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Encounters of Marine Animals with Marine Renewable Energy Device Mooring Systems and Subsea Cables

Many marine renewable energy (MRE) technologies, including floating or midwater wave and tidal devices, require mooring systems (i.e., mooring lines and anchors) to maintain their position within the water column or on the sea surface. In the case of some devices such as tidal kites, these lines and cables can be highly dynamic. An array of non-bottom-mounted devices may also include transmission cables within the water column interconnecting devices to one another, or to offshore substations or hubs on the seabed. The potential for these lines and cables to present hazards for marine animals that may become entangled or entrapped in them, or confused by their presence remains an issue of uncertainty (Figure 8.1). The degree to which mitigation to avoid or reduce entanglement risk might be required for future MRE installations is yet to be determined, pending greater understanding of the actual nature of the risk. In this chapter, the entanglement or entrapment of a marine animal is defined as the cause to become caught in a system without possibility of escaping.

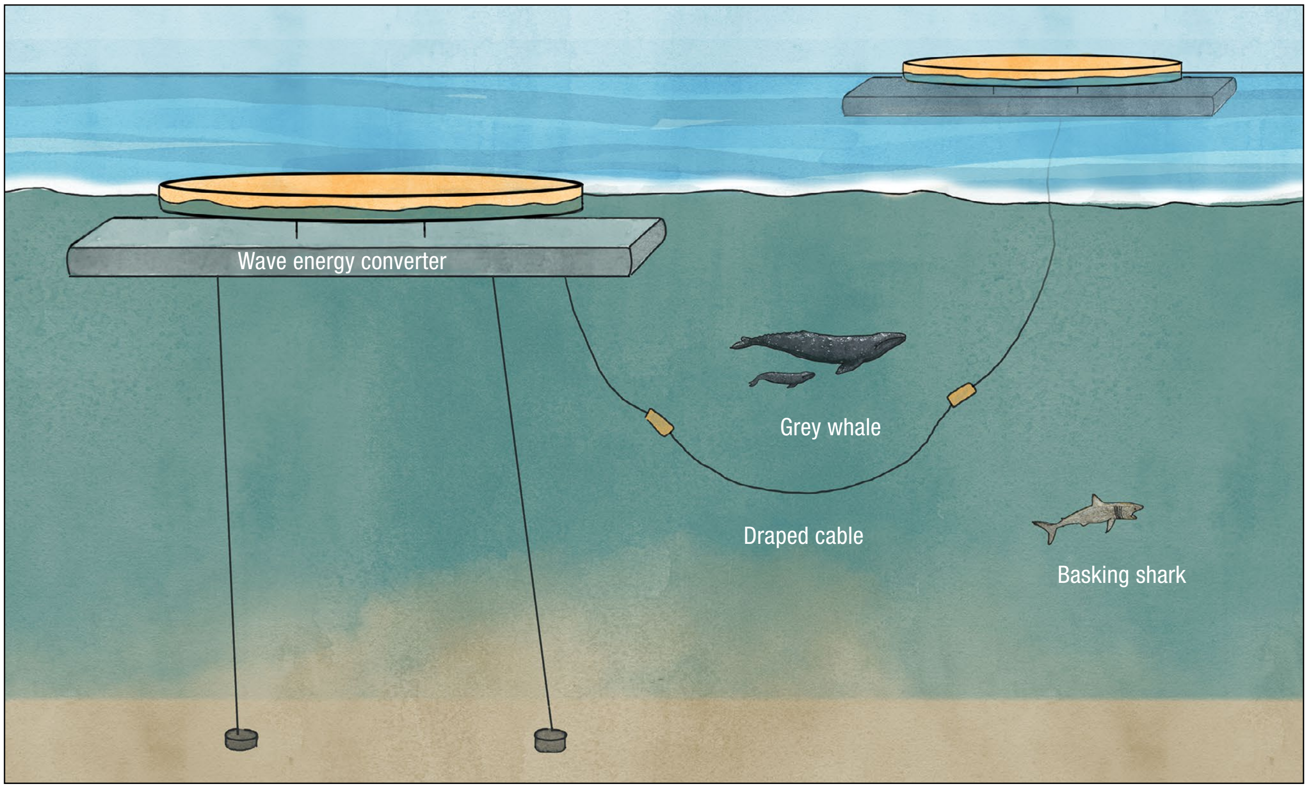

Figure 8.1. Schematic of marine animals' encounters with wave energy devices attached at the bottom by mooring lines and interconnected with a cable. (Illustration by Rose Perry)

8.1. SUMMARY OF KNOWLEDGE

Marine animal encounters with MRE device mooring systems and the associated risk of entanglement and entrapment are emerging topics among the potential environmental effects of MRE; these topics were not discussed in the *2016 State of the Science* report (Copping et al. 2016). Key progress and growth in knowledge and understanding across this topic area are discussed in the following sections.

To date, entanglement has not been considered a significant issue of concern within consenting/permitting (hereafter consenting) processes for single devices and small arrays. However, the extensive legal protection generally afforded to those megafaunal species considered most at risk (e.g., the Marine Mammal Protection Act [1972], in the United States [U.S.]; the Habitats Directive [1992], in the European Union; the Species at Risk Act [2002], in Canada; and the Environment Protection and Biodiversity Conservation Act [1999], in Australia) is likely to lead to precaution in how this issue is considered by regulatory and advisory bodies within consenting processes as the scale of arrays grows.

