BOEM Pacific Region: Ongoing Study

Title	Development of Computer Simulations to Assess Entanglement Risk to Whales and Leatherback Sea Turtles in Offshore Floating Wind Turbine Moorings, Cables, and Associated Derelict Fishing Gear Offshore California (Study #PR-19-ENT)
Administered by	Pacific OCS Region
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Conducting Organizations(s)	National Oceanic and Atmospheric Administration
Total BOEM Cost	$500,000
Performance Period	FY 2019–2022
Final Report Due	August 22, 2022
Date Revised	January 22, 2021
PICOC Summary	
Problem	Offshore floating wind turbine moorings, power cables and associated derelict fishing gear may pose entanglement threats to protected marine species and there is currently no literature available that is applicable to deep water (>500 m) mooring designs.
Intervention	Develop a simulator designed to examine the risk and potential severity of entanglement of fin and humpback whales and leatherback sea turtles with at least two deep water (>500m) offshore floating wind turbine mooring systems and associated derelict fishing gear.
Comparison	This would be the first effort of its kind and will provide an important assessment tool that can be tested for validation once offshore floating platforms are installed in deeper water offshore California.
Outcome	In the absence of empirical data, the simulator will provide resource managers, regulators and industry with a tool to proactively assess and mitigate the risk of entanglement for protected whale species and leatherback sea turtles in deep water offshore floating turbine mooring systems and associated derelict fishing gear.
Context	Focused on the Pacific, but potentially applicable to all OCS regions.

BOEM Information Need(s): BOEM has already received one application to install floating wind turbines offshore northern California in waters approximately 500 m deep. There is currently no applicable information to accurately assess the potential impacts to protected whale and sea turtle species from this nascent industry. This information will assist in the identification of potential mitigation strategies. BOEM needs to acquire this information to inform the environmentally responsible development of any permitted offshore renewable floating energy activities offshore California. Impact assessment information is required under NEPA, ESA and MMPA.

Background: The Hywind Scotland floating wind farm is the world's first and only wind farm, consisting of 5 floating turbines in water 95-129 m in depth, operational since 2017 (https://www.equinor.com/en/what-we-do/hywind-where-the-wind-takes-us.html). The Fukushima

FORWARD Project currently only has a floating sub-station and 2 operational floating turbines offshore the Fukushima Prefecture in Japan in 50 m of water since 2013 (the 7 MW turbine was recently decommissioned; http://www.fukushima-forward.jp/english/). BOEM received an unsolicited application to install an offshore floating wind farm in northern California in 2018. Stakeholder comments received in response to BOEM's Call for Information and Nominations (January 28, 2019) highlighted entanglement as a significant impact of concern related to offshore floating wind farm installation.

BOEM has funded studies to try to visualize the potential interactions of whales with offshore floating wind turbines (e.g., Copping and Grear, 2018). However, there is no applicable scientific information available to inform the potential entanglement risk and impacts from offshore floating wind turbine mooring systems to marine protected species that occur in the deep waters offshore California. The most recent qualitative risk assessment done was for floating turbines in 50 m of water offshore Scotland (Benjamins et al., 2014; Harnois et al., 2015) and they state that recommendations need to be developed, assessing the risk of entanglement of offshore renewable energy mooring configurations at the beginning of their design process. In addition, the entanglement review stated that although risks of entanglement between derelict fishing gear and offshore marine renewable energy (ORE) moorings and structures clearly exist, further studies are required to quantify the level of risk (Benjamins et al., 2014).

Recent advances in the use of computer simulators allow the discovery of risk and severity of entanglement of highly endangered North Atlantic right whales with certain fixed fishing gear such as single-trap lobster pots commonly used in the northeastern fisheries of the United States (Howle et al., 2018). Additionally, one other entanglement simulator has been designed to demonstrate entanglement between the leatherback turtle and a vertical line (MacNicoll et al., 2016).

Following on these efforts, we will develop a morphologically accurate digital model of a fin and humpback whale and a leatherback sea turtle with realistic swimming motions and body appendage articulations. This will be coupled to a simulation environment including a subset of mooring and power cable configurations and designs representative of the current state of knowledge for offshore floating turbines. The moorings and power cables will have various combinations of chain/cable/rope diameters, lengths, strengths, bending strength and flotation systems. In addition, the most likely type(s) of derelict fishing gear anticipated to interact with these structures will be identified and included in the simulations.

