SAND2018-10119 O

Project Overview

Marine and Hydrokinetic (MHK) Environmental Compliance Cost Reduction Strategies Workshop

June 12, 2018

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

PROJECT TEAM

Sandia National Laboratories

integral consulting inc.

KEARNS WEST

H.T. HARVEY & ASSOCIATES
Ecological Consultants

AGENDA

- **Welcome & Project Overview**
- **Updated Quantitative and Qualitative Findings**
- **Qualitative Findings from Other Industries**
- **Next Steps, Adjourn**

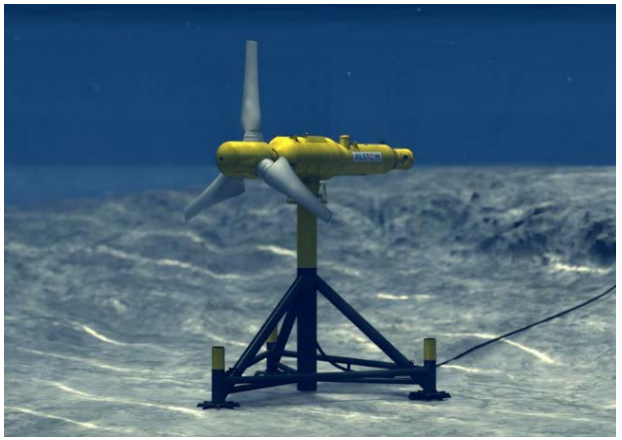
PROJECT OVERVIEW

Issue:
- High environmental permitting costs
- Costs not well understood

Goal:
- Create an economically competitive U.S. MHK industry
  - Create efficiencies in MHK environmental compliance process
    - Reduce time and costs to achieve environmental compliance, while meeting federal, state and local regulatory requirements.
  - Encourage investment in MHK projects
    - Reduce project deployment risk from environmental compliance

Project Objectives:
- Develop detailed and accurate estimates of the environmental compliance costs associated with licensing and permitting MHK developments.
  - Gathered from industry and federal / state regulatory agencies
- Determine how these respective costs contribute to LCOE and investment risk.
- Identify opportunities for cost reduction pathways.

Renewable Energy Futures Study NREL TP-6A20-52409-2



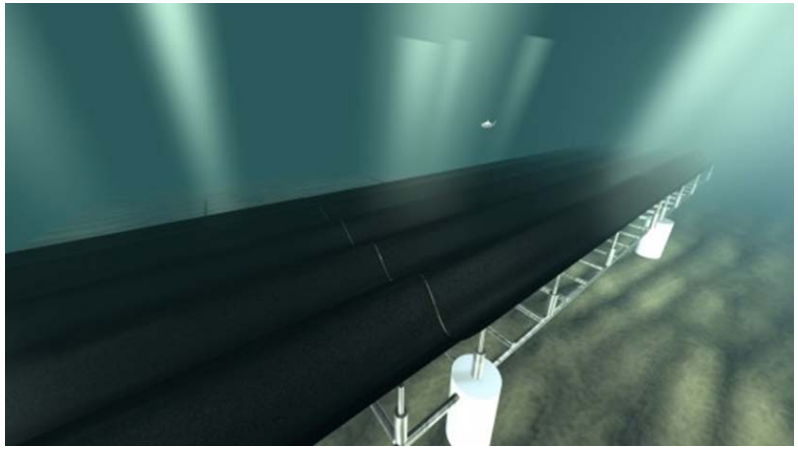
Brown-Saracino 2015

PROJECT PROCESS

PROJECT PROCESS: COSTS AND QUALITATIVE FEEDBACK GATHERED

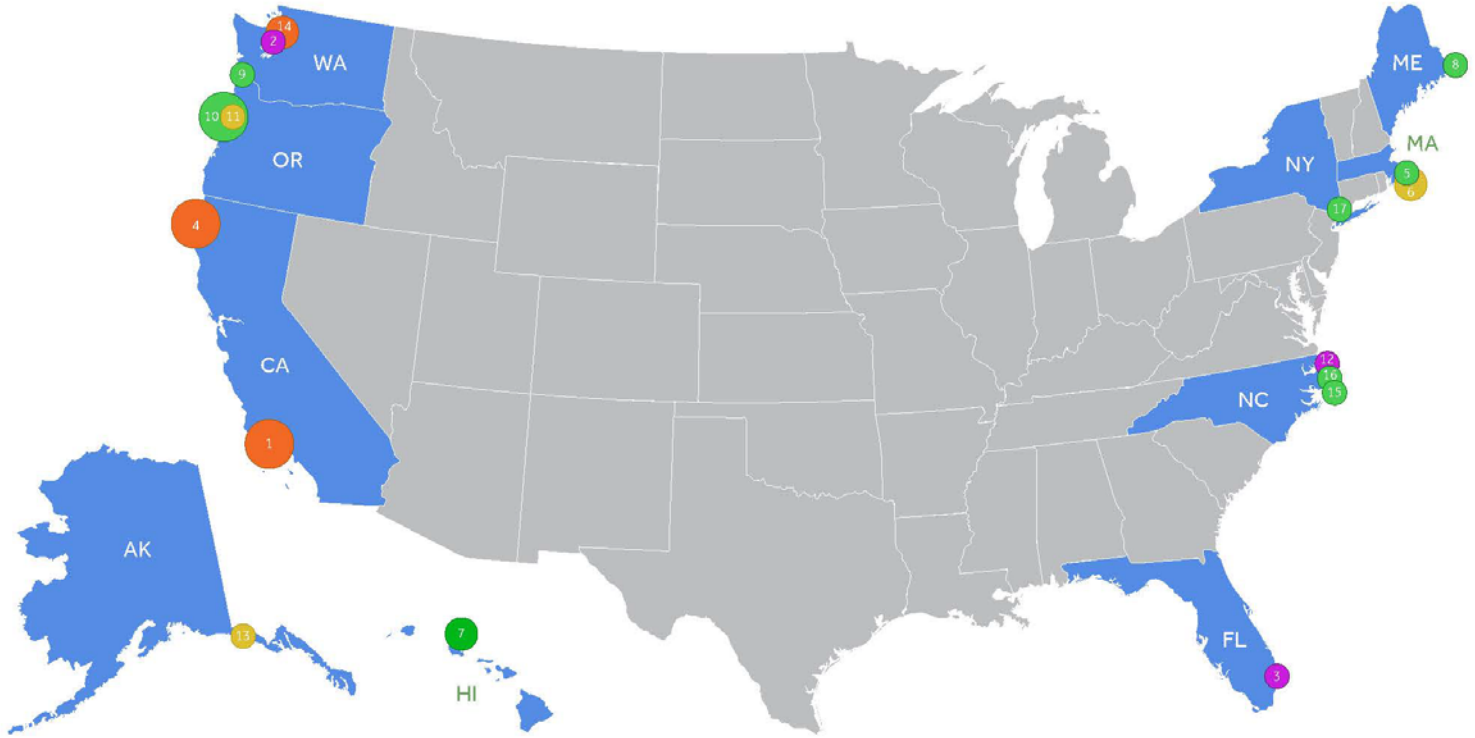
Brown-Saracino 2015

- **Total Project Cost**
- **Permitting/Licensing Costs**
  - Stakeholder Outreach,
  - State and Federal Permitting,
  - Studies (baseline characterization and pre-deployment)
- **Monitoring & Compliance Costs**
  - Studies (post deployment)
  - Adaptive Management
  - Decommissioning



Calwave Wave Carpet 2010

PROJECTS INCLUDED (so far)



#	Project Name	Location	Type	Sub-Type	Capacity (KW)
1	CalWave	Central Coast, CA	Wave	Test Site	30,000
2	Columbia Power - StingRay Wave Power System	Pudget Sound, WA	Wave	Test Deployment	500
3	Florida Atlantic University – Brower Test Site	Boca Raton, FL	Ocean Current	Test Site	N/A
4	Humboldt WaveConnect Pilot Project	Central Coast, CA	Wave	Test Site	25,000
5	MRECo - Bourne Tidal Test Site	MA	Tidal	Test Site	50
6	MRECo - Muskeget Channel	Muskeget Channel, MA	Tidal	Test Deployment	5,000
7	Navy Wave Energy Test Site	HI	Wave	Test Site	1,000
8	ORPC - Cobscook Bay Tidal Energy Project	Eastport, ME	Tidal	Commercial Deployment	300
9	PMEC - North Energy Test Site	Newport, OR	Wave	Test Site	100
10	PMEC - South Energy Test Site	Newport, OR	Wave	Test Site	20,000
11	Resolute Energy Camp Rilea Trials	National Guard Base Camp Rilea - Warrenton, OR	Wave	Test Deployment	60
12	Resolute Marine Energy - Duck Field Research Facility - USACE	NC	Wave	Test Deployment	25
13	Resolute Marine Energy Yakatut Project	Yakutat, AK	Wave	Test Deployment	500
14	Snohomish PUD - Admiralty Inlet	Snohomish, WA	Tidal	Commercial Deployment	1,000
15	UNC - Gulf Stream	Cape Hatteras, NC	Ocean Current	Test Deployment	N/A
16	UNC - Jeanette's Pier	Nags Head, NC	Wave	Test Site	N/A
17	Verdant Power - Roosevelt Inlet Tidal Energy	NY	Tidal	Commercial Deployment	175

U.S. Marine and Hydrokinetic Projects

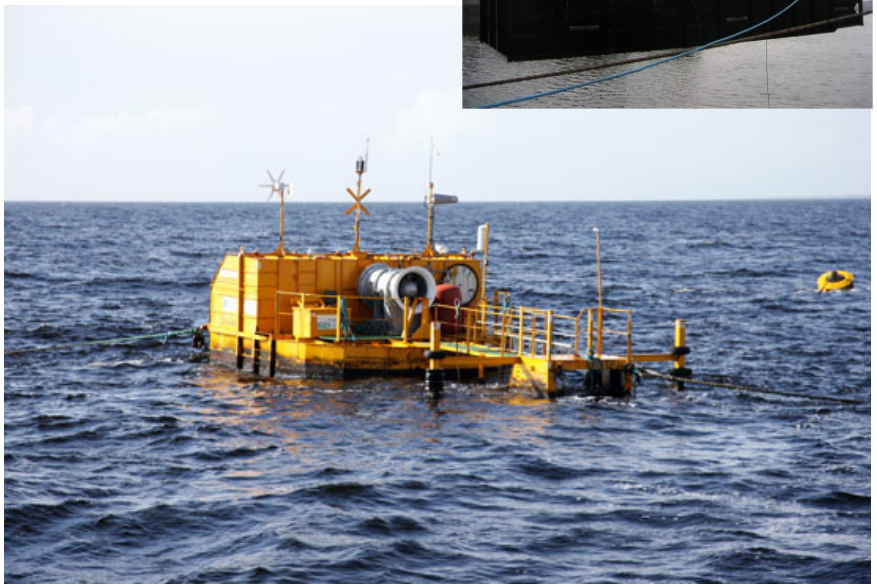
September 2017

Project Size
- >5 MW
- 1 - 5 MW
- <1 MW

Project Status
- Completed
- Active
- On Hold
- Cancelled

INDUSTRY OUTREACH CONDUCTED
(so far)

- **Initial Discussions**
  - **Qualitative and Quantitative Project Details**
- **Economic Discussion Follow-up**
  - **Data Gaps and Comparability**
  - **Project and Study Timelines**
- **Partner Outreach**
  - **Additional Study Costs**

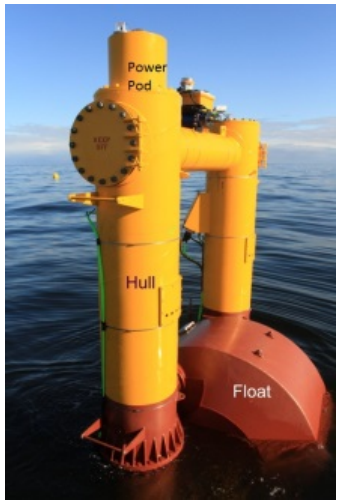


Fore 2015

FEDERAL AND STATE AGENCY DISCUSSIONS

Federal Agencies

- **Bureau of Ocean Energy Management (BOEM)**
- **Federal Energy Regulatory Commission (FERC)**
- **Department of Defense (DOD)**
- **National Marine Fisheries Service (NMFS)**
- **United States Fish and Wildlife Service (USFWS)**
- **U.S. Navy**



Renewable Energy Futures Study NREL TP-6A20-52409-2

State Agencies

- **California –** California Department of Fish and Wildlife, CA Coastal Commission, CA State Lands Commission
- **Maine –** Maine Department of Environmental Protection, Maine Department of Marine Resources
- **New York –** NY Department of Environmental Conservation - Division of Fish & Wildlife
- **Washington** – Washington State Department of Ecology
- **Oregon** – Oregon Department of Fish and Wildlife, Oregon State Lands Commission