Large migratory baleen whale species (e.g., humpback whales *[Megaptera novaeangliae]*, minke whales *[Balaenoptera acutorostrata]*, right whales *[Eubalaena glacialis]*) are typically considered to be at the greatest risk of encounters with MRE device mooring systems because of their life history traits (e.g., migration) and feeding behaviors (Benjamins et al. 2014). Large pelagic elasmobranchs (e.g., whale sharks *[Rhincodon typus]*, basking shark whales *[Cetorhinus maximus]*, manta rays) also have greater potential risk of entanglement because of their large body size and feeding habits, but no information about these species' potential entanglement with MRE structures is available. While generally considered to be of lower risk, the risk to diving seabirds, sea turtles, and large fish cannot be completely discounted, particularly when considering the potential effects of larger arrays. The likely consequences of marine animal encounters with these structures, such as risks of injury or death, remain largely unknown, but some parallels can be drawn from studies related to entanglement with fishing gear.

Most of the available literature about the entanglement of marine animals focuses on observations of injury and mortality caused by entanglement with fishing gear such as nets, cables, and traps. Entanglement of large animals with fixed fishing gear can occur in a number of ways, including as a result of swimming through gear fixed to the bottom, or becoming entangled in a loose end or in a loop. When entangled, large whales may be able to pull the gear away, dragging it along with them; these entanglements frequently result in subsequent injury and/or mortality caused by tissue damage, infection, and mobility restrictions that prevent foraging or migration (Moore et al. 2006; Robbins et al. 2015).

Entanglement in submarine telecommunications cables has been reported prior to 1959 (Wood and Carter 2008). Entanglements of whales (mainly sperm whales) were mostly associated with excessive slack in repaired cables and most occurred in deep waters (118 m). The absence of whale entanglement reports since 1959 is likely due to new cable designs that involve cables being buried below the seabed, as well as improved repair techniques (Taormina et al. 2018; Wood and Carter 2008). Modern and improved methods to inform the need for maintenance, such as the use of remotely operated vehicles to inspect cables and detect anomalies, have probably also contributed to the apparent absence of entanglements.

