

Effects are described in terms of significance, with a significant effect indicating a measureable or observable decrease in survival, or reproductive success of a managed species or a measureable decrease in prey abundance or quality within the ROI. A measureable or noticeable change in some aspect of the habitat, such as turbidity, that does not result in harm to the managed species or degradation of the EFH is not considered significant. Temporal descriptors are based on professional judgment: temporary refers to a few hours or days, whereas short-term describes an effect lasting one to several weeks. A finding of “no effect” indicates that any effect is within the range of natural variability of the feature being described.

Several construction-related activities have the potential to affect water column and soft-bottom substrate EFH or managed species. Effects of the proposed Project from construction to decommissioning are discussed below.

- Displacement of sediments during trenching and other substrate-disturbing activities, resulting in increased turbidities and subsequent respiratory effects on some species; foraging efficiencies may be increased or reduced, depending on species (Section 5.1);
- Smothering and crushing by emplacement of equipment or anchors may alter distribution and abundance of benthic species in the immediate project area; managed species may experience increased foraging opportunities as they take advantage of dead, injured, or disoriented prey (Section5.2);
- Entrainment and impingement of eggs/larvae and juveniles, respectively, during hydrostatic testing (Section 5.3);
- Effects of inadvertent chemical releases from construction and support vessels at the site (Section 5.4);
- Noise-related effects resulting from pile driving during construction (Section 5.5);
- Increase in marine debris (Section 5.6); and
- Creation of hard-bottom habitat at the proposed Project site (Section 5.7).

Construction, operation, and decommissioning of the proposed Port would have either no adverse effect or minimal adverse effect on EFH and managed species in the proposed Project area; contemporaneous beneficial effects would accrue from aspects of the proposed Project. The proposed Project would have no substantial adverse effect on the biological, chemical, or physical properties of water column or soft-bottom substrate designated as EFH.

The ubiquitous presence of numerous overlapping categories of EFH for multiple species make it infeasible to develop an effect determination for each unique combination of species/life stage/EFH. The analysis below, coupled with the extensive details of the proposed Project presented in the EIS, support the overall determination that no aspect of the proposed Project would result in substantial adverse effects on EFH. Potential effects of construction, operation, and decommissioning on EFH are summarized in Table 9 and discussed in the text that follows.

Table 9. Summary of Potential Effects on Essential Fish Habitat during Project Life Cycle

Proposed Activity	Project Phase	Effect on Water Column	Effect on Soft-bottom Substrate
Placement of terminal components	C	Temporary increase in turbidity (NS) Short-term increase in noise (NS)	Displacement of sediments (NS) Localized injury/mortality and temporary displacement of prey species (NS)
Installation and hydrostatic testing of pipelines	C	Temporary increase in turbidity (NS) Mortality of negligible number of ichthyoplankton (NS)	Displacement of sediments (NS) Localized injury/mortality and temporary displacement of prey species (NS)
Treated water discharge	C, O, D	Transient effect on water quality (NS)	No effect
Vessel and aircraft noise	C, O, D	Temporary increase in noise (NS)	Temporary increase in noise (NS)
Anchoring	C, O, D	Temporary increase in turbidity (NS)	Displacement of sediments (NS) Localized injury/mortality and temporary displacement of prey species (NS)
Artificial lighting	C, O, D	Localized redistribution of phototactic ichthyoplankton and mobile predators (NS)	No effect
Presence of terminal	C, O	Creation of hard-bottom habitat (beneficial but NS) Safety/exclusion zone prevents harvest (beneficial but NS)	Creation of hard-bottom habitat (beneficial but NS) Safety/exclusion zone prevents harvest (beneficial but NS)
Marine debris	C, O, D	No effect	No effect
Accidental release	C, O, D	*Minor release:* transient effect on water quality (NS) *Major release:* highly unlikely but large local increase in mortality of ichthyoplankton and adults by freezing; significant local effect on managed species but no long-term significant effect on water column EFH	No effect
Removal of Structures	D	Temporary increase in turbidity (NS) Short-term increase in noise (NS)	Displacement of sediments (NS) Short-term injury, mortality, or displacement of prey species (NS) Short-term increase in noise (NS)

Key: C = Construction Phase; O = Operations Phase; D = Decommissioning Phase; NS = not significant

5.1 Displacement of Sediments/Increased Turbidity

Activities that displace sediment also cause increased turbidity in the immediate area. Sediment displacement is an effect on the soft-bottom substrate, while increased turbidity is an effect on the water column. Because these two effects occur simultaneously in response to the same action, they are considered together here.

Pipelines would be installed by jet-trenching (using a jet-sled trencher). A jetted trench typically has a V-shaped cross-section, ranging in width from approximately 30 feet (9 meters) at the trench top to 10 feet (3 meters) at the trench bottom. The greatest potential to affect surface waters would occur from suspension or deposition of sediments caused by trenching or jetting the pipeline. Trenching or jetting would suspend sediments in the water column for a period of time depending on the size of the sediments.

Coarser sediments would fall out and resettle quickly (hours), while finer sediments could remain suspended for longer periods of time (days).

Considering the cumulative 5 miles (8 kilometers, or 26,300 feet) of pipeline trenching, and conservatively predicting a 100-foot-wide corridor that could be affected over a short time period by deposition to some degree under the “worst-case” scenario, approximately 60 acres (24.4 hectares [ha]) of benthic habitat could be temporarily affected by pipeline installation. An additional 1 to 2 acres (0.4 to 0.8 ha) of benthic habitat would be affected by other substrate-disturbing activities, such as mooring construction, tie-in pits, and anchoring activities.

As most benthic infauna live on or within the upper 6 inches (15 cm) of the sediment surface, it is expected that turnover and burial would result in the loss of these organisms. Generally, disturbance-related effects on benthos would be temporary and reversible because native assemblages would either recolonize the affected area or a new community would develop as a result of immigration of animals from nearby areas or from larval settlement. In contrast to the direct harm that may befall some benthic species, decapod crustaceans and fishes such as coastal migratory pelagics, snappers, groupers, and others may experience increased foraging opportunities as they take advantage of dead, injured, or disoriented prey.

The disturbed area of soft-bottom sediments would be recolonized by larvae recruited from the overlying water or adjacent areas, but recovery may take several months (Germano et al. 1994) to years (Hughes et al. 2010). Species composition may shift during the recovery period as more species more tolerant of residual hydrocarbons return first, followed by other species only after the sediment returns to pre-drilling conditions (Netto et al. 2010). Many physical and biological factors affect the recolonization process, with one being the texture of the disturbed sediment. Any change in the texture of the material after the activity is completed may result in changes to the community that was present before activities took place. Additionally, overturned, deeper sediments may be hypoxic, resulting in longer periods of re-establishment of former communities. Generally, a resident benthic community is quite resilient and recovers relatively quickly from disturbances. As such, it is expected that affected benthic communities would re-establish within a short time, and thus no long-term effects on EFH species are expected.

The potential for direct and indirect adverse effects from trenching and substrate disruption on managed species with EFH designated in the proposed Project area would likely differ from species to species, depending upon life history, habitat use (demersal vs. pelagic), distribution, and abundance. However, it is anticipated that short-term effects would be limited to temporary displacement of juvenile and adult fish (both pelagic and demersal) during initial installation of proposed Project components.

Turbidity associated with the proposed Project would have no or minimal adverse effect on EFH and managed species. Adverse effects would be indirect, short-term, and minor. During construction activities, managed species and EFH may be affected by disturbed sediments, which increase turbidity in the water column. Effects would be strictly physical, as no chemical contaminants were reported in recent analyses of sediment and water at the proposed Project site (see Appendix H of the final EIS for the full contaminant report.)

As a result of pipeline installation and other construction-related bottom disturbance activities (i.e., anchoring), the almost 5 miles (8 kilometers) of new pipeline would result in the suspension of up to 1.4 million cubic feet (40,000 cubic meters) of sediment during pipeline installation (MMS 2001). Because of the fine-grained characteristics of the substrate within the ROI, it is expected that suspended sediment would be in the water column for only hours to days.

The adverse effects of increasing turbidity in coastal marine habitats are generally ascribed to algal blooms resulting from anthropogenic nutrient inputs (Lowe et al. 2015; Wenger et al. 2012). However, the effects of short-term localized increases in suspended sediment concentrations cannot be assumed comparable in either source or adversity to fishes. Turbidity is known to influence the outcomes of predator–prey interactions through effects on perception of both species. What may be perceived as obstruction to a predator is protective cover to its prey. Moreover, not all predatory fish are strictly visual operators; other sensory modalities such as chemoreception and physical contact may offset reductions in vision in turbid environments (Lunt and Smee 2015).

Mobile species in an area of increased turbidity would relocate to clearer water if no foraging advantage was experienced. Generally, reported effects of elevated turbidity levels on fish are associated with long-term events, often mediated through primary habitat degradation, such as algal blooms or inputs of terrestrial sediments to a coastal habitat. No large-scale permanent increase in turbidity would occur as a result of the proposed Project. Effects of sediment displacement and increased turbidity would not be significant.