PROJECT CATEGORIES

- **Project Type**
  - Commercial Deployment (3)
  - Test Deployment (6)
  - Test Site (8)
- **Phase**
  - Active (8)
  - On-hold (3)
  - Cancelled (3)
  - Completed (3)
- **Type of Energy**
  - Tidal (5)
  - Wave (10)
  - Ocean Current (2)

- **Geography**
  - East Coast (8)
  - West Coast (9)
- **Grid Connected or not** (9 connected, 8 not)
- **Early vs More Recent Projects**
- **Nearshore State Waters vs Federal Waters**
- **Permitting Type Lead Agency**
  - FERC (7)
  - USACE (7)
  - FERC/BOEM (2)
  - State (1)
- **Stage**
  - Permitting/Licensing (10)
  - Monitoring and Compliance (7)

Fore 2015

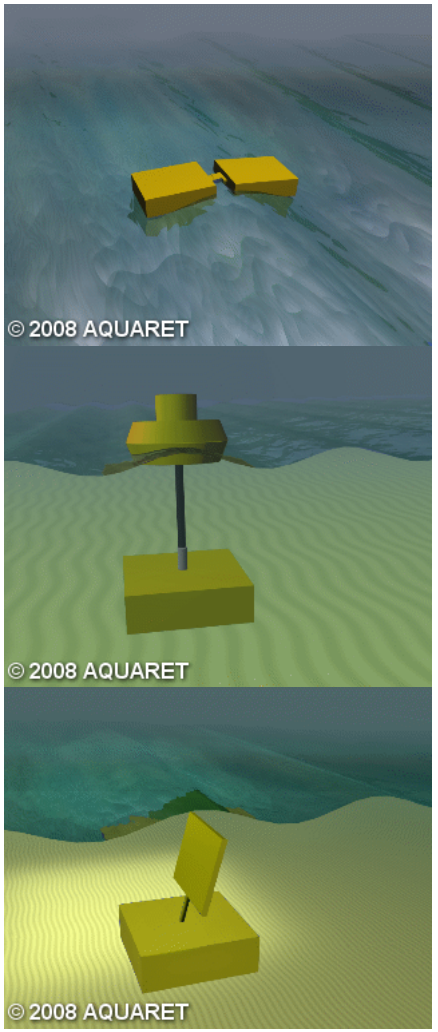
Bassett 2015

DATA ANALYSIS CATEGORIES
(so far)

Comparison of:

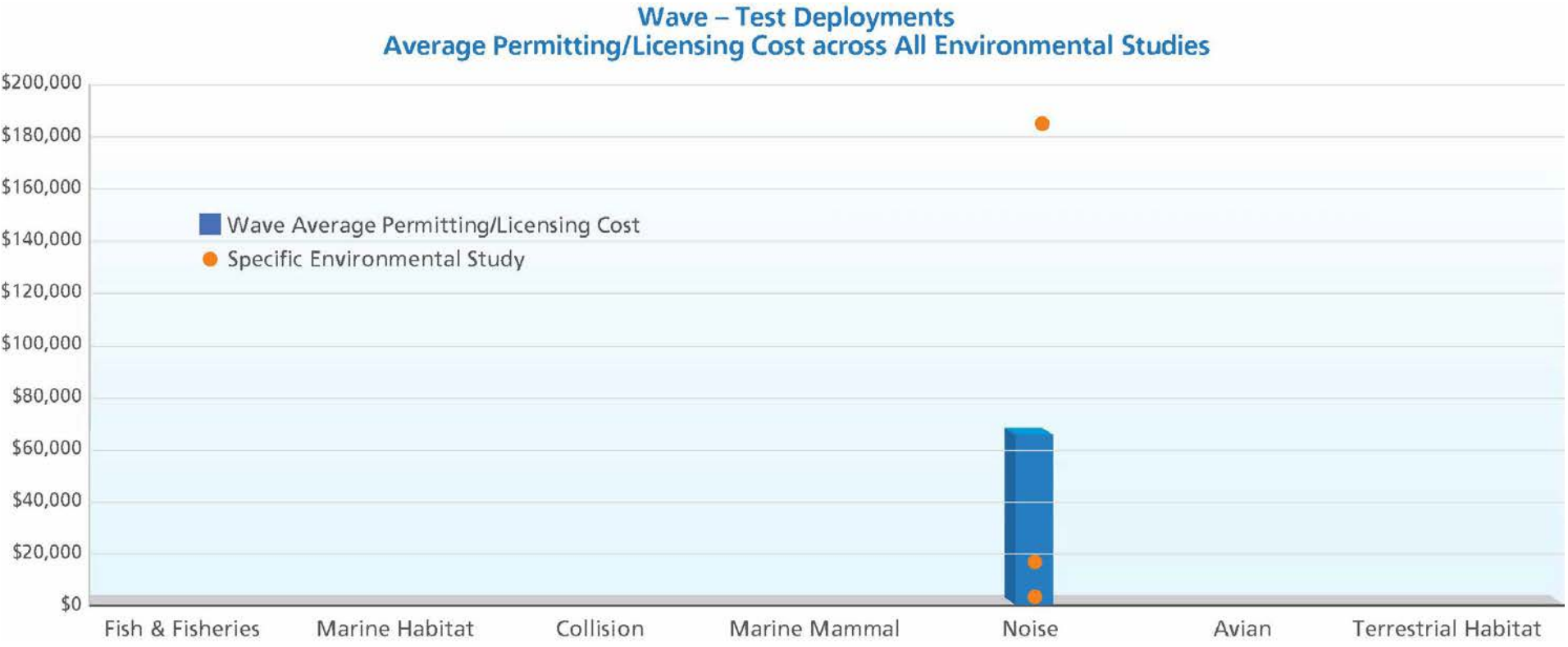
- Wave Test Deployments
- Wave Test Sites and Commercial Tidal Deployments
  - Permitting/licensing study costs
  - Monitoring & compliance costs
- Project Timeline

- Planned:
  - Outreach Costs
  - Permitting Activity Length



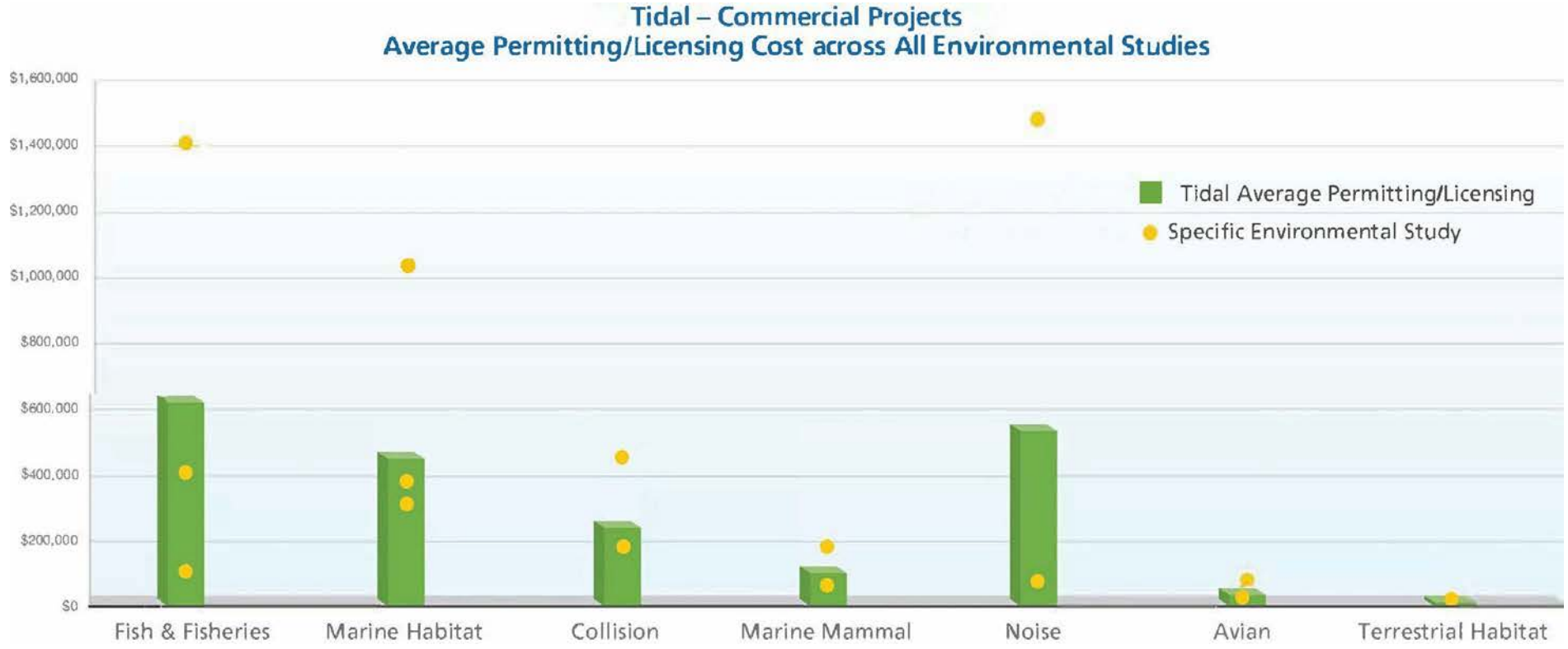
http://www.emec.org.uk/marine-energy/wave-devices/

PERMITTING / LICENSING STUDY COSTS
3 Wave Test Deployments



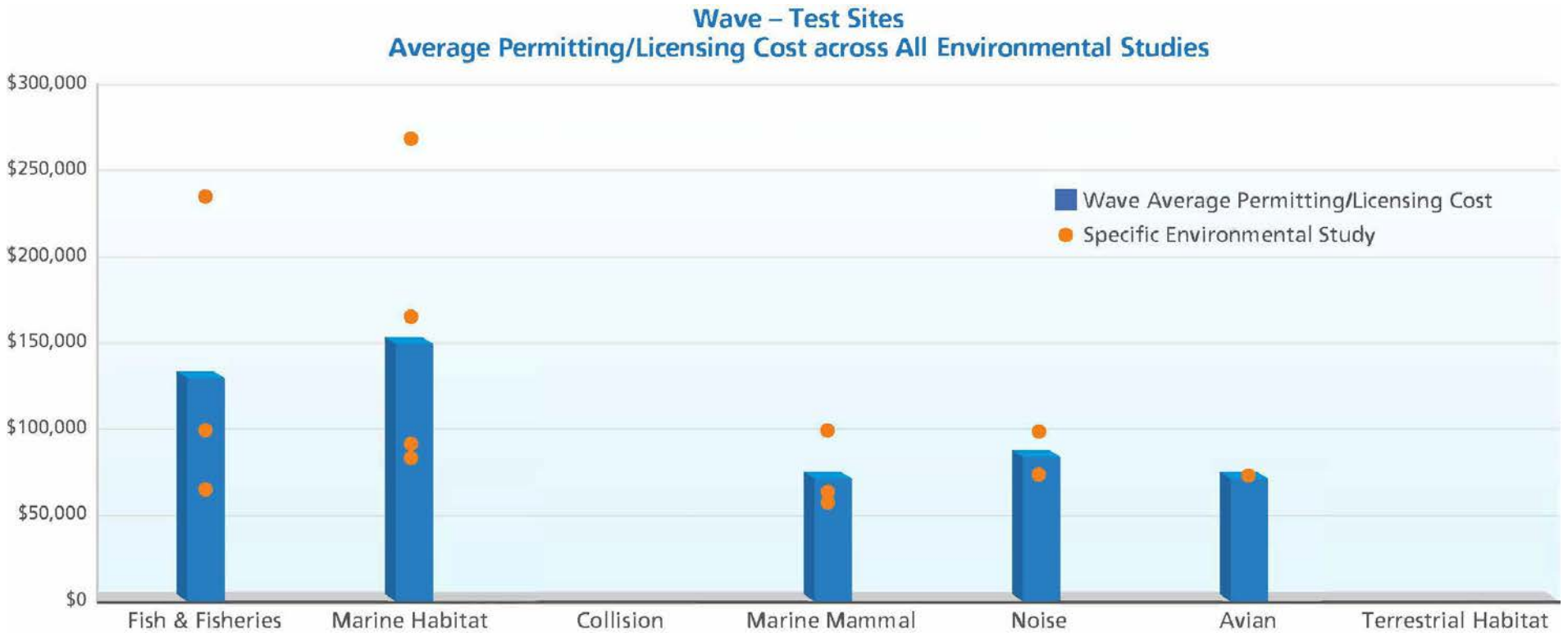
- Only noise studies were conducted at Wave test deployments
- Most deployments were short term, therefore the costs were relatively low.