Derelict (i.e., lost, abandoned, discarded) fishing gear and marine debris are known causes of entanglement for elasmobranchs (sharks and rays, Parton et al. 2019) and smaller marine animals (sea turtles, Gunn et al. 2010; fur seals, sea lions, Page et al. 2004; sea turtles, Wilcox et al. 2015). Once entangled, small marine animals do not have the ability to free themselves and the majority of them die without human intervention (Duncan et al. 2017; Schrey and Vauk 1987). Although no part of a mooring line or cable associated with MRE technologies would be abandoned or discarded, indirect entanglement in anthropogenic debris caught on devices is possible and could be a concern for a large range of species (Taormina et al. 2018).

The entanglement risks associated with MRE device mooring systems and transmission cables are poorly understood, largely because of the lack of empirical data and focused studies. Using the available literature on marine mammal entanglement with fishing gear, Kropp (2013) determined that migrating whales off the coast of Oregon (U.S.) would likely be at relatively low risk of entanglement with MRE device mooring systems because of their rare occurrence in the region and their seasonal migration behavior. Benjamins et al. (2014) and Harnois et al. (2015) employed qualitative risk assessments, using the dynamic analysis software OrcaFlex™, to predict the influence of different mooring configurations under various sea states on entanglement risk. The highest entanglement risk was predicted for catenary configurations—freely hanging mooring lines in the water column that have one part lying on the seabed and a large swept water volume. Overall, the model predicted that mooring lines were a low risk for marine animals, although baleen whales were found to be at greater risk because of their large size and feeding behavior (Benjamins et al. 2014). However, all the mooring configurations examined had too much tension to create a loop that could entangle a whale.

The biological characteristics and sensory abilities of marine animals may have a significant effect on entanglement risk. Minke whales seem to visually detect black and white line ropes more than those of other colors (Kot et al. 2012). North Atlantic right whales have been found to best detect vivid color ropes at longer distances (Kraus et al. 2014). However, vivid colors have been suggested to cause entanglement of humpback whales in Australia (How et al. 2015). The species-specific response of whales to rope colors highlights the need to further investigate this topic for the species of interest. Another important biological characteristic of whales is their ability to communicate acoustically. A mitigation strategy to reduce cetacean bycatch in fisheries is the use of acoustic deterrent devices, but their effectiveness is unclear (Hamilton and Baker 2019).

The likelihood of an encounter between marine animals and MRE device systems depends on the line or cable configuration and depth, as well as on the animal size and behavior (Sparling et al. 2013). As part of the environmental impact assessment performed for the Deep Green Utility units, an encounter model was developed to assess the potential of direct collision that could lead to entanglement between the mooring tether of the tidal kite and marine mammals (Minesto 2016). The model predicted that most marine mammals (grey seals *[Halichoerus grypus]*, harbor porpoise *[Phocoena phocoena]*, and bottlenose dolphins) swimming through the swept area of the device would not encounter the mooring tether when the device is operating. Even in the case of an encounter, the tether would remain taut to avoid the risk of entanglement.