Objectives:

- Develop morphologically accurate whale (fin, humpback) and leatherback sea turtle digital models. Additional species may be added dependent on available funds.
- Develop at least two digital models of floating turbine moorings, power cable systems, and associated derelict fishing gear.
    - Identify at least two appropriate and foreseeable mooring and power cable system designs for deployment in 500-1,100 meter water depths.
    - Analyze applicable and available fisheries data to identify the gear most likely to interact with the identified offshore renewable energy mooring and power cable structures.
- Investigate the dynamics of the interaction between the whale models and floating turbine moorings, power cable systems and associated derelict fishing gear.

    - Incorporate applicable and available data on whale and sea turtle entanglement from all sources, including stranding and necropsy reports.
    - Incorporate certain animal behaviors, such as maintain a pace, veer away, roll, startle reflex and feeding positions to study the effect of these behaviors on the probability of entanglement.
- Assess whale and sea turtle entanglement risk with floating turbine moorings and power cable systems and associated derelict fishing gear.
- Create a high-quality, professional educational product in support of a non-technical audience. This should include at least one non-technical, concise, BOEM branded animated video explaining the importance, application, and results of this study.
- Identify mitigation measures or recommendations, if any, to reduce the potential risk of entanglement from deep water (>500 m) ORE structures and derelict fishing gear to cetacean species and leatherback sea turtles in the California Call Areas.

Methods:

- Simulator program will make use of the Unity3D software system.
- Different gear configurations and protected species digital models will be programmed in C#, and added to the Unity project.
- Make use of applicable literature and expert elicitation for species behavioral information, fishing activities (to the availability of derelict fishing gear) and oceanographic conditions for the Humboldt and Central California Call Areas.

Specific Research Question(s):

1. What is the risk of entanglement in deep water (>500 m) ORE moorings and cables to protected leatherback sea turtles and fin and humpback whales that occur in the California Call Areas?
2. What is the risk of entanglement in derelict fishing gear associated with deep water (>500 m) ORE moorings and cables for protected leatherback sea turtles and fin and humpback whales that occur in the California Call Areas?
3. Are there mitigations that would minimize any identified risk of entanglement in deep water (>500 m) ORE moorings, cables and associated derelict fishing gear?

Current Status: A member of GARFO's Protected Resource Division (PRD) with disentanglement expertise has joined the Design Team. The Advisory Team (mainly NOAA experts) and the Design Team have continued to meet on a regular basis and provided valuable feedback on questions regarding the types of behaviors that should be simulated. The North Atlantic right and humpback whale models have been completed and are currently being fine-tuned regarding structure to accommodate various during and post entanglement behaviors. An external group of experts were consulted to review the North Atlantic right whale simulation model. A test version of a single mussel farm and North Atlantic right whale simulation has been produced and engineering and tank tests to provided data to validate the simulations have been completed. NMFS PRD have provided guidance on which derelict fishing gear are most likely to become entangled in floating wind moorings. A virtual workshop to allow external review of the aquaculture simulator is planned for spring 2021.

Publications Completed: None

Affiliated WWW Sites: None

References:

Copping A, Grear M. 2018. Humpback whale encounter with offshore wind mooring lines and inter-array cables. U.S. Department of Energy, Pacific Northwest National Laboratory, Final Report PNNL-27988. U.S. Department of the Interior, Bureau of Ocean Energy Management, OCS Study BOEM 2018-065. 34 p. https://www.boem.gov/BOEM-2018-065/

Benjamins S, Harnois V, Smith HCM, Johanning L, Greenhill L, Carter C, Wilson B. 2014. Understanding the potential for marine megafauna entanglement risk from marine renewable energy developments. Page Scottish Natural Heritage Commissioned Report No. 791.

Harnois V, Smith HCM, Benjamins S, Johanning L. 2015. Assessment of entanglement risk to marine megafauna due to offshore renewable energy mooring systems. International Journal of Marine Energy. 11:27–49.

Howle LE, Nowacek DP, Kraus SD, Werner TB. 2018. Simulation of the entanglement of a North Atlantic right whale (Eubalaena glacialis) with fixed fishing gear. Marine Mammal Science. DOI: 10.1111/mms.12562.

MacNicoll M, Akers R, Gougey C. 2016. Simulation of Marine Entanglement – A software tool used to predict entanglement of leatherback turtles. NOAA grant NA14NMF4720327 final report.