PERMITTING / LICENSING STUDY COSTS
3 Tidal Commercial Deployments



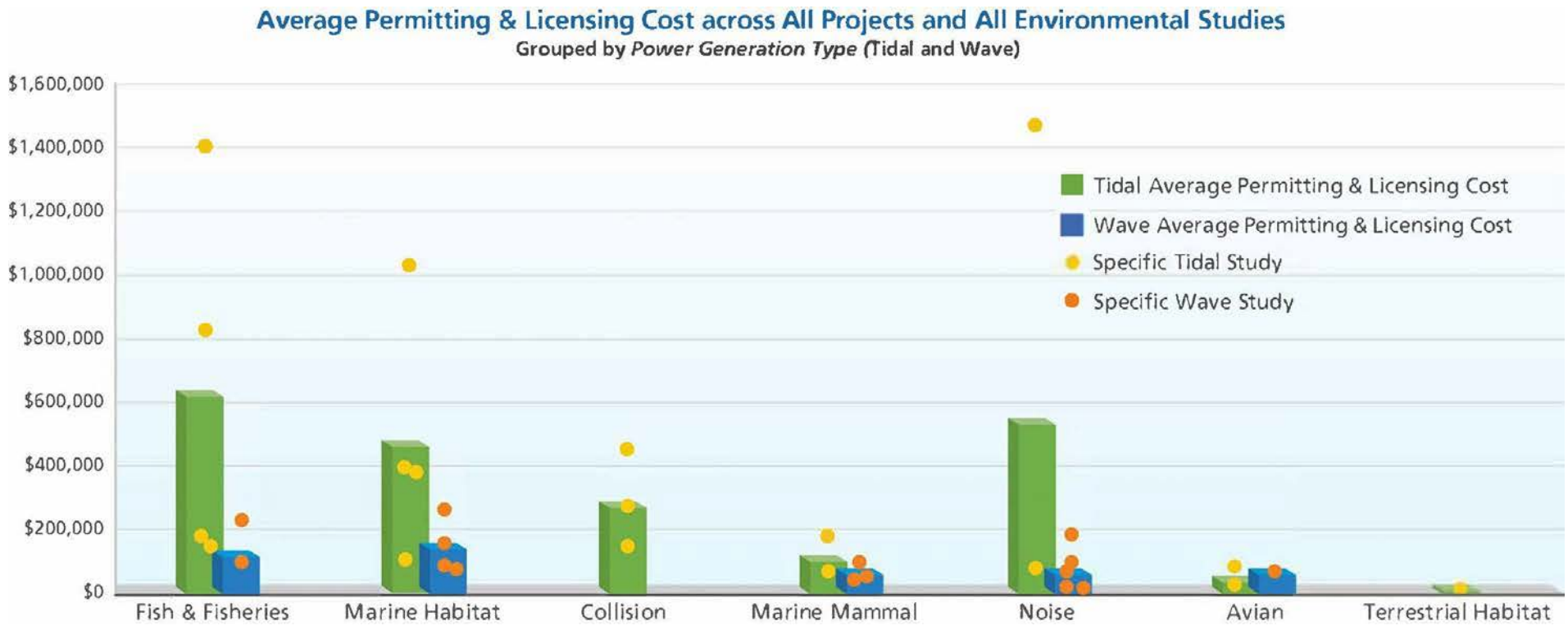
- Fish/fisheries and Noise have highest pre-deployment study costs for this project type
- Tidal projects study types performed depended on:
  - Project Technology
  - Species/location
- High study costs often associated with need to pioneer methods/technologies (1st of a kind)

PERMITTING / LICENSING STUDY COSTS
4 Wave Test Sites



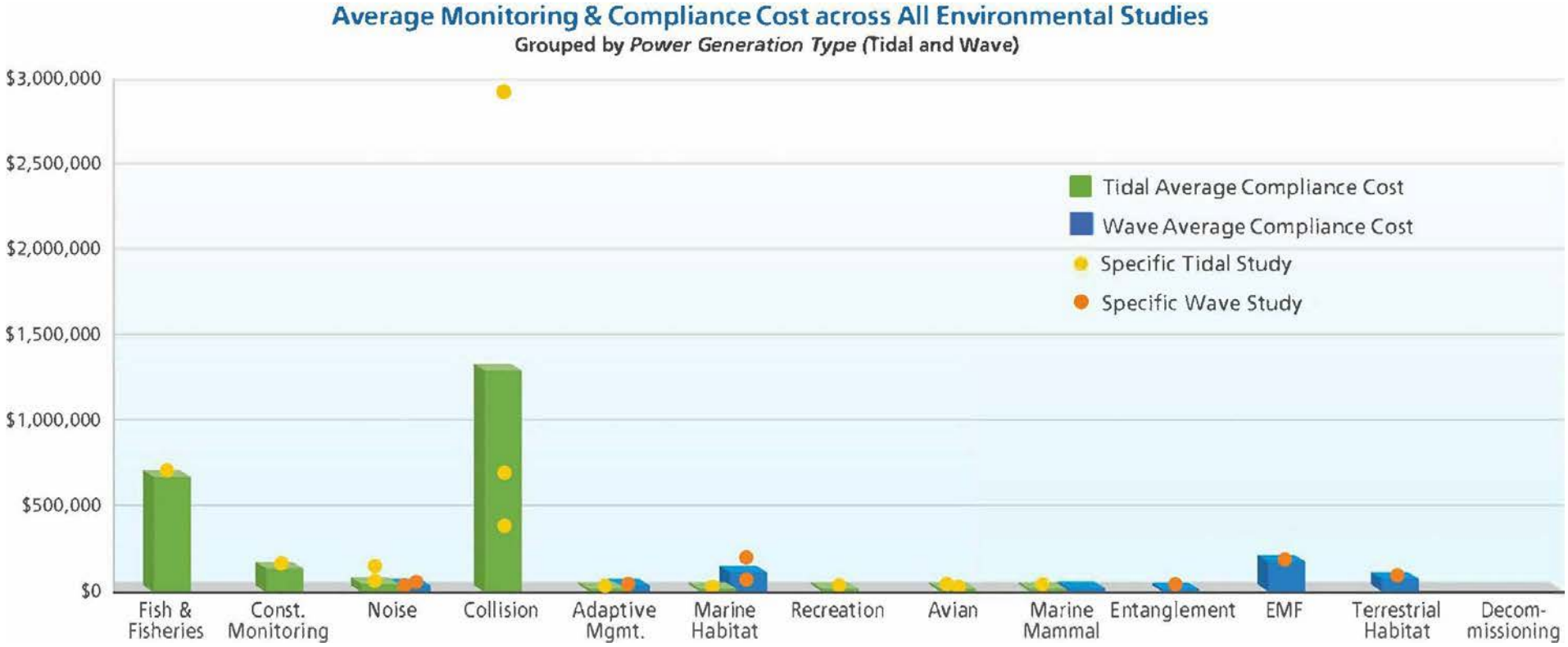
- Highest test site study costs are fish/fisheries and marine habitat characterization
  - May be associated with size of project footprint

PERMITTING / LICENSING STUDY COSTS
7 Wave and 4 Tidal Projects

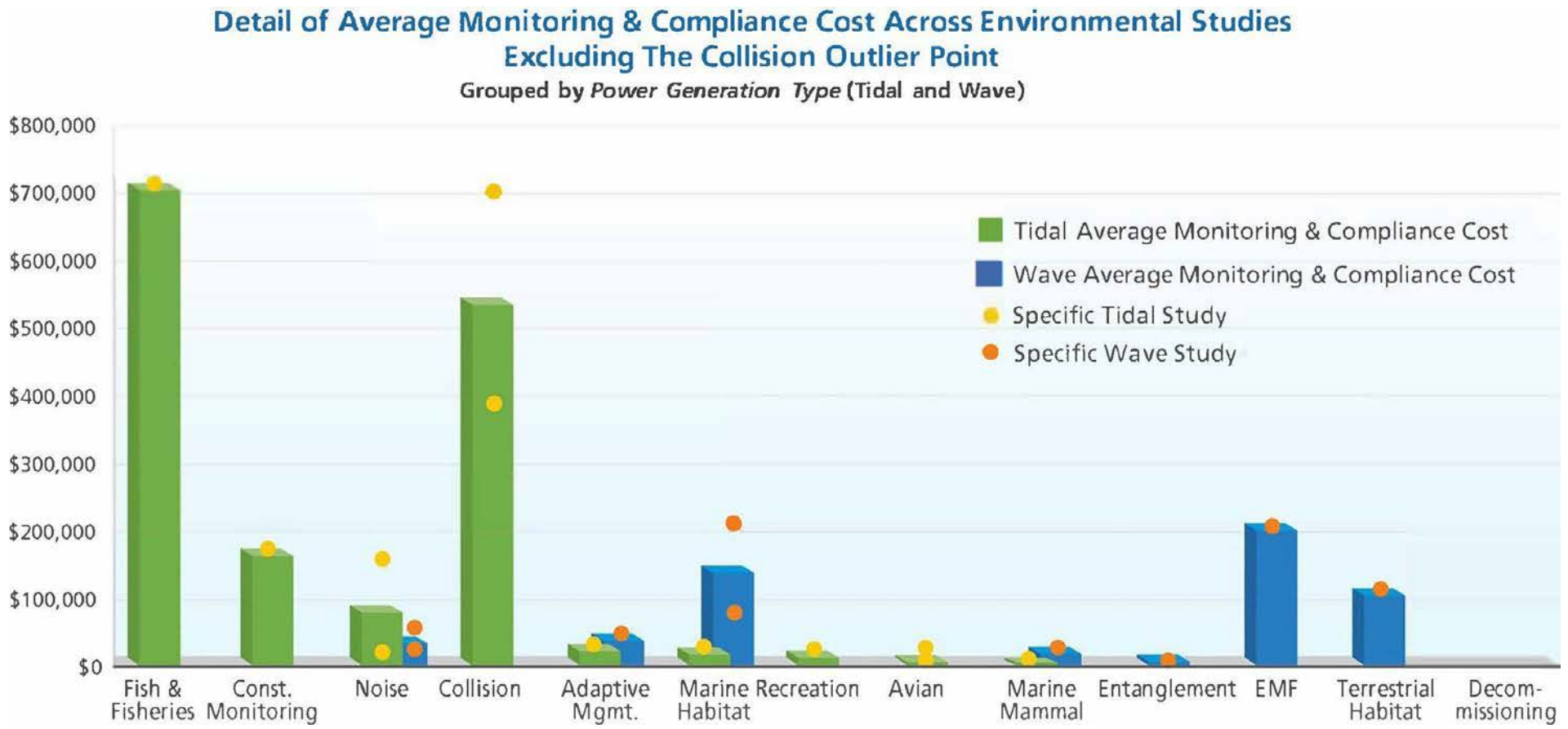


- Study costs for tidal projects are generally more expensive than for wave.
- Environmental risks and uncertainties appear to be less of a concern for wave projects, based on differences in study costs.

MONITORING & COMPLIANCE STUDIES COSTS
3 Wave and 3 Tidal Projects

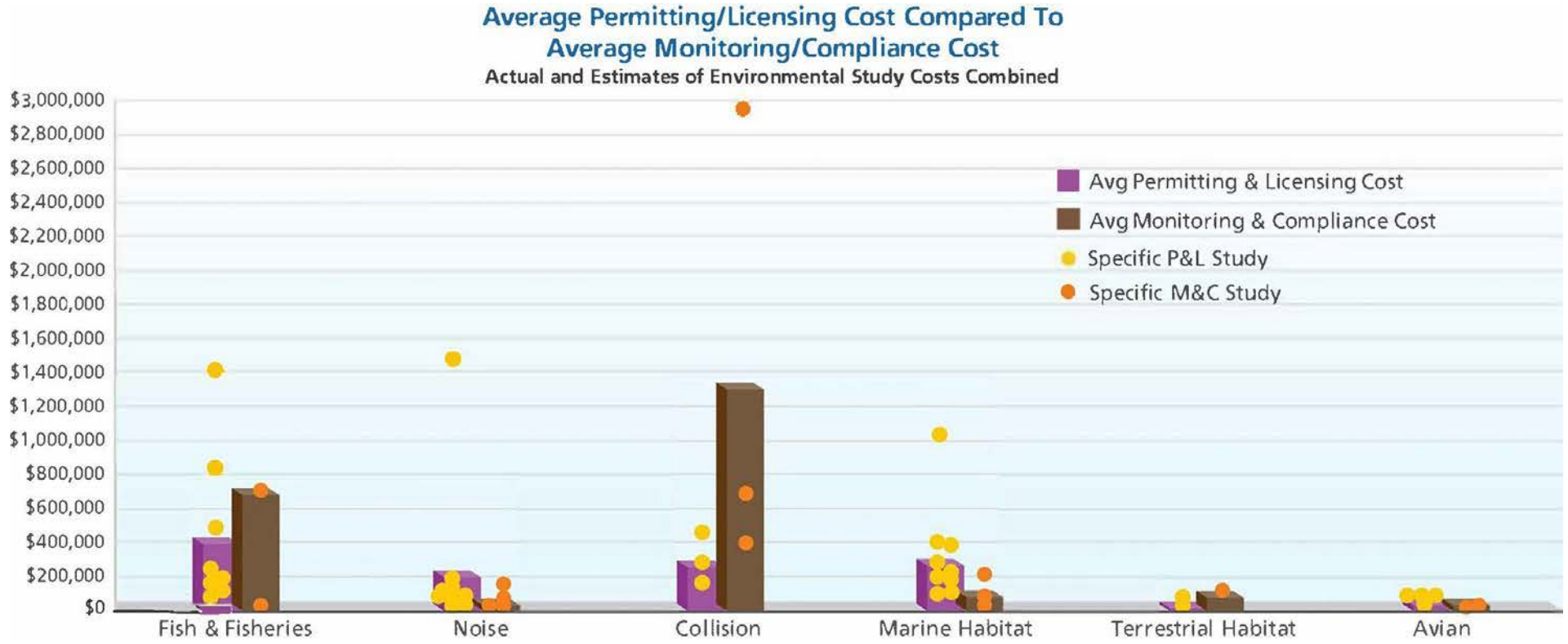


MONITORING & COMPLIANCE STUDIES COSTS
3 Wave and 2 Tidal Projects *(minus outlier)*