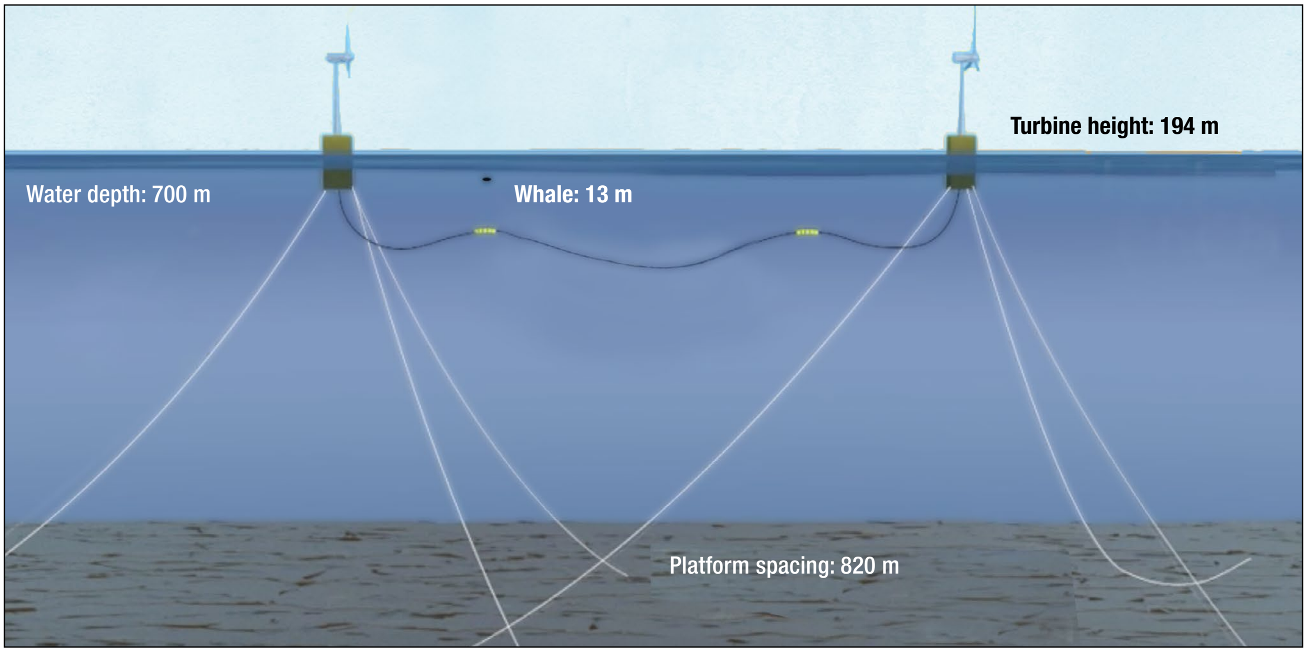

Figure 8.2. Screen capture from the 3D animation on the encounter of a humpback whale with floating offshore wind mooring lines and inter-array cables.[1] (From Copping and Grear 2018)

Overall, for single devices, the probability of encounter is likely to be low because the mooring lines occupy a very small cross section of the marine water column. In a large array of MRE devices, estimating the risk of encountering mooring lines and inter-array cables is less certain. A recent 3D animation developed by Copping and Grear (2018) allows the visualization of a humpback whale female and calf swimming through an offshore floating wind farm array (Figure 8.2). Such tools can provide perspective on the relative spatial scales of MRE devices and associated mooring components, water depth, and the size of marine animals.

8.2. RESEARCH AND MONITORING NEEDS TO RESOLVE THE ISSUE

Additional studies of the habitat preferences and diving behaviors of marine animals are needed to evaluate the risk of encounters that could lead to entanglement. Combining modeling and field observations will enhance the assessment of the risk. While encounter models can help predict the number of animals in the vicinity of MRE devices, empirical data are needed to validate these models. Identifying large whale breeding and feeding habitats as well as assessing their seasonal migration pathways will help inform siting MRE installations, or determine the likelihood of any interactions. Similarly, the identification of crucial habitat for other key migratory species such as turtles and large pelagic elasmobranchs could help manage and mitigate any entanglement risk. Thoughtful approaches to project siting can help to avoid migration corridors and important habitats.

Measures to facilitate routine monitoring of mooring systems, for example with autonomous or remote operating vehicles, could minimize entanglement risk by detecting the malfunction of mooring systems or the presence of derelict fishing gear. If such monitoring detects gear entanglements, the debris can be removed, thereby further reducing the risk of marine animal entanglement. Finally, studies focusing on the development of MRE arrays should be targeted to evaluate the probability of entanglement risk when successive mooring lines or cables are present.