5.2 Emplacement of Structures

Emplacement of TYMSs and other anchoring devices would result in adverse effects on benthic macroinvertebrates, with potential subsequent secondary adverse effects on managed species through reduction of forage species. Direct effects on benthic organisms would include crushing, localized disruption, removal, turnover, and deposition of sediment in the immediate vicinity of the anchors and other similar structures. About 1 to 2 acres (0.4 to 0.8 ha) of benthic habitat would be affected by mooring construction, tie-in pits, and anchoring activities. The area beneath the TYMSs would become unavailable as soft-bottom habitat. However, the TYMS themselves would provide hard substrate at a range of depths from the seafloor to near the water surface, increasing habitat for attaching and encrusting organisms and their predators (see Section 5.7 below).

5.3 Entrainment Effects

Effects from ichthyoplankton fish larvae and egg entrainment/impingement were analyzed for hydrostatic testing of pipelines during constructions and FLNGV water intake during operations. The potential loss of equivalent age-1 fish for four target species including red drum (*Sciaenops ocellatus*), red snapper (*Lutjanus campechanus*), bay anchovy (*Anchoa mitchilli*), and Gulf menhaden (*Brevoortia patronus*) is measurable but not significant. Entrainment effects on managed species are summarized below; see Appendix I for details of the analysis.

5.3.1 Entrainment during Pipeline Hydrostatic Testing

Hydrostatic testing of the former UTOS pipeline would require approximately 10.5 Mgal of water. The water would be withdrawn from the Gulf of Mexico at WC 167. The HIOS line would be need to be flooded with water withdrawn from the Gulf of Mexico at HI A264. Approximately 22.6 Mgal would be needed to fill the HIOS pipeline; another 0.9 Mgal would be needed for hydrostatic testing of all laterals. After the hydrostatic testing of the former UTOS pipeline, the WC 167 bypass and the laterals to the FLNGVs would be installed. The UTOS and HIOS fill water would be tested for hydrocarbons and other contaminants. If necessary to meet water quality requirements, the water would be filtered and treated prior to discharge. After testing and any needed filtration and treating, the water would be discharged into the Gulf of Mexico at HI A264. The total water volume discharged from the UTOS and HIOS pipelines and the four laterals would be approximately 34.0 Mgal.

During hydrostatic testing, water would be pumped into the pipe and filtered through a size 100 mesh screen (mesh opening = 0.0059 inch [0.15 mm]) to prevent debris and foreign material from entering the pipeline. Impingement of juvenile and early stage adult fish and invertebrates on intake screens could occur during this process, and these individuals would likely be killed or injured. It is expected that the short filling duration and limited occurrence of fish during construction activities would significantly limit impingement effects.

Any eggs or larvae entrained during hydrostatic testing would likely be killed, based on the mechanical pumping required for filling, the corrosion inhibitors and/or biocides expected to be used, and the time element for water retention required during pipe integrity tests.

The 59 SEAMAP stations within the established block had an overall density of 0.274 fish larvae/cubic meter and 4.616 fish eggs/cubic meter or an average of 1,037 larvae and 17,484 eggs in 1 Mgal of seawater (see Appendix I). Using these average egg and larvae densities, the use of 34.0 Mgal (129,461 cubic meters) of seawater would result in the loss of approximately 35,000 larvae and 600,000 eggs (all taxa combined). An unknown fraction of these would be eggs and larvae of managed species. Entrainment would take place in a marine environment where natural mortality is high. Precise mortality estimates are not available, but consider that most managed marine fishes spawn thousands, if not hundreds of thousands, of eggs in a lifetime. For several EFH species in the Gulf of Mexico, annual fecundity can range from thousands to millions of eggs per spawn, e.g.:

- Red snapper – 220,000 to 320,000 eggs
- King mackerel – 500,000 to more than 1,600,000 eggs
- Spanish mackerel – 100,000 to 2,100,000 eggs
- Swordfish – 1,000,000 to 4,000,000 eggs
- Lane snapper – 347,000 to 995,000 eggs

Copious gamete production is an adaptive strategy of species survival where mortality is the norm. The survival to adulthood of only two egg is necessary to replace the parents. Each additional egg surviving to maturity would represent an enormous increase in the stock size. Therefore, it is very rare that survival processes occurring in ichthyoplankton are used to set subsequent adult stock levels, and such correlations are almost impossible to detect with oceanographic sampling. For this reason, significant effects to populations of ichthyoplankton as a result of offshore construction processes in the ROI would be nearly impossible to detect. Thus, considering the fecundity potential for all EFH species addressed, along with natural mortality expected, the limited and one-time entrainment of eggs and larvae during hydrostatic testing would cause no measureable effect on the populations of fisheries present in the northern Gulf of Mexico.

5.3.2 Effects of Entrainment by FLNGVs

As proposed, a single FLNGV would take in 3.0356 Mgal per day. Estimates of larvae and eggs that could be entrained at the proposed Project site were calculated by multiplying the observed densities of organisms in the SEAMAP samples by the daily average intake volume by the days of intake (see Appendix I for details). The estimates were based on the following assumptions, which were purposefully biased toward overestimating entrainment:

1. The depth-integrated samples reflect the densities that would be encountered at the depth of the intake location.
2. The densities in SEAMAP summer-fall samples are representative of mean annual densities.
3. Exposure would occur intermittently over the entire year.
4. Net extrusion effects were accounted for by multiplying observed densities by 3.

Annual estimates of impingement and entrainment of fish eggs and larvae by the four FLNGVs in the proposed Project are shown in Table 10.

Table 10. Estimates of Impingement and Entrainment by Four Floating Liquefied Natural Gas Vessels

Plankton	Lower 95% Confidence Limit (LCL)	Annual Mean	Upper 95% Confidence Limit (UCL)
Fish Eggs	15,014,889	36,471,801	416,323,508
Fish Larvae	886,620	2,153,639	24,583,659

Expected mean larval densities and upper and lower confidence intervals for the four managed species of concern are in Table 11.

Table 11. Estimated Annual Larval Entrainment Values

Managed Species	Associated Taxa in SEAMAP Samples	LCL	Mean	UCL
Bay anchovy	F. Engraulidae, *Anchoa* spp.	800,772	1,904,146	21,464,680
Gulf menhaden	F. Clupeidae, *Brevoortia patronus*	28,109	84,231	16,215,205
Red drum	*S. ocellatus* and Sciaenids	30,325	114,349	1,574,483
Red snapper	*L. campechanus* and F. Lutjanidae	27,412	50,911	477,442
Key: LCL = lower confidence limit; UCL = upper confidence limit				

Because eggs were not identified to species, species-specific egg entrainment was determined by first calculating the ratio of total eggs to total larvae for the SEAMAP database. Respective densities were adjusted by a multiple of 3 for net extrusion. This yielded estimates of larvae and egg entrainment for the average, upper confidence limit (UCL), and lower confidence limit (LCL) cases from which egg/larvae ratios were determined. Egg/larvae ratios (16.9) were multiplied by annual larval entrainment for each species and each entrainment scenario (LCL, average, and UCL) to yield the projected egg entrainment for each representative species, as presented in Table 12.

Table 12. Projected Annual Floating Liquefied Natural Gas Vessels Egg Entrainment Values

Managed Species	Associated Taxa in SEAMAP Samples	LCL	Mean	UCL
Bay anchovy	F. Engraulidae, *Anchoa* spp.	13,561,065	32,246,655	363,503,693
Gulf menhaden	F. Clupeidae, Brevoortia patronus	476,029	1,426,464	18,070,526
Red drum	*S. ocellatus* and Sciaenids	513,563	1,936,497	26,663,822
Red snapper	*L. campechanus* and F. Lutjanidae	464,231	862,184	8,085,465
Note: Estimates were calculated by multiplying larval entrainment by species from Table G-11 by the egg-to-larvae ratio for each entrainment scenario. Key: LCL = lower confidence limit; UCL = upper confidence limit				

5.4 Chemical Releases (Small Spills from Support Vessels)

Several sources of chemical releases would be present during the lifetime of the proposed Project. During construction, biocides would be released during hydrostatic testing of the pipelines. Operational releases would include permitted discharges from FLNGVs and LNG carriers. Accidental spills from support vessels could occur during all phases of the proposed Project. Neither accidental nor intentional releases of chemicals would adversely affect EFH.

Intentional releases of small amounts of chemicals would comply with USCG and EPA permits. Biocides, which typically contain copper and aluminum compounds, may be used during hydrostatic testing of the pipelines, with subsequent discharge into surrounding Gulf of Mexico waters. Laboratory experiments have shown high mortality of Atlantic herring eggs and larvae at copper concentrations of 30 micrograms per liter (µg/L) and 1,000 µg/L, respectively, and vertical migration of larvae was impaired when copper concentrations exceeded 300 µg/L (Baxter 1977). To eliminate effects from biocide discharge into surrounding waters, Delfin LNG would pump hydrostatic test water from the pipeline into a diffuser to re-oxygenate the water before discharging it back into the marine environment. The diffuser would spread the discharged water within a sufficiently large area so that the biocide concentration in the seawater would be diluted to acceptable levels.

During the operational period, maintenance of the pipeline would include pigging to periodically clean out residual materials. The release of these materials into the surrounding environment could lead to water quality effects and contamination of adjacent benthic habitats. However, due to the expected short duration of these effects, if they occur, no significant negative effects on EFH species' populations within the proposed Project area are expected. It is anticipated that such internal inspections would be conducted approximately once every 7 years.