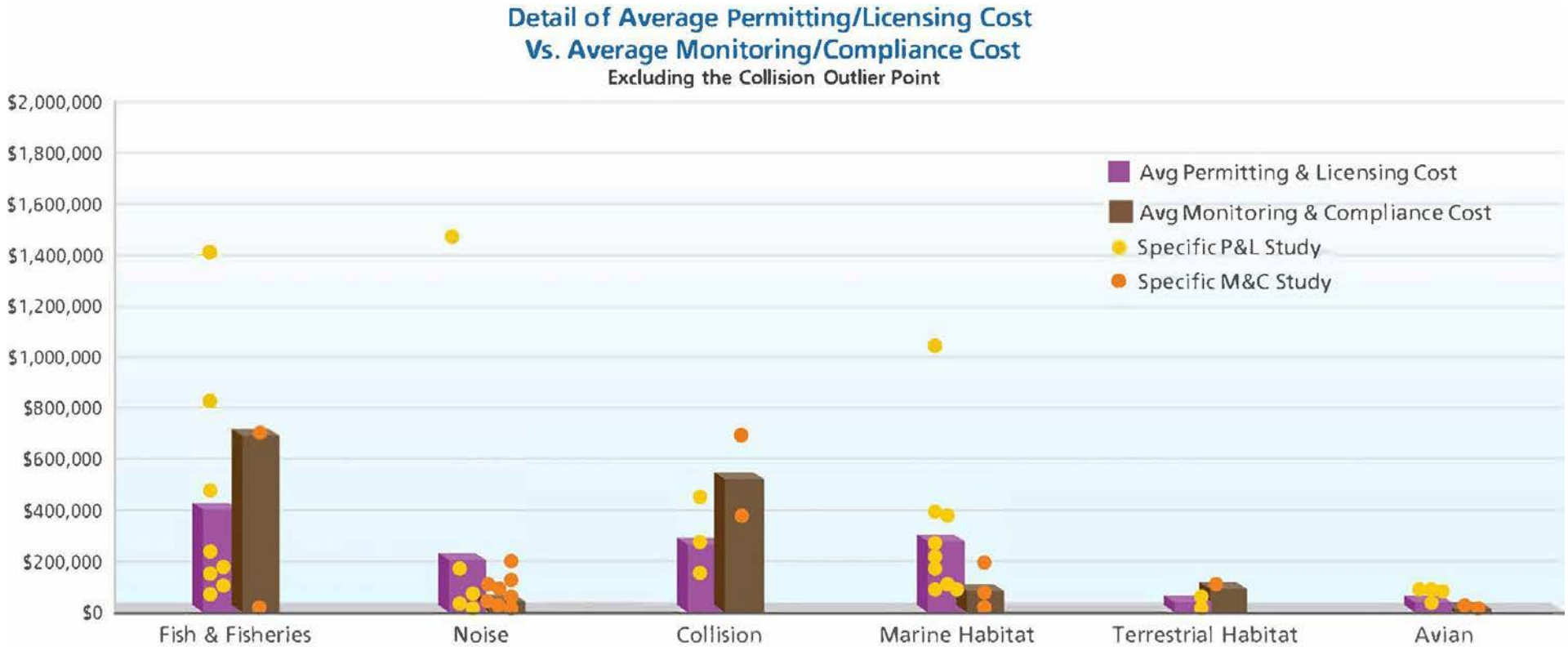


- Wave projects: highest three costs are EMF, terrestrial, and marine habitat
- Tidal projects: highest three costs are fish/fisheries, collision, and noise

P&L STUDIES COSTS VS. M&C STUDIES COSTS
9 Wave and 4 Tidal Projects



P&L STUDIES COSTS VS. M&C STUDIES COSTS
9 Wave and 3 Tidal Projects

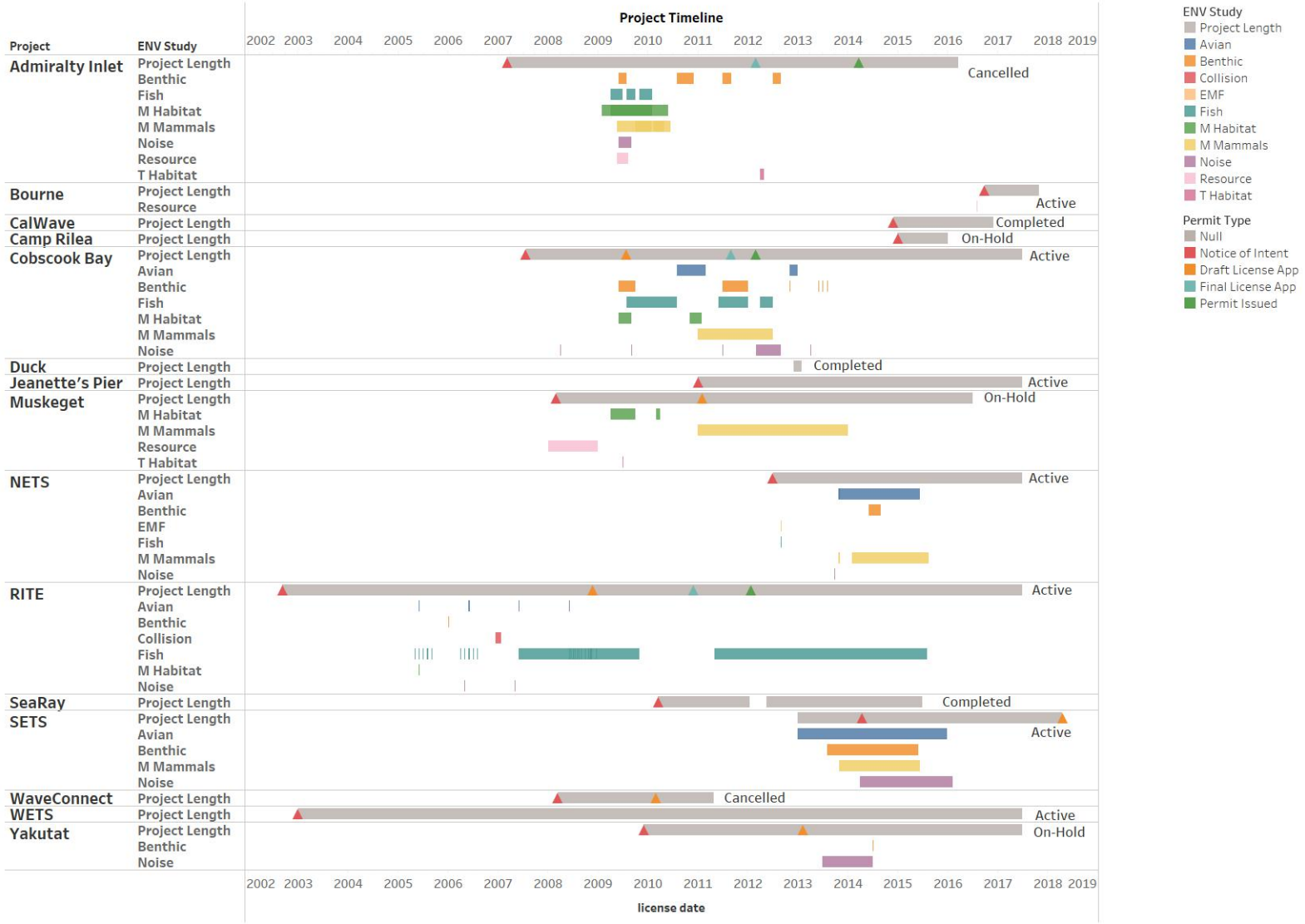


- Opportunity: Explore ways to reduce high costs of studies for both permitting/licensing and monitoring/compliance.

Project Timelines

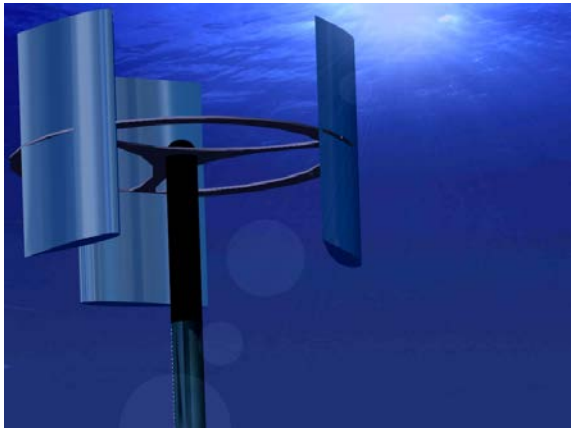
Timeline of Marine Hydrokinetic Projects

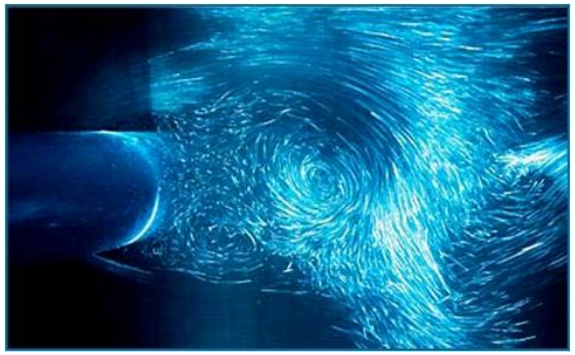
Includes Enviromental Study Duration and Permitting



INITIAL CONCLUSIONS

- Project type and design determine what impacts are a concern and what environmental studies are needed for permitting/licensing and monitoring & compliance driving cost variability.
  - There are a limited number of projects at the monitoring and compliance stage.
- Need to find ways to reduce the high costs of studies.
- Pioneering technologies increase individual project costs, but may reduce costs for later projects.
- Most projects involve developer and federal/state funding (13 out of 17 projects).
- Geographic location (East vs West) is hard to compare because of differing project phases and deployment types.