1. See the animation from Copping and Grear (2018) on *https://www.pnnl.gov/news-media/exploring-encounters-between-humpback-and-floating-wind-farms*

8.3. REFERENCES

Benjamins, S., Harnois, V., Smith, H. C. M., Johanning, L., Greenhill, L., Carter, C., and Wilson, B. 2014. Understanding the potential for marine megafauna entanglement risk from marine renewable energy developments (Report No. 791). Report by Scottish Natural Heritage. *https://tethys.pnnl.gov/publications/understanding-potential-marine-megafauna-entanglement-risk-marine-renewable-energy-0*

Copping, A., and Grear, M. 2018. Humpback Whale Encounter with Offshore Wind Mooring Lines and Inter-Array Cables (PNNL-27988). Pacific Northwest National Laboratory, Richland, Washington. Report by Pacific Northwest National Laboratory for Bureau of Ocean Energy Management. *https://tethys.pnnl.gov/publications/humpback-whale-encounter-offshore-wind-mooring-lines-inter-array-cables*

Copping, A., Sather, N., Hanna, L., Whiting, J., Zydlewski, G., Staines, G., Gill, A., Hutchison, I., O'Hagan, A., Simas, T., Bald, J., Sparling, C., Wood, J., and Masden, E. 2016. Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report by Pacific Northwest National Laboratory for Ocean Energy Systems. *https://tethys.pnnl.gov/publications/state-of-the-science-2016*

Duncan, E. M., Botterell, Z. L. R., Broderick, A. C., Galloway, T. S., Lindeque, P. K., Nuno, A., and Godley, B. J. 2017. A global review of marine turtle entanglement in anthropogenic debris: a baseline for further action. *Endangered Species Research*, 34, 431-448. doi:10.3354/esr00865 *https://tethys.pnnl.gov/publications/global-review-marine-turtle-entanglement-anthropogenic-debris-baseline-further-action*

Environment Protection and Biodiversity Conservation Act 1999 (Cth). [Australia].

Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). OJ L 206, 22.7.1992, p. 7-50. [European Union].

Gunn, R., Hardesty, B. D., and Butler, J. 2010. Tackling 'ghost nets': Local solutions to a global issue in northern Australia. *Ecological Management & Restoration*, 11(2), *88-98.* doi:10.1111/j.1442-8903.2010.00525.x *https://tethys.pnnl.gov/publications/tackling-ghost-nets-local-solutions-global-issue-northern-australia*

Hamilton, S., and Baker, G. B. 2019. Technical mitigation to reduce marine mammal bycatch and entanglement in commercial fishing gear: lessons learnt and future directions. *Reviews in Fish Biology and Fisheries*, 29(2), 223-247. doi:10.1007/s11160-019-09550-6 *https://tethys.pnnl.gov/publications/technical-mitigation-reduce-marine-mammal-bycatch-entanglement-commercial-fishing-gear*

Harnois, V., Smith, H. C. M., Benjamins, S., and 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. doi:10.1016/j.ijome.2015.04.001 *https://tethys.pnnl.gov/publications/assessment-entanglement-risk-marine-megafauna-due-offshore-renewable-energy-mooring*

Kot, B. W., Sears, R., Anis, A., Nowacek, D. P., Gedamke, J., and Marshall, C. D. 2012. Behavioral responses of minke whales *(Balaenoptera acutorostrata)* to experimental fishing gear in a coastal environment. *Journal of Experimental Marine Biology and Ecology*, *413, 13-20.* doi:10.1016/j.jembe.2011.11.018 *https://tethys.pnnl.gov/publications/behavioral-responses-minke-whales-balaenoptera-acutorostrata-experimental-fishing-gear*

Kraus, S., Fasick, J., Werner, T., and McFarron, P. 2014. Enhancing the Visibility of Fishing Ropes to Reduce Right Whale Entanglements. *Bycatch Reduction Engineering Program 1*, 67-74. *https://tethys.pnnl.gov/publications/enhancing-visibility-fishing-ropes-reduce-right-whale-entanglements*

Kropp, R. K. 2013. Biological and existing data analysis to inform risk of collision and entanglement hypotheses (PNNL-22804). Pacific Northwest National Laboratory, Richland, Washington. Report by Pacific Northwest National Laboratory for U.S. Department of Energy. *https://tethys.pnnl.gov/publications/biological-existing-data-analysis-inform-risk-collision-entanglement-hypotheses*

Marine Mammal Protection Act of 1972. 16 U.S.C. ch 31 § 1361 et seq. [United States].