As discussed in Section 2.4.1 of the final EIS, operational discharges from the FLNGV, including engine cooling water, ballast water exchange, wastewater, scrubber water, deck drainage, and bilge water, would comply with the applicable National Pollutant Discharge Elimination System (NPDES) permit. Temperature changes, total suspended solids, and oil and grease from several sources would result in short-term changes to the marine environment in the area immediately adjacent to the discharge point.

Operational discharges from the visiting LNGC at the proposed Port would include bilge water, wastewater, scrubber water, deck drainage, engine cooling and other required services. LNGC would operate under the International Convention for the Prevention of Pollution from Ships (MARPOL) standards, as implemented under 33 CFR 151. Temperature changes, total suspended solids, and oil and grease from several sources would result in short-term changes to the marine environment in the area very close to the discharge point.

The presence, noise, and exhaust fumes of vessels are not expected to affect underwater EFH. On rare occasions, a vessel may accidentally release a small volume of diesel fuel to the water. The quantity of fuel and chemicals in the proposed Project area is limited. Prior to construction and operation, Delfin LNG would prepare and submit for approval a construction and operation Spill Prevention, Control, and Countermeasure (SPCC) Plan and Facility Response Plan detailing emergency procedures for addressing accidental releases and spills during construction and releases. The specific procedures would vary depending on the product spilled, location, sea state, weather, and other immediate conditions. Regardless of the particular cleanup methods, a small spill would be quickly contained and recovered, causing no long-term effect to EFH. It is possible that a limited area of EFH could be temporarily degraded by a small spill that caused a short-term effect on water quality. A small fuel or chemical spill is extremely unlikely to cause any significant effect beyond the immediate proposed Project area, which represents a negligible fraction of the millions of acres of water column EFH in the Gulf of Mexico. The chemical would dissipate or be collected before it could be transported more than a few miles from the lease area (NOAA 2006). Diesel is lighter than water and readily volatilizes, so a small fuel spill would not affect any benthic EFH. Effects on the water column would be transient and negligible. No long-term significant effects to EFH would result from a small fuel or chemical spill under the Proposed Action.

5.5 Effects of Construction Noise on Managed Fish Species

Marine fish can be affected by noise both physiologically and behaviorally. The majority of research involves studies of the physiological effect of effect pile driving on fish due to changes in water pressure. Fish with swim bladders would be more vulnerable to such pressure changes, which can cause capillaries to rupture or the swim bladder to rapidly expand and contract[2] (Caltrans 2001). Temporary loss of hearing (temporary threshold shift [TTS] or permanent threshold shift [PTS]) also may occur as a result of exposure to noise from impact pile driving (Popper and Hastings 2009; Popper et al. 2005). When caged juvenile coho salmon (*Oncorhynchus kisutch*) were placed as close as 6.6 feet (2 meters) to steel piles being driven, no fish mortality was observed (Ruggerone et al. 2008).

Potential effects of exposure to continuous sound on marine fish include TTS, physical damage to the ear region, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and, perhaps, lack of response due to masking of acoustic cues. Most of these effects appear to be either temporary or intermittent, and therefore, probably do not significantly affect the fish at a population level. The studies that resulted in physical damage to the fish ears used noise exposure levels and durations that were far more extreme than would be encountered under conditions similar to those expected at the proposed Port.

Fish react to underwater noise from vessels and move out of the way, move to deeper depths, or change their schooling behavior. The received levels at which fish react are not known and apparently are somewhat variable, depending upon circumstances and species of fish. To assess the possible effects of underwater Project noise, it is best to examine Project noise in relation to continuous noises routinely produced by other projects and activities, such as shipping and fishing, and pulsive noises produced by seismic exploration.

Most of the construction vessels used in the shallow water depths present at the proposed Port and along the proposed pipeline routes would be positioned by anchors and do not have installed thrusters. Pipe laying barge thrusters emit approximately 172 decibels (dB) microPascal root mean squared (μPa rms) at 1 meter and tugs emit 170 dB μPa rms, which attenuates to 144 dB μPa rms within 60 meters (Wyatt 2008). The anchored vessels will require servicing from an offshore supply vessel for crew changes, maintenance, and delivery of construction materials.

5.5.1 Pulsive Sounds

The pulsive sounds expected during construction scenarios are much less intense than the pulses from the air guns used in Gulf of Mexico offshore seismic surveys by the oil and gas industry. Such surveys routinely have source levels of 250 dB in reference to 1 μPa (dB re 1 μPa) at 1 meter. The available information suggests that seismic exploration has minor to moderate effects to fisheries resources and EFH (BOEM 2014). It is highly unlikely that the low levels of pulsed noise from construction activities would have any permanent effects on fish populations in the area.

Four TYMS would be constructed to allow permanent mooring of each FLNGV. Construction of each TYMS would involve jacket and pilings installation, and each TYMS platform would require four pilings, which would be installed in sections. Each pile would require 1 to 1½ days for installation (time includes welding, fit-up, and pile handling), for a total of 4 to 6 days for each TYMS platform, with an estimated strikes-per-day of 3,600.

5.5.1.1 Approach for Estimating Pile-Driving Noise Levels

Acoustic zones of influence (ZOIs) for potential injury and behavioral disturbance thresholds were calculated based on mitigated source levels for impact-driven, 78-inch steel pipe piling within an air

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[2] Hitting a steel pile with a large hammer produces sound that causes water pressure changes that impact fish. Sudden changes in water pressure can cause gases such as oxygen to come out of fish blood faster than normal, leading to a decompression sickness much like the bends that divers experience when they rise to the surface too fast. Pressure changes also affect a fish's swim bladder, an internal, air-filled sac that helps the fish maintain weightlessness at different water depths. Alternating pressure changes cause the swim bladder to quickly expand and compress, which punches and bruises neighboring organs and can rupture the swim bladder itself. (http://www.pnnl.gov/news/release.aspx?id=930)

bubble-infused coffer dam. Affected area radii representing potential behavioral and injurious effects to fish were calculated based on the 2016 NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) criteria for fish (GARFO 2016). Acoustic thresholds for the onset of behavioral effects have not been updated by NOAA Fisheries, and so the acoustic threshold for TTS onset is used here as a proxy for behavioral disturbance threshold and ZOI. The GARFO criteria rely on the acoustic metrics of peak (pk) and root mean square (rms) of the anticipated sound pressure level (SPL) and sound exposure level (SEL) to define thresholds. The SPLpk is a measure of the maximum instantaneous sound pressure from a specified source. It is used as a metric for the criteria for effects of underwater sound on fish. SPLrms is primarily used in the assessment of the behavioral effects on fish. The SPLrms is the square root of the sum of the squares of the pressure contained within a defined period from the initial time to a final time (Equation 1) (ICF Jones & Stokes, and Illingworth and Rodkin, Inc. 2009).

Equation 1:

$$SPL_{rms} = 20log_{10}(\left[\frac{1}{t_f - t_i}\int_{t_f}^{t_i} p^2\ (t)dt\right]^{1/2} / \mathrm{p_{ref}})$$

Where:

p = pressure
$pref$ = reference pressure for water (1µPa)
ti = initial time
tf = final time

Further, SEL is the constant sound level in one second, which has the same amount of acoustic energy as the original time-varying sound (i.e., the total energy of an event). SEL is calculated by summing the cumulative pressure squared over the time of the event. The accumulation of exposure over a designated period of time or number of instances of a sound is termed cumulative SEL (cSEL). The cSEL can be estimated from a representative single-strike SEL value and the number of strikes that likely would be required to place the pile at its final depth by using the following equation:

Cumulative SEL = Single Strike SEL + 10 log (# of pile strikes).

It was estimated in the original application that 3,600 pile strikes would occur per day. The cSEL is used for injury metrics in fish (GARFO 2016) and in revised impact metrics for marine mammals (NOAA Fisheries 2016). To determine the affected area, the transmission loss (TL) of the sound was computed across varying ranges from the source. The practical spreading equation (Equation 2) was used to determine the amount of sound loss.

Equation 2:

$$TL=15log_{10}r$$

Where:

r = range (m)

SPL measurement references were found for the proposed 78-inch steel pile. Therefore, measurements from piling of 96-inch cast-in-steel-shell (CISS) piles for the Benicia-Martinez Bridge were used as proxies for the impact analysis (ICF Jones & Stokes and Illingworth and Rodkin Inc., 2009; Caltrans 2015). In order to account for the smaller pile diameter considered in this analysis, the 96-inch proxy measurements were reduced by 5 dB to estimate the source level of the 78-inch piles. As directed by the client, this modified source level was then reduced by 11 dB to account for the mitigative effects of an air bubble-infused cofferdam surrounding each pile and carried through the propagation calculations to determine impact radii (Table 13). This follows the protocols set forth in the NOAA Fisheries pile-driving impact calculation guidance (GARFO 2016). No other modifications in the calculations were made.

Table 13. Estimated Sound Pressure Levels Produced by a 78-inch Steel Pile Calculated for Seven Propagation Distances a/

Approximate Distance b/	Sound Pressure Levels (dB)		
	SPL	RMS	SEL
5 meters	209	194	183
10 meters	204	189	178
20 meters	199	184	173
50 meters	194	179	168
100 meters	189	174	163
500 meters	179	164	153
1,000 meters	174	159	148

Note:
a/ The source level used for the propagation calculations was reduced by 11 dB to account for the mitigative effects of an air bubble-infused coffer dam surrounding each pile.
b/ Distance measured from the pile at about mid-depth (10-15 meters deep).
Key:
dB = decibels; RMS = root mean squared; SEL = sound exposure level; SPL = sound pressure level (zero to peak)
Source: Based on Benicia-Martinez Bridge measurements from ICF Jones & Stokes and Illingworth and Rodkin, Inc. (2009)

The criteria used for the fish ZOI radii calculations are based on 2016 guidance from NOAA's GARFO noise threshold criteria for impulsive sources (Table 14). Fish noise thresholds are based on sound levels that have the potential to produce injury or illicit a behavioral response.