Fore 2015

QUALITATIVE FINDINGS

- Nascent Industry
  - Industry
    - Some developers with less experience or understanding of environmental regulations and permitting
    - Little permitting precedence
  - Agencies
    - Limited understanding of the technologies
    - In some cases, there is no simple regulatory pathway for testing devices or very small, temporary deployments

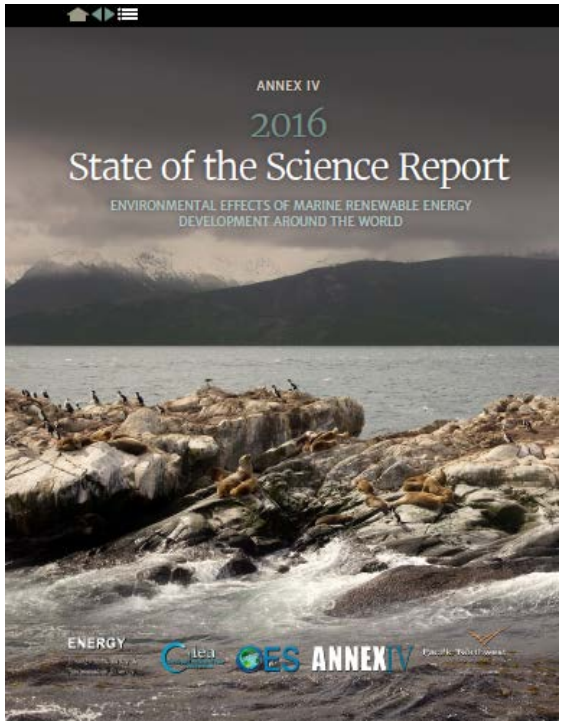
- New Use of Marine Resources; Suggestions are to:
  - Seek to minimize conflicts based on site selection
  - Conduct early agency and stakeholder interaction

Bassett 2015

QUALITATIVE FINDINGS

Based on State of the Science and Our Findings

- Use findings from other locations or other similar types of projects
- Share knowledge
- Make the most out of monitoring efforts: monitoring at sea is expensive and challenging:
  - What are the potential effects of greatest concern, e.g., with greatest potential impact?
  - What are the methods and technologies needed to survey, and can they detect the effects you are trying to understand?
  - What is the statistical power/level of information needed to discern effects?
  - What decision-making will the results inform?
- Retire risk

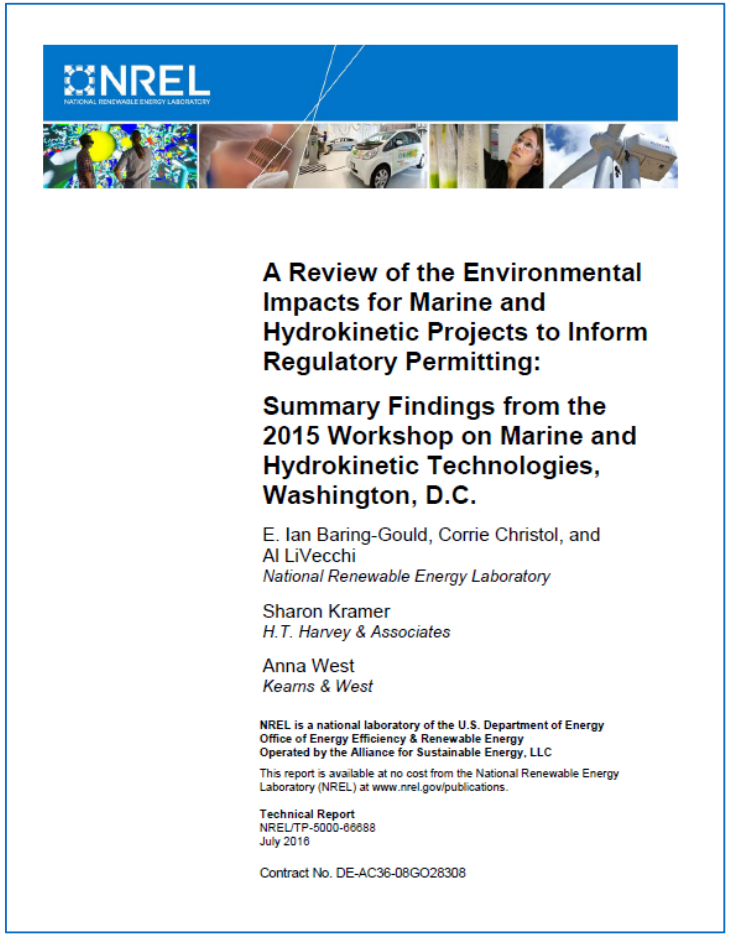


https://tethys.pnnl.gov/publications/state-of-the-science-2016

QUALITATIVE FINDINGS

Based on State of the Science and Our Findings

- Lack of guidance documents for the MHK permitting process, we need:
  - Topic-specific approaches to analyzing effects and monitoring protocols, and understanding of baseline needs
  - Identification of best management practices to ease future permitting
  - Understanding the regulatory needs for project descriptions
  - Online source of information on MHK project permitting documents



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

A Review of the Environmental Impacts for Marine and Hydrokinetic Projects to Inform Regulatory Permitting:

Summary Findings from the 2015 Workshop on Marine and Hydrokinetic Technologies, Washington, D.C.

E. Ian Baring-Gould, Corrie Christol, and Al LiVecchi
National Renewable Energy Laboratory

Sharon Kramer
H.T. Harvey & Associates

Anna West
Kearns & West

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

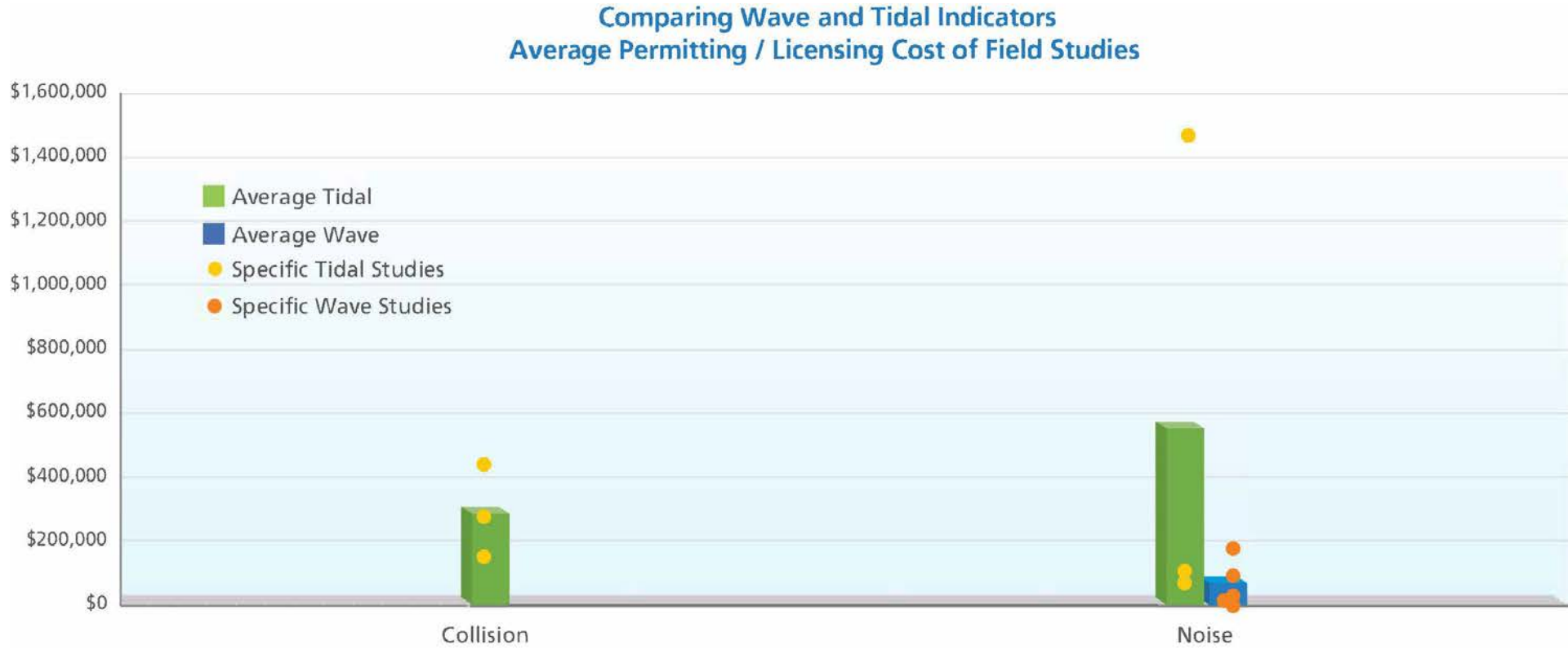
This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Technical Report
NREL/TP-5000-66688
July 2016

Contract No. DE-AC36-08GO28308

https://tethys.pnnl.gov/sites/default/files/publications/Baring-Gould-et-al-2016-Workshop.pdf

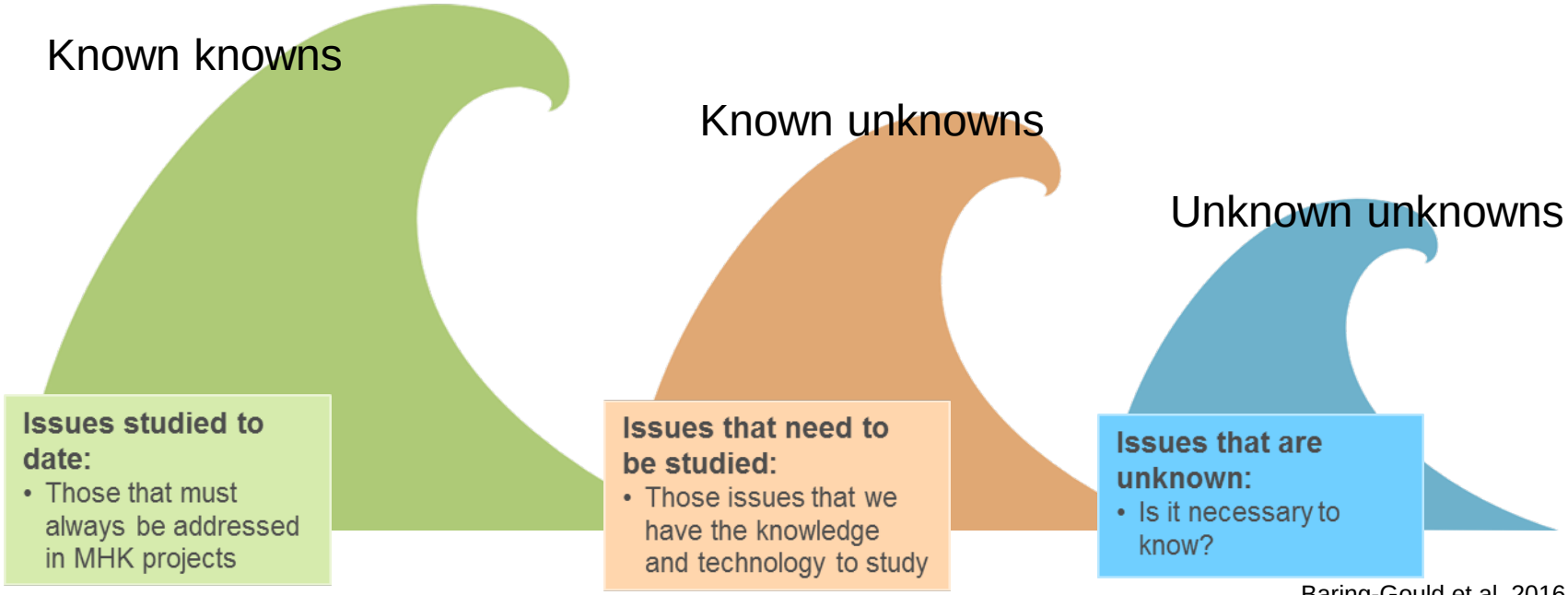
COMPARING WAVE AND TIDAL INDICATORS
3 Wave and 7 Tidal Projects



NOISE – WAVE & TIDAL; COLLISION - TIDAL

Key Questions from Wave and Tidal Project Case Studies

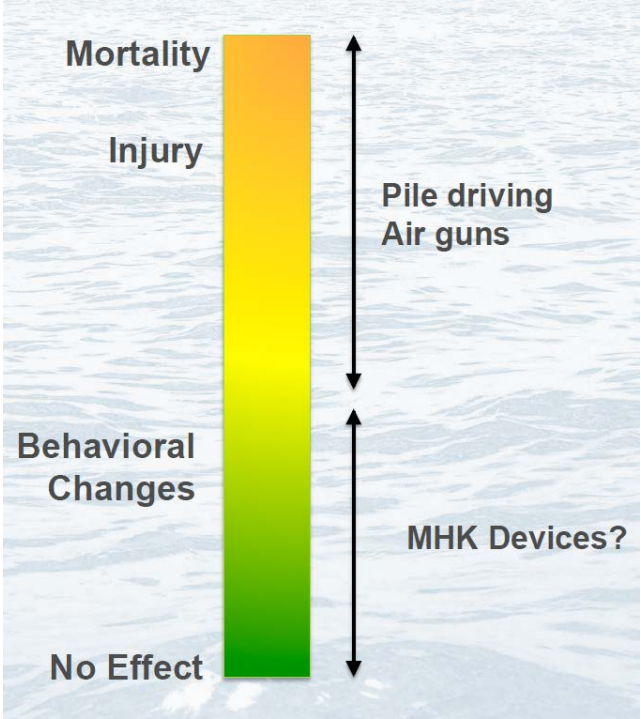
- What is the state of the science and gaps in information?
- What have we learned from studies and adaptive management/monitoring for the MHK projects on noise and collision, and how do they relate to the costs?
- What are the implications for future projects?