Minesto. 2016. Deep Green Holyhead Deep Project Phase I (0.5 MW) - Environmental Statement. *https://tethys.pnnl.gov/publications/deep-green-holyhead-deep-project-phase-i-05-mw-environmental-statement*

Moore, M. J., Bogomolni, A., Bowman, R., Hamilton, P. K., Harry, C. T., Knowlton, A. R., Landry, S., Rotstein, D. S., and Touhey, K. 2006, 18-21 Sept. 2006. Fatally entangled right whales can die extremely slowly. Paper presented at OCEANS 2006, Washington, D.C. doi:10.1109/OCEANS.2006.306792 *https://tethys.pnnl.gov/publications/fatally-entangled-right-whales-can-die-extremely-slowly*

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Haase, T., Berris, M., Dowie, D., Shaughnessy, P. D., and Goldsworthy, S. D. 2004. Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem. *Marine Pollution Bulletin*, 49(1), 33-42. doi:10.1016/j.marpolbul.2004.01.006 *https://tethys.pnnl.gov/publications/entanglement-australian-sea-lions-new-zealand-fur-seals-lost-fishing-gear-other-marine*

Parton, K. J., Galloway, T. S., and Godley, B. J. 2019. Global review of shark and ray entanglement in anthropogenic marine debris. *Endangered Species Research*, 39, 173-190. doi:10.3354/esr00964 *https://tethys.pnnl.gov/publications/global-review-shark-ray-entanglement-anthropogenic-marine-debris*

Robbins, J., Knowlton, A. R., and Landry, S. 2015. Apparent survival of North Atlantic right whales after entanglement in fishing gear. *Biological Conservation*, 191, 421-427. doi:10.1016/j.biocon.2015.07.023 *https://tethys.pnnl.gov/publications/apparent-survival-north-atlantic-right-whales-after-entanglement-fishing-gear*

Schrey, E., and Vauk, G. J. M. 1987. Records of entangled gannets *(Sula bassana)* at Helgoland, German Bight. *Marine Pollution Bulletin*, 18(6, Supplement B), 350-352. doi:10.1016/S0025-326X(87)80024-3 *https://tethys.pnnl.gov/publications/records-entangled-gannets-sula-bassana-helgoland-german-bight*

Sparling, C., Coram, A., McConnell, B., Thompson, D., Hawkins, K., and Northridge, S. 2013. Wave and Tidal Consenting Position Paper Series: Marine Mammal Impacts. Report by SMRU Consulting for Natural Environment Research Council. *https://tethys.pnnl.gov/publications/wave-tidal-consenting-position-paper-series-marine-mammal-impacts*

Species at Risk Act, S.C. 2002. c. 29. [Canada].

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., and Carlier, A. 2018. A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews*, 96, 380-391. doi:10.1016/j.rser.2018.07.026 *https://tethys.pnnl.gov/publications/review-potential-impacts-submarine-power-cables-marine-environment-knowledge-gaps*

Wilcox, C., Heathcote, G., Goldberg, J., Gunn, R., Peel, D., and Hardesty, B. D. 2015. Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. *Conservation Biology, 29(1), 198-206.* doi:10.1111/cobi.12355 *https://tethys.pnnl.gov/publications/understanding-sources-effects-abandoned-lost-discarded-fishing-gear-marine-turtles*

Wood, M. P., and Carter, L. 2008. Whale Entanglements With Submarine Telecommunication Cables. *IEEE Journal of Oceanic Engineering*, 33(4), 445-450. doi:10.1109/JOE.2008.2001638 *https://tethys.pnnl.gov/publications/whale-entanglements-submarine-telecommunication-cables*

NOTES

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REPORT AND MORE INFORMATION

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