Table 14. Threshold Levels Used To Determine the Zone of Influence Radii for Fish

Criterion	Definition	Metric	Threshold
Behavior	Impulsive or continuous source	SPLrms	150 dB re 1 µPa
Injury	Peak sound pressure level (SPLpeak)	SPLpk	206 dB re 1 µPa
Injury	Injury >2 g fish size for cumulative sound exposure level over 12 hours	cSEL	187 dB re 1 µPa2·s
Injury	Injury <2 g fish size for cumulative sound exposure level over 12 hours	cSEL	183 dB re 1 µPa2·s

Key:
dB re 1 µPa = decibels relative to one micropascal; cSEL = cumulative sound exposure level; SPLpk = peak sound pressure level; rms = root mean square
Source: GARFO 2016

The calculated impact threshold radii for a 78-inch steel pile encompassed in the coffer dam are listed in Table 15.Weighting functions are not used in calculating the SPLpk threshold radii for fish. To calculate the cSEL threshold isopleths for fish, the GARFO criteria use broadband frequencies equally across the energy spectrum and account for exposure time using the estimated number of pile strikes.

Table 15. Estimated Distances to Fish Species Threshold Levels for a Mitigated 78-inch Pile

Noise Source	Distance to Threshold (meters)			
	Onset of Physical Injury			Behavioral 150 dB rms
	206 Peak (dB)	Fish ≥ 2 g 187 SEL	Fish < 2 g 183 SEL	
Distance from Pile- Driving Noise Source (in meters)	7	590	736	3,981

Note:
a/ Assumes single strike SELs < 150 dB do not accumulate to cause injury (i.e., effective quiet).
Key:
dB = decibels; g = grams; rms = root mean square; SEL = cumulative sound exposure level

The threshold isopleths are graphically displayed in Figures 10 through 12. The figures are shown to visually represent the calculations described above. Other parameters that influence the propagation and attenuation of sound underwater, such as water depth, sediment type, and sound speed profile, were not accounted for in the model.

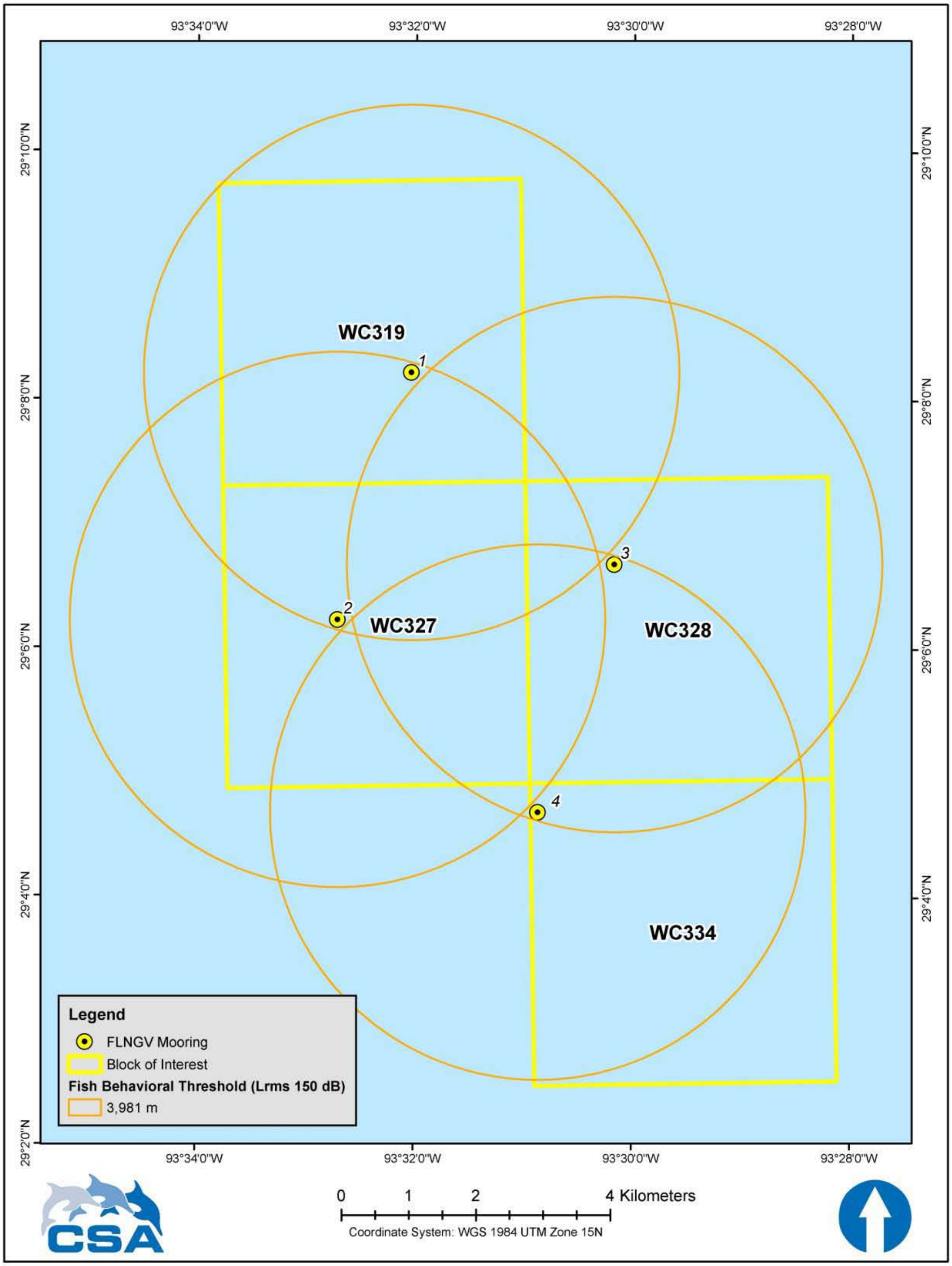

Figure 10. **Fish Behavioral Threshold (based on calculations for salmonids and sturgeon) Radii for the150-dBrms Isopleths Surrounding the Pile Locations. The noise propagation distances depicted are based on a mitigated impulsive source.**

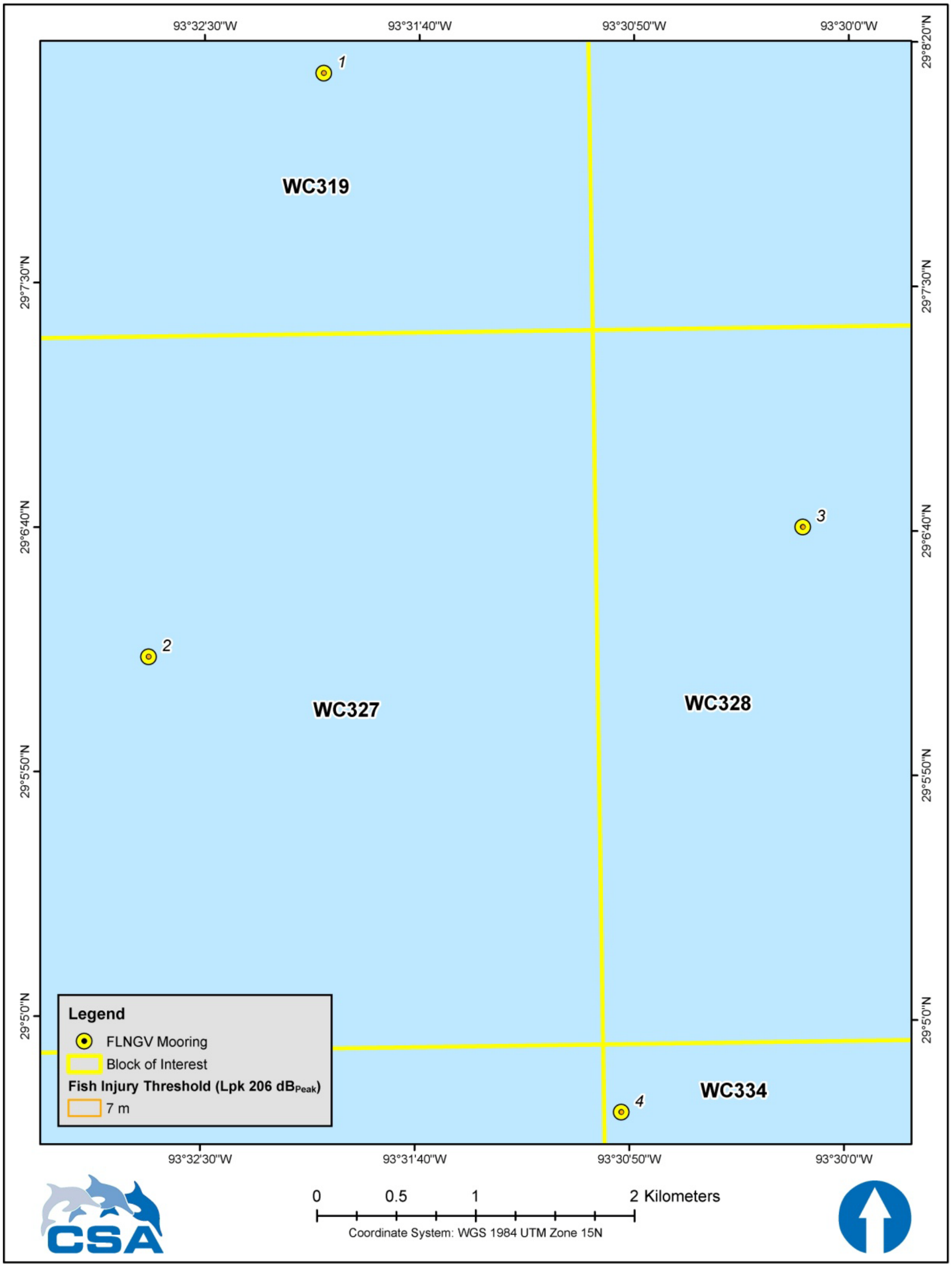

Figure 11. **Fish Injury Threshold (based on calculations for salmonids and sturgeon) Radii for the 206-dBpeak Isopleths Surrounding the Pile Locations. The noise propagation distances depicted are based on a mitigated impulsive source.**