Baring-Gould et al. 2016

STATE OF THE SCIENCE: UNDERWATER SOUND

- Results of 19 field studies worldwide of operational tidal and wave projects have indicated that the level of operational noise from individual marine renewable energy devices is unlikely to be harmful to marine animals.
- Construction noise, especially pile driving, is noisy and is well understood.
- However, gaps or uncertainties include:
  - Need for additional field investigations especially for “new” device types, to characterize ambient noise prior to deployment activities, and during calm conditions when the device is not operating, and accurate detection of sound generated from the device under a variety of physical regimes (e.g., tidal cycles, wave heights).
  - No information yet on arrays and cumulative noise levels

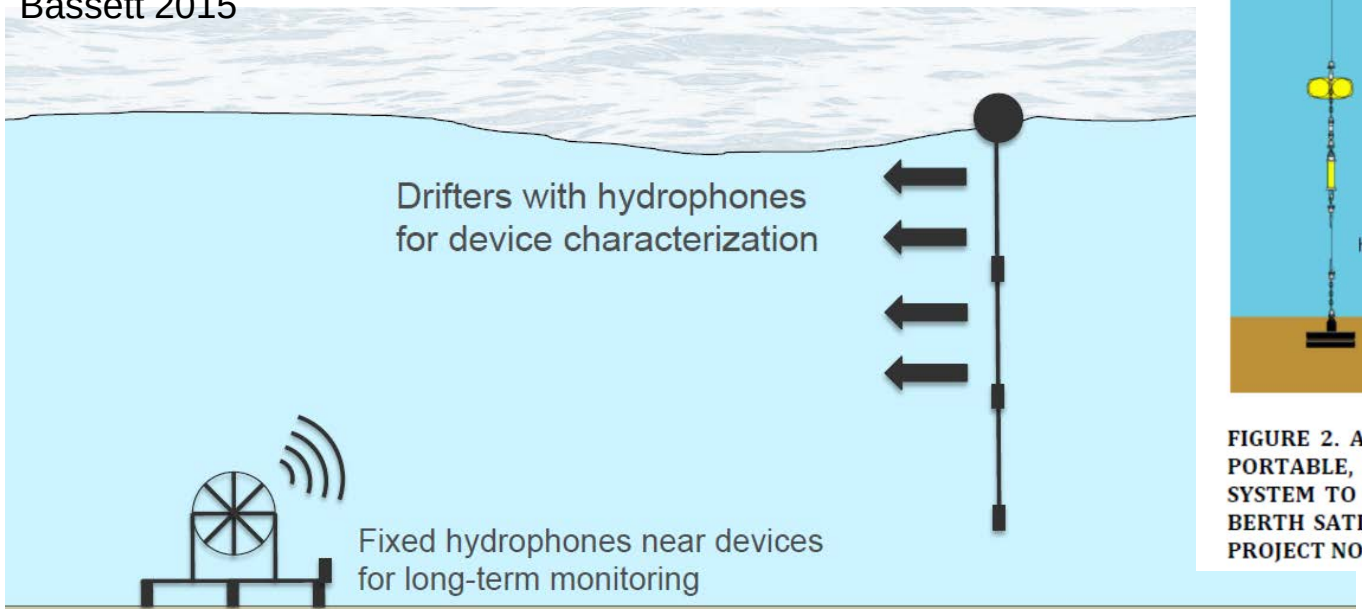


Bassett 2015

ACOUSTIC MEASUREMENT TECHNOLOGIES

- The methods/techniques are not off the shelf nor are there standards for measuring noise.

Bassett 2015



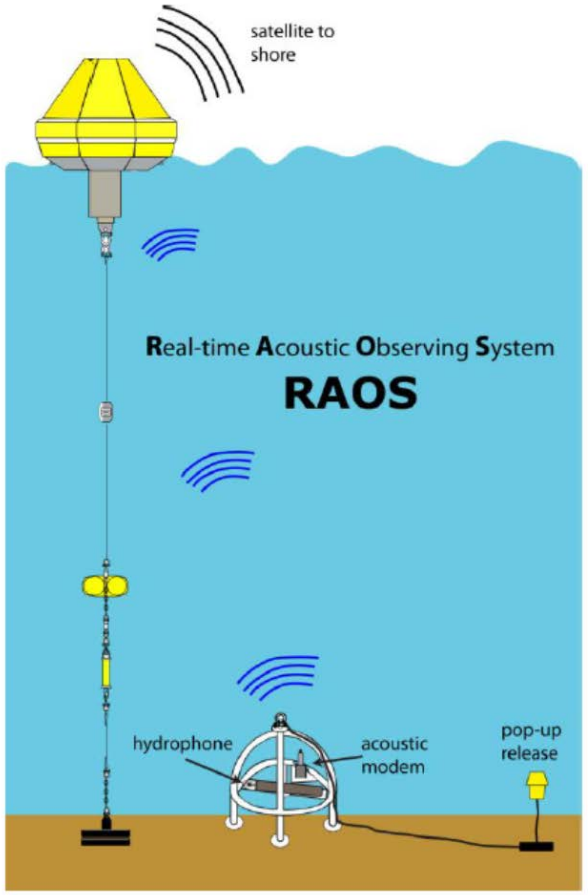
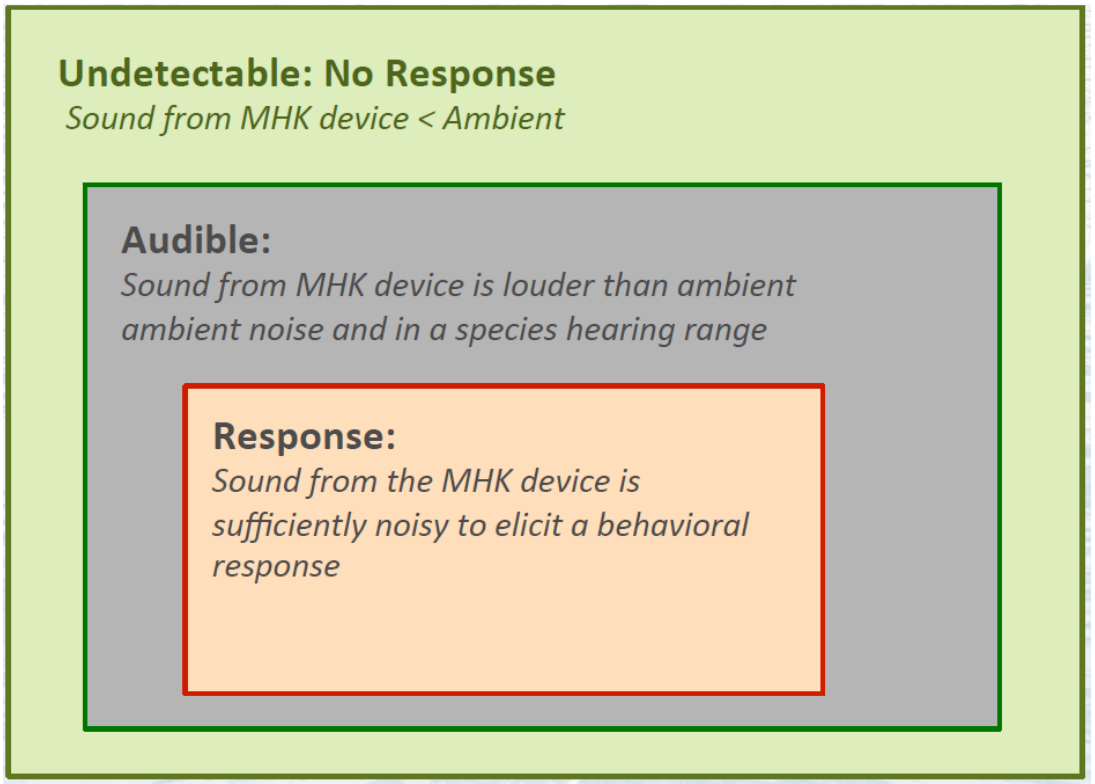


FIGURE 2. A SCHEMATIC OF THE RAOS SYSTEM. A PORTABLE, REAL-TIME ACOUSTIC OBSERVING SYSTEM TO BE DEPLOYED AT EACH WEC TESTING BERTH SATISFYING TIME CRITICAL REPORTING OF PROJECT NOISE LEVELS.

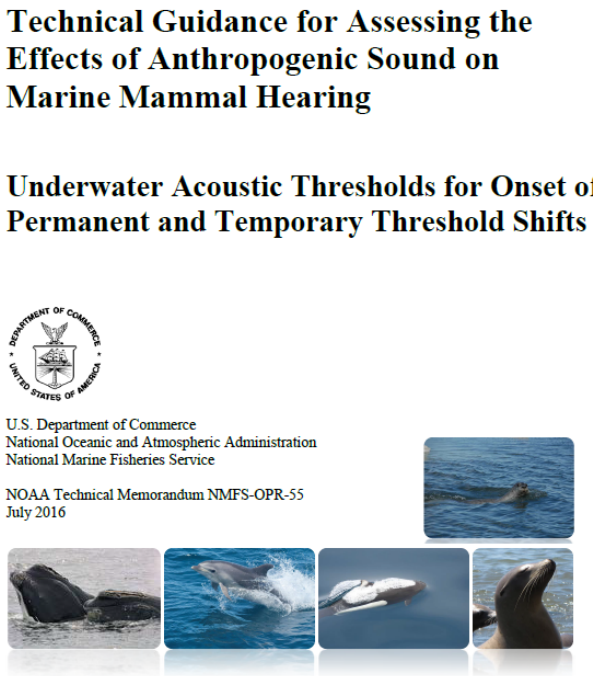
Haxel et al. 2016

BEHAVIORAL RESPONSES TO SOUND

- Laboratory and field studies are needed to elucidate dose/response relationships pertaining to the response by organisms to various amplitudes and frequencies of sounds.



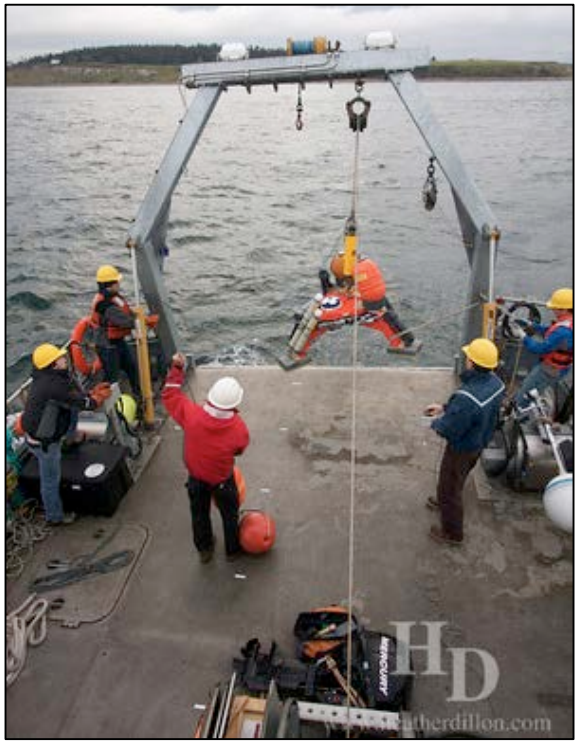
Bassett 2015



UNDERWATER SOUND CHARACTERIZATION AND COSTS

Baseline or pre-project ambient sound conditions

- Most study costs range from $10,000's to $200,000
- Most studies have been short-term (e.g., a few days, using drifting hydrophones), providing snapshots of ambient sound conditions. Tidal projects can be characterized using this method because boat-based deployments can be done under a variety of tidal conditions.
- Wave project acoustic studies will need longer continuous deployments (e.g., months), and are more costly to conduct (e.g., landers).
- The most costly studies have had to develop the technology to do longer term, continuous monitoring; power and data storage issues are significant and costly. Trade off: self contained power/battery and data storage vs cable to shore providing power and data transfer.



Bassett 2015

UNDERWATER SOUND CHARACTERIZATION AND COSTS

Post-licensing compliance sound monitoring

- Results from wave and tidal projects deployed to date in the US and EU indicate that sound levels are measureable but generally do not exceed NMFS threshold for marine mammal harassment.

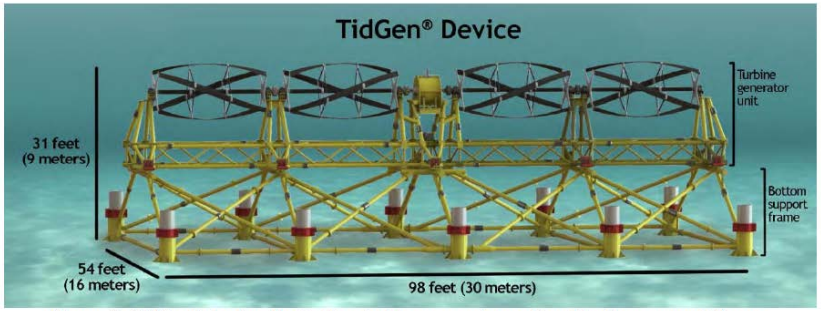


Figure 2. TidGen® device illustrating turbine generator unit and bottom support frame.