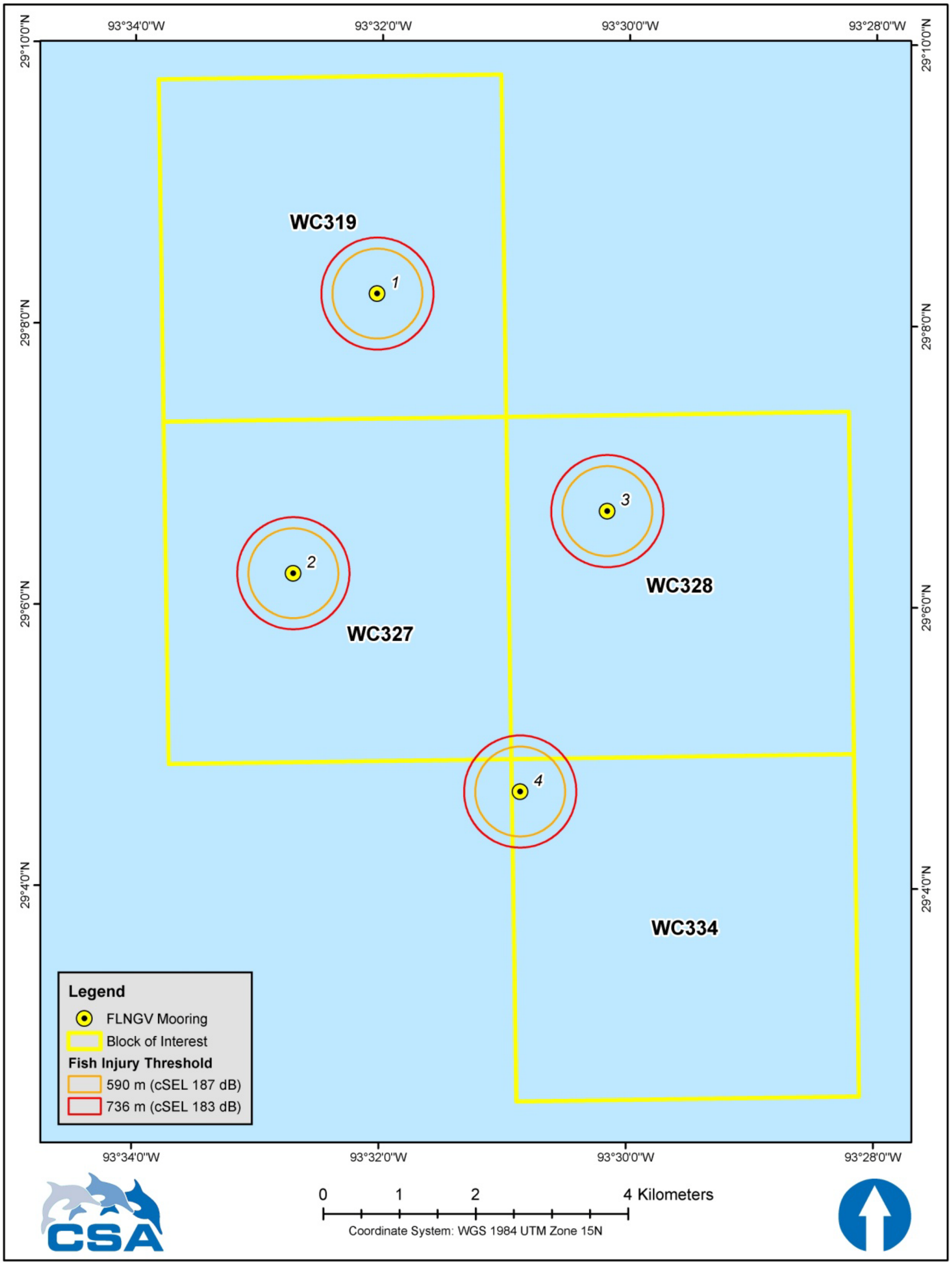

Figure 12. **Fish Injury Threshold (based on calculations for salmonids and sturgeon) Radii for Cumulative Sound Exposures. The 187- and 183-dB isopleths surrounding the pile locations relate to injury thresholds for fish weighing >2 g and fish weighing less than or equal to 2 g, respectively. The noise propagation distances depicted are based on a mitigated impulsive source.**

5.5.1.3 Ambient Noise Levels

Background noise, or ambient noise, is noise that already exists in the environment prior to the introduction of another noise-producing activity. Background noise can come from a number of sources, both natural and man-made. Natural sources of ambient/background noise include biological sources (i.e., various marine species), wind, waves, rain, or naturally occurring seismic activity (i.e., earthquakes). Human-generated sources can include vessel noise (e.g., commercial shipping/container vessels), seismic air guns, and marine construction. Various factors contribute to the background noise within the proposed Project ROI. One of the major contributors to background noise would be the commercial shipping traffic near the proposed Project area associated with the Sabine-Neches Ship Channel and the Port of Lake Charles. Between the two ports, approximately 3,044 port calls for vessels >1,000 gross register tons (GRT) were made in 2012 (USDOT Maritime Administration 2012). Based on the proximity of the proposed Project area to these important shipping centers, it is expected that the background noise is dominated by large vessels (e.g., tankers, container ships) that produce source levels of 180 to 190 dB re 1 µPaRMS at frequencies between 200 and 500 hertz (Hz) (Jasney et al. 2005).

Knowing the background noise of an area is important to understanding the overall effect that the introduction of more noise could have on the marine fishes. If background noise levels in the vicinity of the proposed Project exceed the NOAA Fisheries thresholds, then fish would not be affected by any sound less than the already existing dominant noise levels. See Attachment A for additional discussion of ambient noise. For the purposes of this evaluation, background noise levels have been assumed to be 150 dB.

5.5.1.6 Summary of Pulsive Noise Effects

With no mitigation measures employed, physical injury (all types) to fish could potentially occur within both the SPL and SEL ZOIs (see Figures 10 through 12). Generally, for the SEL ZOI, noise could affect juveniles, small species, or benthic taxa that typically are less motile than mid-water or pelagic species. Fish within the rms ZOI could experience behavioral effects. A small number of studies investigating the possible effects of noise, primarily seismic sound, on fish behavior have been conducted over the years. Studies looking at change in distribution are often conducted at larger spatial and temporal scales than are typical for studies that examine specific behaviors, such as startle response, alarm response, and avoidance response. The studies that examine those specific defined responses often involve caged fish rather than free-ranging fish (Hirst and Rodhouse 2000). Masking of natural/ambient sounds (e.g., communication, detection of predators and prey, gleaning of information about the surrounding environment) also has the potential to affect fish behavior.

Pile-driving activities at each TYMS would only occur for approximately one week. It is highly probable that some fish would avoid the area because of disturbing levels of sound when the impact hammer is operating; noise levels exceeding assumed “background” of 150 dB re 1 µPa rms can cause fish to avoid the immediate area around a pile being driven. However, because of the short timeframe for pile placement, it is predicted that no fish would be permanently deterred from entering the area for foraging. Also, because the area of disturbance would be small and similar habitat surrounds the site, any avoidance activity would not require extra energy expenditures. It is expected that some acoustic disturbance of fish close to an individual pile being driven, or within the immediate proposed Project area, could occur, but these effects would be short-term and negligible, and would not be expected to result in population-level effects.

5.5.2 Continuous Noise

Vessel transits between the Gulf of Mexico shipping lanes and noises generated at the loading terminal are long-term sources of continuous noise associated with the proposed Project. Delfin LNG modeled effects of continuous noise for one construction and one operational scenario. The two scenarios represent the most likely and potentially longest duration source of dynamic positioning (DP) vessel noise, and therefore provide a good overview for calculating the most likely extent of impact areas (Attachment A). The modeling provides a predicted range of distances from a sound source, or group of sources, to the boundaries of regulatory acoustic thresholds for fish. Noise produced by a non-impulsive (continuous) sources such as ship engines, thrusters, and propellers, unlike an impulsive source (pile driving, seismic surveys with air guns), is characterized by gradual intensity variations over time. DP vessel operation, even though thruster engagement may be varied and intermittent, is considered a continuous noise source.

Construction vessels (pipelay barge, crane barge, and dive support vessel) will be anchored during construction. However, construction vessels may be periodically serviced by an offshore supply vessel that will operate in a dynamic positioning mode while delivering supplies and materials to the construction vessels. Some vessels will use thrusters during operations, as well. DP systems and thrusters will generate noise during construction and operations.

Activities associated with construction and operation of the Delfin LNG port facility will require vessels that use thrusters for primary propulsion as well as for DP during station keeping and maneuvering. Individual DP vessels may use a variety of thrusters and adjustable propellers for propulsion and steering. The cavitation noise generated by engagement of these thrusters and propellers can produce noise levels well above that of other machinery operations or vessel propulsion noise (Erbe et al. 2013; Roth et al. 2013; Fisher 2000; Lee et al. 2010). While general vessel noise may affect the acoustic environment, the noise levels produced during thruster engagement present the greatest potential for acoustic impacts exceeding regulatory thresholds to fish (Erbe et al. 2013; Roth et al. 2013; Fisher 2000; Lee et al. 2010).

Affected area radii represent the distance at which regulatory acoustic thresholds (see specific metrics in the following paragraphs) are predicted to be met or exceeded, resulting in potentially detrimental auditory or physical effects to fish and marine mammals. Acoustic thresholds for continuous sources rely on two SPL metrics for establishing the thresholds at which a fish, exposed to acoustic energy, would reach the “dosage” necessary to elicit a regulatory impact. These regulatory thresholds are measured in either SPLrms (Popper et al. 2014; GARFO 2016; NOAA Fisheries 2016) or cSEL (NOAA Fisheries 2016). The SPLrms is a measure of the root-mean square, or “effective” sound pressure, converted to dB and used to quantify noise of a continuous nature. The time period over which measurements are taken is not relevant as the measurement will give the same result regardless of the period over which the measurements are averaged. This is contrasted with cSEL, which is calculated by summing the accumulated SPLrms, squared, over the time of the event. It effectively takes account of both the level of the sound, and the duration over which the sound is present in the acoustic environment.

Standard acoustic criteria used for establishing acoustic impacts to fish are the GARFO (2016) guidelines. However, these criteria are only applicable to pile driving activities and do not address continuous noise sources addressed in this assessment. Therefore, we used the best available information and recommended guidelines from Popper et al. (2014) to establish impact radii for fish. Because of the limited exposure and response data available for fish, Popper et al. (2014) did not assign specific threshold levels for impacts. For most fish groups, Popper et al. (2014) only provide subjective impact criteria such as “low, medium, and high” for injury risk potential of fish in zones defined as “near, intermediate and far” from the sound source. These subjective criteria, therefore, are impossible to apply in the current acoustic assessment. The only defined threshold levels for continuous noise given by Popper et al. (2014) are for fish with swim bladders that provide some hearing (pressure detection) function for the fish. Threshold levels are given for acoustic impacts resulting in recoverable injury and acoustic impacts resulting in TTS (Table 16). Popper et al. (2014) uses a 48-hour accumulation period for recoverable injury and 12-hour accumulation period for TTS. Additionally, NOAA Fisheries and the U.S. Fish and Wildlife Service have used a level of 150 dBrms as a threshold for behavioral responses in fish (Hawkins and Popper 2014). This 150 dBrms threshold levels has subsequently been used in the acoustic impact literature for fish although the scientific origin of this value is not known (Hasting 2008). As this threshold level has been used by regulatory entities, we have included the 150 dBrms threshold for potential behavioral impacts.

Table 16. Threshold Levels Used To Determine the Zone of Influence Radii for Fish

Fish Category	Criteria Definition	Exposure Assessment Period	Metric	Threshold
Fish (non-descriptive)	Onset of behavioral reaction a/	12 hours	SPLrms	150 dB re 1 μPa
Fish: swim bladder involved in hearing (primarily pressure detection)	Temporary Threshold Shift(TTS) b/	12 hours	SPLrms	158 dB re 1 μPa
	Recoverable injury b/	48 hours	SPLrms	170 dB re 1 μPa

Notes:
a/ No documented scientific basis for criteria (Hastings 2008).
b/ From Popper et al. (2014) Table 7.7.
Key:
SPL_{rms} = peak sound pressure level root mean square
dB re 1 μPa = decibels relative to 1 microPascal

Fish thresholds were not met due to the short time period (3 to 4 hours) of exposure, which falls below the 12- to 48-hour exposure period necessary to meet the guidelines for onset of impacts. Continuous noise would not adversely affect EFH or maned species during construction or operation. See Attachment A for more details. Furthermore, Delfin LNG will prevent or mitigate potential noise impacts by maintaining minimal safe operating power at all times. Delfin LNG's FLNGVs will not engage thrusters if they are not required to do so.

5.6 Ingestion of Marine Debris

Short-term, negligible, adverse effects on marine fish would result from the accidental release of marine debris (e.g., ropes, plastic, etc.) during construction. Marine debris of a size that can be swallowed by a fish could be eaten either at the surface, in the water column, or at the seafloor; therefore, all six trophic guilds may be affected. Open-ocean planktivores and piscivores are most likely to ingest materials in the water column, though. Coastal bottom-dwelling predators and estuarine bottom-dwelling predators, such as crab-eaters and benthivores, could ingest materials from the seafloor. The potential for fish to encounter and ingest marine debris depends on their feeding group, size, and geographic range. While no aspect of the Proposed Action includes the intentional "dumping" of debris in the marine environment, it is possible that during routine construction activities some construction-related debris could end up as marine debris.

Delfin LNG's standard operating procedures for minimizing marine debris are aligned with MARPOL 73/78 Annex V requirements and Federal regulations. Construction workers may not purposefully discard trash or debris overboard into the marine environment. To discourage illegal dumping, Federal regulations require that all equipment, tools, and containers (such as drums) be marked with permanent identification (30 CFR 250.300(c)). As required by the USEPA and USCG, Delfin LNG will prepare a waste management plan and require construction workers to follow it. Best practices such as covering trash bins, sending ashore, and minimizing solid waste in general, would reduce effects of marine debris on fisheries to negligible levels.

5.7 Effects of Introducing Structural Habitat

Introduction of the structures associated with the proposed Project would affect EFH in the immediate area in several ways. For example, the FLNGVs would provide a fixed area of shade and lower water temperature in the otherwise open sea. Floating objects of visible size are known to function as fish-aggregating devices (FAD). Intentionally placed FADs are moored at specific locations to attract pelagic fishes (Girard et al. 2004; Macfadyen et al. 2009; Seaman 2007). For example, the State of Hawaii maintains 55 moored floating fish aggregating devices specifically designed to attract pelagic fishes such as tuna, wahoo, mahi mahi, and billfish (University of Hawaii 2010). The FLNGVs would serve as FADs in the proposed Project area.

The above-water portion of the proposed Project would provide roosting, resting, perching, and nesting surfaces that favor predators and increase the vulnerability of some fish species. The Pacific Fishery Management Council raised concerns that floating alternative energy facilities may create additional roosting sites for piscivorous birds; the Council recommended that floating structures be designed to prevent or discourage bird roosting (PFMC 2012). The assemblage of aerial predators in a given area influences the risk of predation for fish species in complex ways beyond the scope of this EFH.

Underwater portions of the proposed Project would be used as substrate for encrusting and attaching organisms, serving as the non-living framework for a biogenic reef that in turn supports a community of prey and predator species. The increased complexity of the biogenic habitat may provide enhanced refuge opportunities for small prey species, including newly recruited juvenile fishes (NOAA 2007). The presence of the proposed Project in concert with other energy infrastructure may influence local distributions of predators and prey species on a small spatial scale.

Scientists and fisheries managers are engaged in an ongoing debate over whether artificial structures lead to an increase in fish abundance or simply cause existing populations to become redistributed (Shipp and Bartone 2009; Love et al. 2006; Girard et al. 2004). Apart from the argument over whether fish abundance is increased, there is little disagreement over the direct habitat value of artificial structures (NOAA 2007; GMFMC 2013). Marine infrastructure may support attaching and encrusting organisms, including corals, mussels, barnacles, and other invertebrates. When these organisms are detached by storms, maintenance, or other forces, their shells drop to the seafloor, where they accumulate in shell mounds around the base of the platform, providing a hard-bottom area in the surrounding soft-bottom habitat (Goddard and Love 2008; Love et al. 2006). Fishes are known to use platforms as mid-water cover and to associate with the shell mounds beneath the platforms. In the southeast U.S., some types of artificial structures are designated as EFH, while in the Gulf of Mexico artificial structures that were placed in the water for purposes other than fish habitat (such as piers, wharfs, docks, pilings, oil rigs, and shipwrecks) are not considered EFH, although many occur in waters designated as EFH (GMFMC 2013).

The proposed Port would not create complex habitat in the same way as a fixed platform because the FLNGVs are designed not to accumulate encrusting organisms on their hulls. However, as a large floating structure, the proposed Port would serve as a temporary aggregating locale for mobile pelagic fishes. The commercial fishing interests that harvest tuna from the Gulf of Mexico would not set their lines beneath the FLNGVs, and so tuna and other pelagic fishes that were attracted to the proposed Port would be temporarily protected from capture. The physical presence of the proposed Port would have a minor temporary beneficial effect on pelagic fishes such as tuna because it would create a temporary no-take zone that would protect some individuals from fishing pressure.