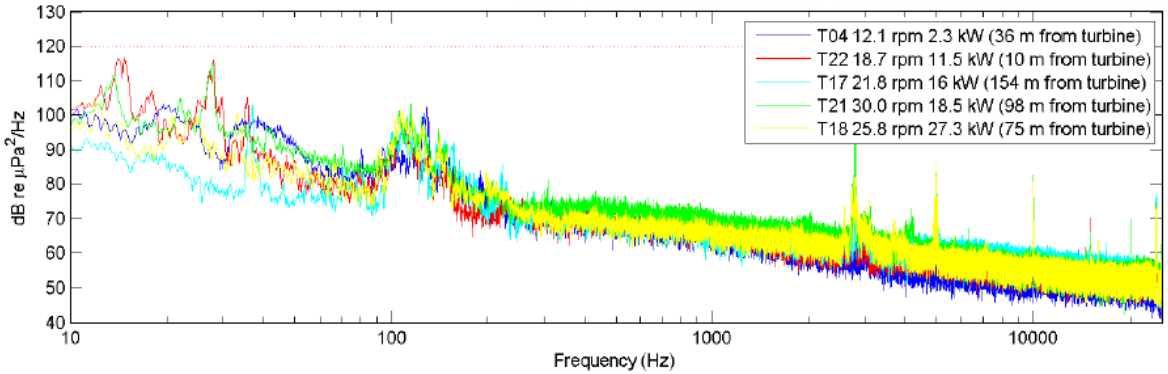


Figure 15. Acoustic results while generating, indicating spikes at 105 and 210 Hz as well as 5 kHz.

ORPC 2014

MONITORING SOUND: FUTURE PROJECTS

- Monitoring sound produced by novel wave and tidal energy devices should be conducted; however, if devices are deployed that already have sound monitoring information there may be no need for additional monitoring.
  - No information on sound produced by arrays.
  - “Snapshots” using drifting hydrophones may provide sufficient information on tidal projects if a range of tides can be evaluated.
  - If monitoring is appropriate, adaptive management may be a useful approach to curtail monitoring if sound levels are not problematic for a specific device type.

Bassett 2015

MONITORING SOUND: FUTURE PROJECTS

- Early projects are developing and refining “cutting edge” technologies to monitor sound levels over long time periods and provide information in real time when sound thresholds are exceeded (e.g., RAOS)
  - Future projects should be able to capitalize on the technologies and methods developed for early projects.
  - Sound propagation modeling is a helpful tool for permitting purposes but they require validation using field measurements.

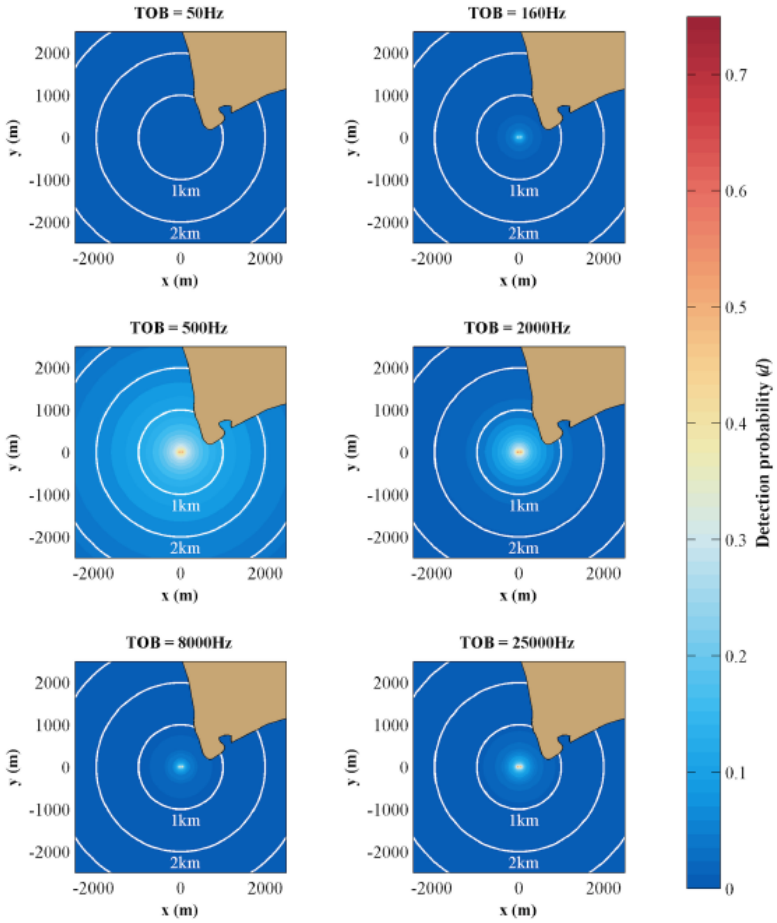


Figure 7.4: Probability of detecting operating turbines for killer whales (mid-frequency cetaceans).

Bassett 2013

MONITORING SOUND: FUTURE PROJECTS

- There is poor understanding of responses of marine animals to non-impulsive sound. Therefore, NMFS guidelines for sound thresholds are evolving.
  - NMFS guidelines currently provide thresholds for cumulative sound exposure levels for non-impulsive sounds for various marine mammal "hearing groups" based on sound frequency.
- Long term/continuous sound monitoring will result in huge amounts of data; automation of data processing and analyses will also be helpful to future projects.
- Industry-wide standards for measuring sound from MHK devices will be helpful.
- Sound monitoring can be a useful tool to identify issues with devices or moorings - Loud sounds can indicate problems with devices or moorings

STATE OF THE SCIENCE: TIDAL PROJECTS AND COLLISION

- Field studies indicate effects of tidal devices on fish behavior, extensive work done by University of Maine in Cobscook Bay
  - Fish avoid or evade operating tidal turbines in field studies, no evidence of strike or collision
  - However, actual observations of strike causing injury or mortality are difficult because these events are rare with a low probability of detection

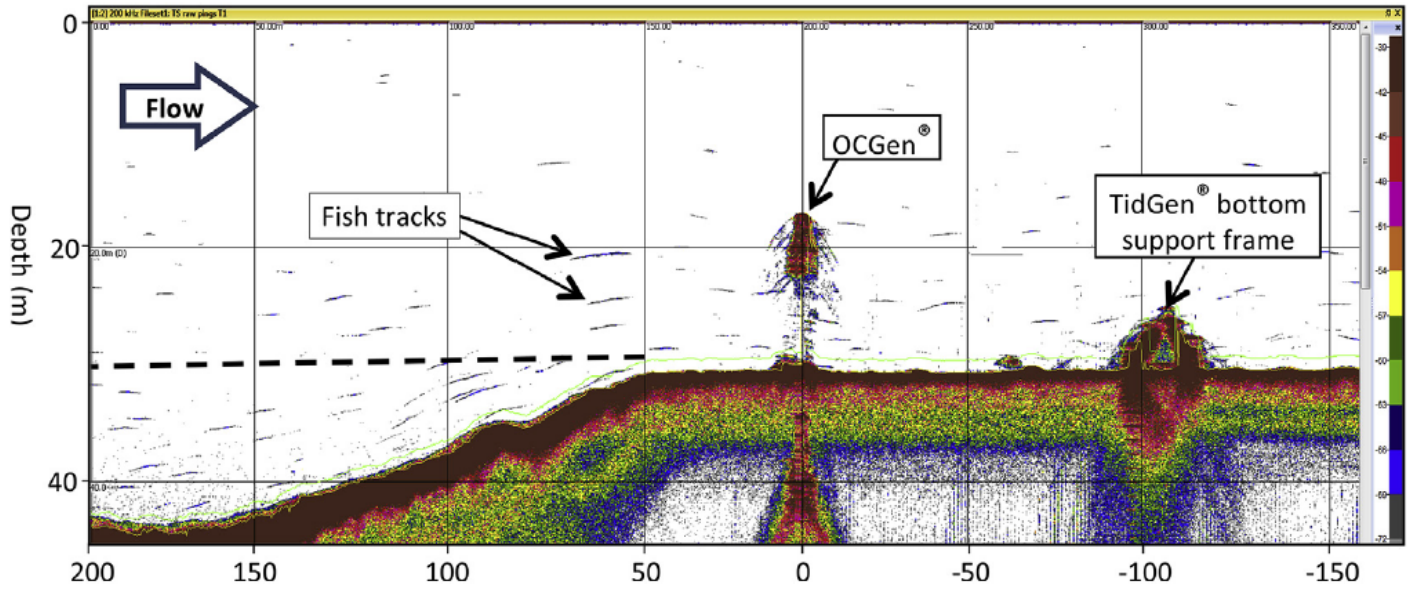


Fig. 3. One mobile transect over the OCGen® and the TidGen® bottom support frame during a flood tide. Fish tracks below the dashed line were excluded from analysis to ensure equal amounts of water sampled during the length of one transect.

Shen et al. 2016

STATE OF THE SCIENCE: TIDAL PROJECTS AND COLLISION

- Tidal environments are harsh, high flows and turbidities, low light levels
  - Technology and methods to document interactions are not off the shelf
  - Limitations on what the equipment “samples” in the water column and for determinations of species
    - Hydroacoustics (no species distinction)
    - Acoustic cameras (difficult to discern species)
    - Optical cameras (require additional lighting, duty cycle considerations)

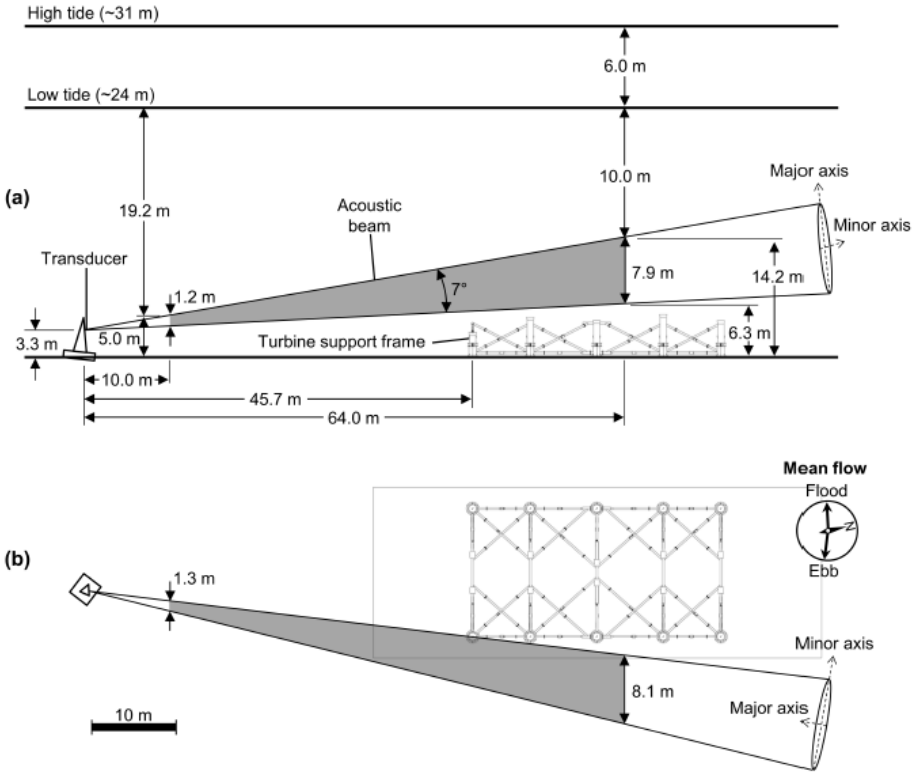


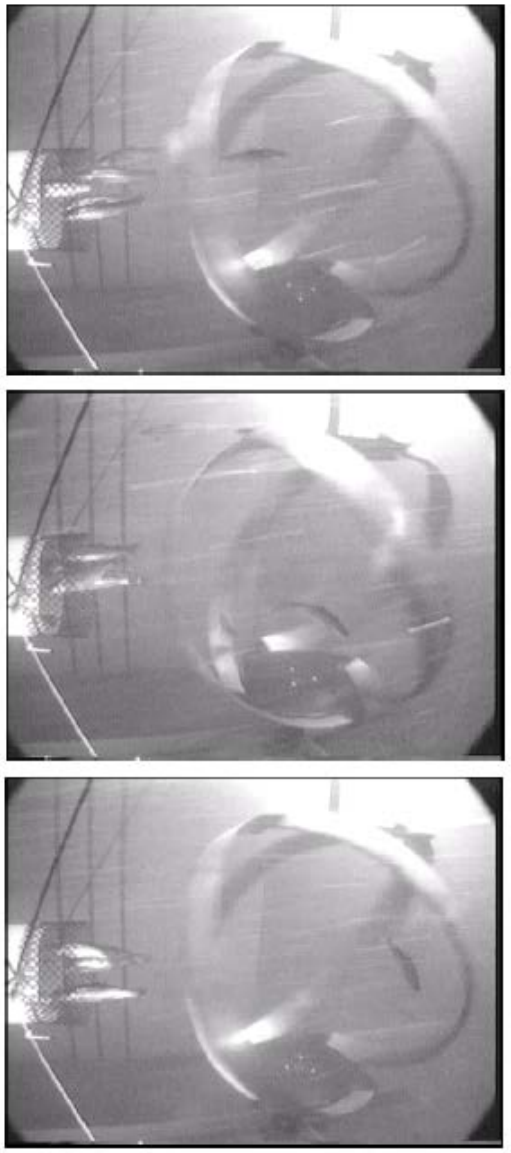
Fig 2. Echosounder setup in Cobscook Bay, Maine. The bottom support frame of the MHK tidal energy device was present during data collection. The gray area indicates the sampled volume used in this study. Device schematic provided by Ocean Renewable Power Company.