The TYMS and FLNGVs are not meant to become valuable habitat for any given species, yet they would serve that function, especially because hard-bottom and topographic relief are scarce in the proposed Project area. Delfin LNG would make decisions about decommissioning based on business needs, safety guidelines, or other factors unrelated to EFH. The physical presence of the proposed Project would have adverse or beneficial effects on various managed species. In cases where the physical structures increased the value of EFH for a given species, its removal would constitute an adverse effect, and vice versa.

Regardless of formal definitions, in-water portions of the proposed Project certainly provide at least temporary structural habitat to managed fishes, their prey, and their predators. On balance, the presence of the structures is considered either neutral or beneficial to most types of EFH. Decommissioning and removal of components of the proposed Project would have a minimal adverse effect on some types of EFH, with a possible contemporaneous beneficial effect on other types of EFH. As artificial habitat, the proposed Project would have no permanent effect on EFH or populations of managed species; no particular species would be favored or disadvantaged.

6.0 CONCLUSIONS

Most effects of from proposed Project construction, operation, and decommissioning would be temporary to short- term and highly localized, occurring primarily during construction or shortly thereafter. A change in the type of benthic habitat in the immediate area from soft-bottom to hard-bottom would be long-term, but neutral (neither adverse nor beneficial) (Table 17).

Table 17. Summary of Potential Project Effects on Essential Fish Habitat within the Region of Influence

Type of Effect	Temporary Recovery (Days to Weeks)	Short-term Recovery (<3 Years)	Long-term Recovery (>3 to <20 Years)	Permanent (>20 Years)	Cumulative
Direct					
Sedimentation/Turbidity	X				
Displacement of Organisms	X				
Injury or Death of Benthic Organisms			X		
Change in Bottom Habitat				X	X
Indirect					
Change in Prey Resources (Benthic and Planktonic)	X	X			
Reduced Water Quality	X				

Potential adverse effects would be minimized by siting the pipeline along a route that is devoid of complex benthic habitats or other ecologically important topographic features. Overall, effects on managed species identified as having EFH in the proposed Project area would vary depending on the species. It is expected that species at greatest risk from various construction activities would be those with demersal life stages, where loss could be expected during trenching and other substrate-intrusive activities. In general, due to their mobility, pelagic species and those with mobile early life stages would avoid the proposed Project area during construction. Eggs and larvae would move through the proposed Project area with the prevailing currents. Any loss of eggs and larvae during hydrostatic testing or operation of the proposed Port would be inconsequential to regional populations.

Short-term changes in turbidity would occur as a result of disturbance of bottom sediments during construction. These effects would likely be highly localized and thus not be expected to be significant. Sediment disturbance along the pipeline route would also be expected to cause mortality to benthic organisms within and adjacent to the pipeline route. Direct effects to benthic organisms would favor some predators over others temporarily but not adversely affect a species at the population level. This effect would be short-term and minor, as the community would become re-established over a relatively short period of time through immigration and recruitment. The short-term loss of the benthic community during pipeline construction would not be a significant adverse effect. Effects from pile driving are expected to be less than significant considering the mitigation measures proposed. While some individual fish could be injured by noise, no population-level effects would occur. Effects would be short-term and not significant.

7.0 CUMULATIVE EFFECTS AND MITIGATION MEASURES

7.1 Cumulative Effects on EFH and Managed Species

Cumulative effects are “impacts 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 person undertakes such other actions” (40 CFR 1508.7). A summary of other projects that may contribute to cumulative effects on all resources is provided in Chapter 6 of the final EIS. Most of the projects within the 20-mile radius generally used in cumulative effects analysis are not in the marine environment and are not expected to cause overlapping effects on EFH. Two of the projects described in Chapter 6 are considered to contribute to cumulative effects on EFH in the proposed Project area: Cameron Parish Shoreline Restoration Project and Bureau of Ocean Energy Management (BOEM)-permitted oil and gas exploration and production (Table 18).

No in-water construction projects are currently scheduled within the near vicinity of the proposed Project; however, there are ongoing regional activities within the proposed Project’s locale. However, BOEM has issued long-term leases to independent operators for oil and gas exploration and development in the surrounding areas, so additional construction is possible (BOEM 2016). The proposed Project area is used by recreational and commercial fishing vessels, especially state-regulated commercial trawls and long-line operators. These permitted fishing activities, as well as non-fishing impacts, are accounted for in GMFMC’s analysis of the status of EFH (GMFMC 2010). Non-fishing impacts in the northern Gulf of Mexico that may be cumulative with the proposed Project include construction noise and small fuel spills.

Table 18. Regional Projects Considered for Cumulative Effects Analysis for the Proposed Project

Project	Location	Date	Description	Expected
Cameron Parish Shoreline Restoration	Cameron Parish, LA	50-year master plan (2012-2062)	$45.8 million project involving a 9-mile stretch of Gulf of Mexico coast and dredging sand resource blocks Five proposed offshore sand resource blocks overlap proposed Project sites Part of a 50-year master plan to combat and reverse coastal land loss http://coastal.la.gov/project/cameron-parish- shoreline-protection/	Substrate disturbance and increased vessel traffic in proposed offshore FLNGV locations
Oil and Gas E&P Gulf of Mexico Central Planning Area Lease Sales	Cameron Parish, LA	2012–2017	Oil and gas activities may occur on Outer Continental Shelf leases after a lease sale pursuant to the Proposed Action and the activities may extend over a period of 40 to 50 years. Activities could include seismic surveys, drilling oil and natural gas exploration and production wells, installation and operation of offshore platforms and pipelines, onshore pipelines, and support facilities, and transporting oil using ships or pipelines. http://www.data.boem.gov/homepg/pubinfo/repcat/arcinfo/zipped/gomr_leases.htm	Erosion and runoff, sediment disturbance and turbidity, vessel discharges, and accidental releases of oil, gas, or chemicals

The offshore construction zone is located outside the major shipping channel(s) into the ports of Lake Charles, Louisiana, and Beaumont/Sabine Lake, Texas; therefore, no commercial vessel traffic would transit the immediate proposed Project area. Project vessel traffic during construction would increase noise levels and minor spills. The Applicant would ensure compliance with all Federal safety and environmental requirements during construction in order to reduce the potential for impacts on managed species.

Offshore oil and gas exploration and production involves activities similar to those required for the proposed Project, including pipeline installation, installation and removal of mooring devices, and placement of floating or fixed platforms. The same types of construction and support vessels are used, with the associated effects of noise, small chemical spills, and marine debris.

Activities and effects of the proposed Project on EFH are consistent with those evaluated in BOEM's Programmatic and Lease Sale EISs for the area (BOEM 2014 and 2016) in which cumulative effects on EFH were found to be not significant. The proposed Project would not introduce any novel stressors to EFH, nor would it cause notable changes to the quality or quantity of EFH in the ROI or surrounding area. Effects of noise will be mitigated (see Section 7.2 below). Chemical discharges will comply with NPDES and USGS permits. Accidental spills will be efficiently contained and cleaned up in accordance with the Applicant's SPCC Plan. All effects on EFH would be either temporary or short-term. The only effect that would last longer than a few years is the presence of the structure itself, which would be neither adverse nor beneficial to existing EFH or managed species, but add a type of habitat that does not currently exist in the ROI.

7.2 Mitigation Measures

Based on the previous analysis, there is a potential risk to managed (and other) species as a result of planned pile-driving activities for the proposed Port. To minimize effects, Delfin LNG would institute effect minimization and mitigation measures throughout the course of the proposed Project. Although specific mitigation measures are not yet final, if required, they may include the following:

- Use of the lowest-noise-producing impact hammer available for pile driving to reduce in-water noise levels.
- Various operational procedures, including "soft starts." Prior to operating at full capacity, Delfin LNG would implement a "soft start" with several initial hammer strikes at less than full capacity (i.e., approximately 40 to 60 percent energy levels) with no less than a 1-minute interval between each strike.
- Bubble Curtain. A bubble curtain functions to restrict sound waves from emanating away from the noise source. Air is pumped into a nozzle hose lying on the seabed and escapes through holes that are provided for this purpose. This produces an air bubble curtain within the water column due to buoyancy. Sound generated by pile-driving work must pass through the ascending air bubbles and is thus attenuated.
- Hydro Sound Damper (HSD). The HSD system consists of a fisher net where HSD elements with different sizes and distances from each other are mounted. Using a ballast ring on the seabed and a flotation system on the sea surface, the fisher net, including the HSD elements, can be located a short distance (less than 1 meter) around the pile. The HSD elements can be foam plastic elements or gas-filled balloons. The radiated noise from the pile must cross the HSD elements and is reduced due to reflection and absorption. In principle, the HSD elements act like air bubbles in the water, with the advantage that they cannot be drifted by current and their size, and therefore their resonance frequency, is adjustable.
- Noise Mitigation Screen (NMS). An NMS system consists of a double-wall steel screen (tube). The pile is inserted into this system. The space between the two screens is filled with air, and air bubbles can be feed in between the pile and NMS system (water-air composite). The radiated sound crosses the internal bubble curtain and the air-filled double-wall steel screen and is reduced due to reflection (impedance gap).

- Cofferdam. The cofferdam system consists of a single-wall steel tube. The pile is be inserted into this system. Near the seabed, a gasket (seal ring) is installed so that water in the space between pile and cofferdam can be evacuated by pumps. In principle, the pile is installed "in air" and not in water, so sound generated by pile driving radiates into the air and the crosses the steel tube. Due to the different impedances, the pile-driving noise is reduced by reflection.

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Attachment A

Acoustic Modeling: Effects of Continuous Noise

SOUND PROPAGATION MODELING

The modeling software, dBsea (©Marshall-Day), was used to forecast the underwater acoustic fields resulting from the construction and operation of a floating liquefied natural gas vessel (FLNGV) export terminals at the Delfin LNG site. The model makes use of several types of user-defined environmental data, including bathymetry, speed of sound through the water column (sound speed profiles), and geoacoustic properties of the seabed. Frequency dependence of sound propagation characteristics is treated by computing acoustic transmission loss at the center frequencies of 1/3-octave bands. The sound exposure levels (SEL) received along the radius in each band are computed by applying the frequency-dependent transmission losses to the corresponding 1/3-octave band source levels.

AMBIENT NOISE

Ambient noise is considered as the composite sound from both natural and anthropogenic sources within an area of interest that excludes the contributions of the sources being measured or assessed. Ambient conditions are important to consider in impact assessment as it affects the zone of audibility that an animal will have for perceiving any added sound sources. If the propagated sound level from the noise source is lower than ambient noise levels, then for this exercise it is considered that noise is not within the perceptibility of the selected animal (Kyhn et al. 2014; Wang et al. 2014).

During preliminary baseline surveys conducted by Fairwood in 2015, ambient noise measurements were recorded using a Loggerhead Instruments DSG underwater acoustic recorder with a calibrated HTI hydrophone. Results from these measurements indicate that maximum third-octave band spectral noise levels in the vicinity of the site were generally between around 115 and 150 decibels relative to 1 microPascal squared hertz (dB re 1μPa^2 Hz^{-1}) with these peak band levels occurring in frequencies of a few hundred hertz, depending on time. This is fairly typical of coastal underwater noise, having higher noise levels at frequencies around a few hundred hertz and falling off at higher frequencies. The overall sampling average for the site was 118 dB re 1μPa^2 Hz^{-1}; which was the ambient level used in our analyses. The primary anthropogenic contributors to the ambient noise level in and around the proposed LNG facility are from nearby commercial shipping lanes which pass within 50 kilometers (km) of the site and nearby vessels supporting existing oil and gas facilities.

MODELING SCENARIOS

Two activity scenarios, one for construction and one for LNG vessel mooring operations, were modeled to determine the expected acoustic isopleths. The propagation distances for the two scenarios were calculated based on the combined source levels (SL) of the dynamic positioning (DP) vessels and the environmental parameters. The specific vessels to be used on the project are not known and therefore, no direct measurements of the sources were available. The modeled scenarios, therefore, used proxy vessel measurements that were comparable to the vessels that are expected to be used during the associated project phases. The vessels modeled for the activity scenarios are described in Table A-1.

Scenario 1 (Construction) Model

Construction will require the use of DP vessels for delivery of supplies and construction materials and potentially for positioning of construction vessels as they prepare for anchoring at the construction site. All of the constructions vessels in this scenario (pipelay barge, crane barge, and dive support vessel) are assumed to be already in place and anchored and will not operate in a dynamic positioning mode within the modeled 24-hour assessment period. The anchored vessels will require servicing from an offshore supply vessel (OSV) for crew changes, maintenance, and delivery of construction materials. The servicing OSV will remain relatively stationary while operating in DP mode as it makes the service calls to each anchored platform. The OSV will not be on-site for longer than 3 hours every 24-hour period. Additionally, all DP activity is assumed to occur within a 1 km range over the entire 3-hour period. Because there is only one OSV vessel operating in DP mode in the scenario, the source level for the scenario is 186 dBrms, which is equal to that of the OSV alone.

Table A-1. Description of Vessel Activity Parameters Used for Modeling Two Activity Scenarios, at One Location within the Delfin LNG Project Area, Over One 24-Hour Time Period a/

Scenario	Noise Source	Activity	Proxy Source	Proxy Source Description	Number in use	Modeled Broadband per Vessel SL (dB re1 µPa·@1m)	Hours of operation within a 24-hour period
Construction Scenario	Offshore Support Vessel	Servicing anchored vessels	Setouchi Surveyor a/	Length: 64 m Draft: 5 m Source Depth:4.8 m	1	186.1	3
	Pipe Lay Vessel	Anchored	N/A	Idle	1	N/A	N/A
	Crane Barge	Anchored	N/A	Idle	1	N/A	N/A
	Dive Support Vessel	Anchored	N/A	Idle	1	N/A	N/A
Operations Scenario	LNG Escort Tug	Positioning LNG carrier	Pacific Ariki b/	Length: 64 m Draft:6.6 m Source Depth: 6 m 6,437 HP	4	185.7	4
	LNG Carrier	Positioning to FLNG	N/A	Idle	1	N/A	N/A
	FLNGV	Weathervaning on mooring to stabilize with LNG carrier	FPSO b/ with thrusters operating	(2) 8000 HP azimuth thrusters operating at full power	1	188.9	4

Notes:

a/ The modeled activity location is at planned FLNG mooring #1, located in OCS Lease Block WC 319, Latitude: 29°8’13.100”N; Longitude 93°32’2.200”W.

b/ Hannay et al. 2004.

c/ Duncan 2014; McCauley 1998.

Key:

dB re 1 µPa @ 1 m – decibels relative to 1 microPascal at 1 meter
FLNGV – floating liquefied natural gas vessel
HP – horsepower
m – meter
N/A – not applicable
SL – sound level

Scenario 2 (Operations) Model

Under normal operational procedures, an empty liquefied natural gas carrier (LNGC) will berth at the FLNGV (liquefaction vessel). LNG Carriers are escorted into the Delfin LNG facility area by tugs. Four tugs are attached and provide assistance within approximately 1 km of the FLNGV mooring. The tugs are connected by line to the LNGC and use their engines/thrusters to control and arrest the LNGC as it positions alongside the FLNGV. The FLNGV is moored to a tower yoke mooring system (moored by the bow in a weather vanning arrangement) but can use any of its three installed propulsion thrusters to position the FLNGV in relation to the wind/waves. The propulsion thruster on the FLNGV is an azimuthing directional thruster (one of three propulsion thrusters). During normal operations, the propulsion thrusters are engaged only when the FLNGV is receiving an LNGC. For this scenario, we assumed that when an LNGC is arriving or departing, there will be four tugs with thrusters operating at very slow speed (1 to 2 knots) and the FLNGV is using one of its thrusters for positioning to receive or release the LNG carrier with tugs attached. While the tugs are moving very slowly during mooring (three hours) and departure (1 hour) they could be using their thrusters under significant power to arrest the incoming ship or move the FLNGV into position (or away from the FLNGV during unmooring). The scenario assumes that while there are a total of four moorings proposed for the facility, only one mooring operation will be conducted within a single 24-hour period. These single mooring operations may be conducted up to 40 times per year.

The tugs are used for 3 hours within the vicinity of the mooring during arrival and 1 hour during departure. Thus, the combination of tug thrusters and FLNGV thrusters (for positioning) are only expected to last for a maximum of 4 hours to complete a cycle within any single 24-hour period. During this time, the LNGC is expected to be at or near idle and will not contribute appreciable to the source levels. All DP activity is assumed to occur within a 1km range over the entire 4-hour period. The activity of the four tugs plus the FLNGV positioning produces a combined source level of 193.1 dBrms.

MODELING RESULTS

The propagation distances for the modeled noise sources were plotted for the received levels of SPLrms and cSEL for the construction and operations scenarios. The distances are plotted for mooring #1 with the locations of the other three moorings provided for reference. It is assumed, based on the environmental parameters, that the propagation distances will be the same for each mooring location.

The isopleths corresponding to the recommended threshold levels for the fish (derived from Popper et al. 2014) were calculated using the unweighted sound field estimations modeled using dBsea acoustic modeling software (© Marshall Day). These results are listed in Table A-2. The threshold metric (SPLrms) does not directly account for the exposure time during which DP operations are active in the same way the cSEL metric accounts for exposure time. However, to meet the threshold criteria it is assumed that a fish would need to be exposed to the DP source levels at the distances listed in Table A-2 for 48 hours in the case of recoverable injury, or 12 hours in the case of TTS.

Table A-2. **Estimated Average Radial Distances from Source to Potential Fish Threshold Levels for Each Activity Scenario a/**

Scenario	Average Radial Distance in Meters to SPL_{rms} Thresholds		
	Recoverable Injury (170 $dB_{rms\ for\ 48\ hours}$)	TTS (158 $dB_{rms\ for\ 12\ hours}$)	Onset of Behavioral Reaction (150 $dB_{rms\ for\ 12\ hours}$)
Construction	590	795	1,214
Operations	1,099	1,474	1,618

Note:

a/ To reach the impact thresholds, fish would need to be at these distances for prescribed amount of time established in each threshold level.

Key:

dB_{RMS} – decibels root mean squared; TTS – temporary threshold shift

The ZOIs (km^2) are the areal extent encompassing cetacean and fish threshold sound levels expressed for construction and operation scenarios. Fish thresholds were not met due to the short time period (3 to 4 hours) of exposure which falls below the 12- to 48-hour exposure period necessary to meet the guidelines for onset of impacts.