https://doi.org/10.1371/journal.pone.0176405.g002

Viehman and Zydlewski 2017

STATE OF THE SCIENCE: TIDAL PROJECTS AND COLLISION

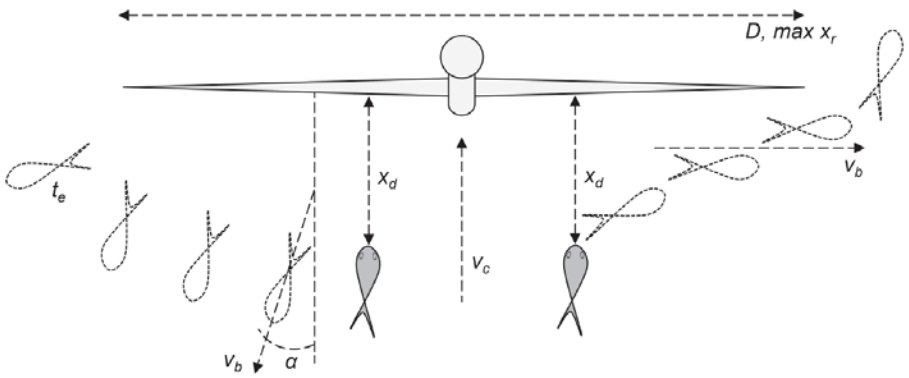
- Additional evidence is related to collision or strike.
  - Lab studies of fish interaction with blades indicate fish can avoid strike even if forced into the rotor-swept area, survival rates typically >99%.
  - Hydroelectric facilities studies on fish interactions with turbines are useful but not necessarily directly applicable, because fish can detect and swim around tidal turbines they are not forced through them.



EPRI 2011

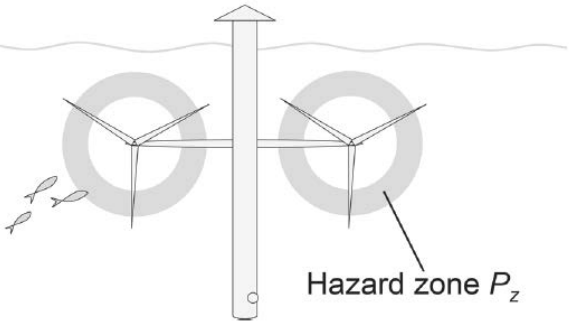
COLLISION MONITORING COSTS

- Costs for studies are high
  - Events are rare, so large amounts of data need to be collected and analyzed; machine learning will help address data mortgage
  - Difficult environment, methods/technologies are not off the shelf
- Collision risk models are being developed using lab and field observations, building on analogies to terrestrial wind projects.
  - Study costs to gather information on fish in the project area are also high, but contribute information to modeling efforts
  - Models can reduce costs and increase confidence with limited field information supported by laboratory studies.



'reverse' strategy

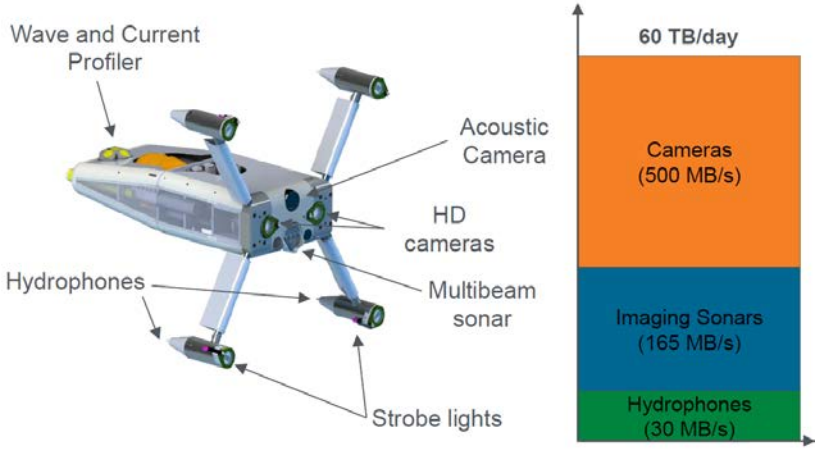
'diverge' strategy



Hammar et al. 2015

MONITORING COLLISION: FUTURE PROJECTS

- Early projects are developing and refining technologies and methods to evaluate collision that future projects can employ, if monitoring is needed.
  - Integrated sensor packages show promise, based on integrating hydroacoustic, acoustic, and optical sensors. Hydroacoustics see “far” but do not distinguish species, optical methods are best for species identification but have limited “reach”.
  - High power requirements and huge amounts of data will require data and power cabling to shore.
  - Processing and analysis of huge data streams will also be helpful to future projects; machine learning and other automation will need to be developed.



Polagye 2017

MONITORING COLLISION: FUTURE PROJECTS

- Future efforts should focus on using models to evaluate collision risk, and if confidence in model results is low, consider focused monitoring efforts to improve model results.

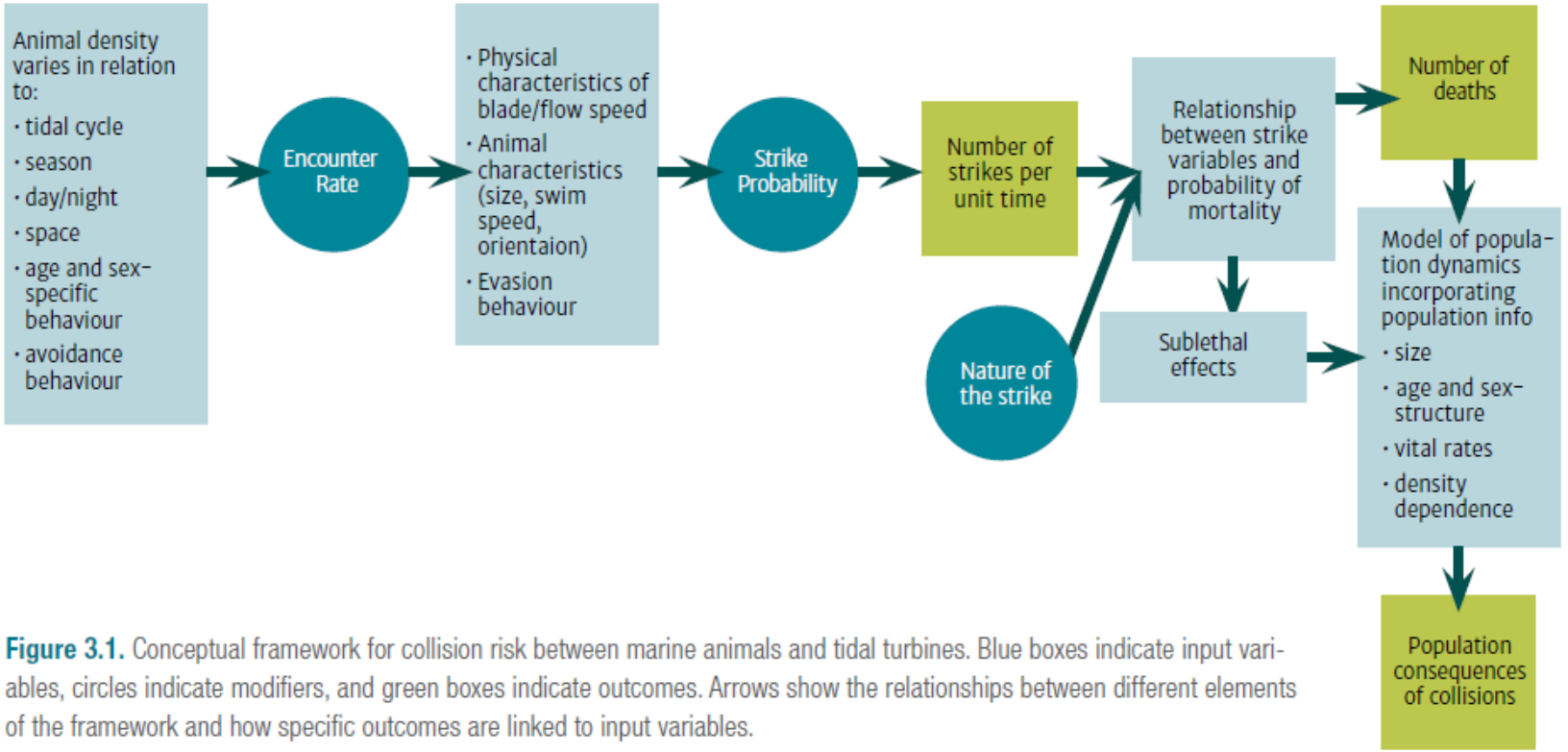
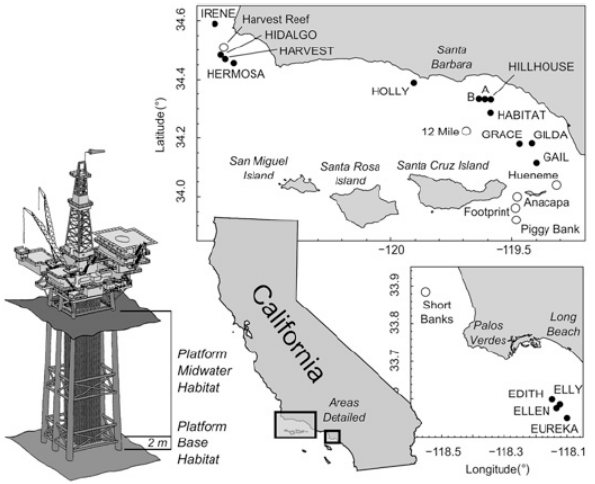


Figure 3.1. Conceptual framework for collision risk between marine animals and tidal turbines. Blue boxes indicate input variables, circles indicate modifiers, and green boxes indicate outcomes. Arrows show the relationships between different elements of the framework and how specific outcomes are linked to input variables.

Zydlewski et al. 2016

OVERVIEW
OTHER INDUSTRIES ANALYSIS

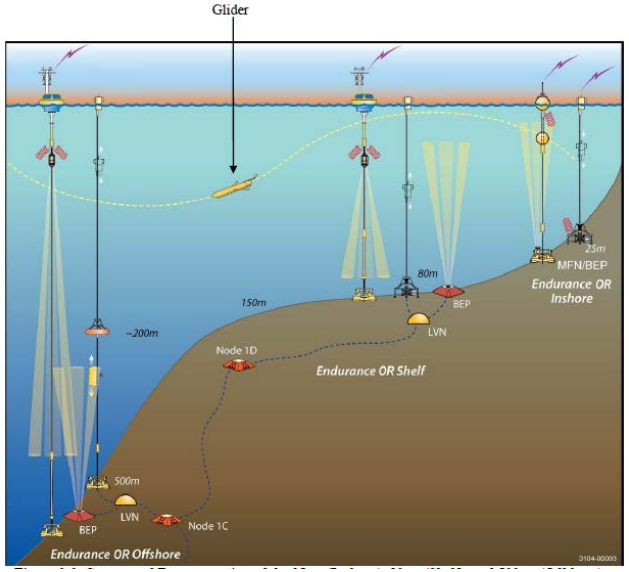
- Other Energy and Marine Industries Reviewed
  - Offshore Oil & Gas
  - Offshore and Onshore Wind
  - Onshore Solar
  - Subsea Power and Data Cables
- Examined
  - Changes in Levelized Cost of Electricity (LCOE) Over Time
  - Permitting Pathway
  - Potential Environmental Effects and Types of Monitoring
  - Factors Contributing to Easing Environmental Permitting
- Discussions with Regulatory Agencies Underway



Claisse et al. 2014

LESSONS FROM OTHER INDUSTRIES

- Use existing baseline studies and effects analyses for analogous projects
- Apply permitting and regulatory solutions
- Form partnerships among industry, agencies, and scientists, and conduct collaborative research to address important concerns
- Develop and implement guidance, protocols, and siting tools
- Continue to hone technology and installation



OOI FEIS

NEXT STEPS

- Improve the quantitative analysis:
  - state and federal permitting
  - outreach costs
  - updating with better information on state and federal funding contributions
  - separate costs for commercial deployments, test deployments
  - Test sites, and considering regional effects on costs (e.g. west coast vs. east coast and changes from north to south of each coast)
  - Update and refine project timeline data and analysis

- Develop an updated discussion guide to support subsequent rounds of outreach during FY 18.

- Continue to assess environmental compliance progression within other industries
  - Regulatory agency discussions
  - Refine lessons learned that can apply to the MHK industry

Project Overview

Questions?

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY