Frequently Asked Questions: Offshore Wind and Whales

February 2024

Developed by the Whale Communications Specialist Committee of the Environmental Technical Working Group, with support from the Biodiversity Research Institute

Introduction

The Environmental Technical Working Group (E-TWG) is an independent advisory body to the State of New York, formed in 2017, with a regional focus on offshore wind and wildlife issues from Maine to North Carolina. It is comprised of offshore wind developers, science-based environmental non-government organizations, and state and federal wildlife agencies. The E-TWG undertakes activities such as the development of best management practices and identification of research needs regarding wildlife. With direction from the E-TWG and the New York State Energy Research and Development Authority (NYSERDA), topically focused Specialist Committees (SCs) bring together science-based subject matter expertise to develop specific products and recommendations that inform or advance the environmentally responsible development of offshore wind. Specialist Committees include both E-TWG and non-E-TWG members from a range of backgrounds, as appropriate for each committee's charge.

The Whale Communications Specialist Committee was formed in May 2023 to develop communications materials to aid in the dissemination of current, accurate, and readily understandable information around whale mortality events[1] and the level of potential risk to whales from offshore wind energy development activities. The Specialist Committee includes representatives from environmental nonprofit organizations, state agencies, and offshore wind energy developers, and receives scientific support from the Biodiversity Research Institute and facilitation support from the Consensus Building Institute. External reviewers of Committee products include a number of scientific experts including federal and state agency representatives, academics, and other environmental stakeholders.

The main outcome of the Committee to date is this Frequently Asked Questions (FAQs) document, which groups topics into overarching themes and aims to provide two to three levels of information in response to each FAQ: 1) Brief bulleted summary; 2) Broad Answer: concise answer to key question (when necessary); and 3) Detailed Answer: Extended answer with associated scientific citations to provide readers with a better understanding of the facts and information sources. .

In addition to scientific citations, FAQ responses in many cases have a "for more information" section that refers the reader to other materials aimed at a general audience, including web pages, videos, and popular media. In many cases, the FAQ responses include discussion of other marine mammals besides large whales, and/or other anthropogenic activities besides offshore wind energy development, to provide detail and context.

The FAQ is intended primarily as a resource for stakeholders who are in direct communication with the general public, and who regularly receive questions from the public on these topics. The intent of this document is to provide scientifically sound, accurate answers, in varying levels of detail, to address common questions. End users should feel free to use or adapt the information in the FAQ as they see fit.

Given the urgency of disseminating accurate information, this is intended to be a living document that is updated over time to address key emerging questions related to whales and offshore wind energy development. The document has been through multiple layers of review by Specialist Committee members, E-TWG members, and external reviewers. If readers with appropriate expertise would like to help review drafts of future FAQ topics, please reach out to Julia Gulka at julia.gulka@briwildlife.org.

[1] T. Tully and W. Choi-Schagrin. 2023. Why 23 Dead Whales Have Washed Up on the East Coast Since December. Article by New York Times, 28 February 2023.

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Offshore Wind Development Process

What are the major components of an offshore wind farm?

- Offshore wind farms are typically comprised of turbines, whose rotors convert mechanical energy from wind into electrical energy, and an offshore substation, which are linked to each other by a network of electrical cables. The electricity is transported onshore via export cables (which are typically buried in the seafloor) so that the energy can be integrated into the electrical grid.
- Turbines can either have fixed foundations, in which the foundation is driven into the seabed, or floating foundations, which have a series of anchors attached to the foundation via mooring lines. Floating turbine designs are newer and are generally deployed in much deeper waters (50-300 m, or 164-984 ft).

Detailed Answer

Offshore wind (OSW) farms comprise a network of offshore structures that are linked to each other by a network of array cables, and to onshore connection sites by an export cable that is typically buried in the seafloor. Offshore structures primarily include substations, which are platforms that collect turbine-generated power and prepare for the transmission of power to shore, and turbines, which are the quintessential structures that rotate to harness and convert mechanical energy of wind into electrical energy (NYSERDA OSW101; Figure 1). The electricity generated by the turbines is transported to shore via export cables to an onshore substation, where the energy is integrated into the electrical grid (Figure 2).

Fixed foundation turbines comprise a number of important parts (Figure 1), including the turbine foundation, which is driven into the seabed. Scour protection prevents erosion of the seabed around the foundation. A transition piece connects the foundation to the tower, which extends skyward from the sea surface and supports the rotating pieces of the structure.[2] There may also be a work platform that sits between 0-30m (0-98 ft) above sea level on the tower, and includes handrails, a boat landing and ladders, and other equipment required for maintenance. The nacelle is on top of the tower and houses the components that transfer mechanical power from the rotating hub and blades into electrical energy, and also has a platform for maintenance purposes. The blades capture wind energy and extend from the hub, which houses the blades and the system that controls blade pitch and rotation speed.

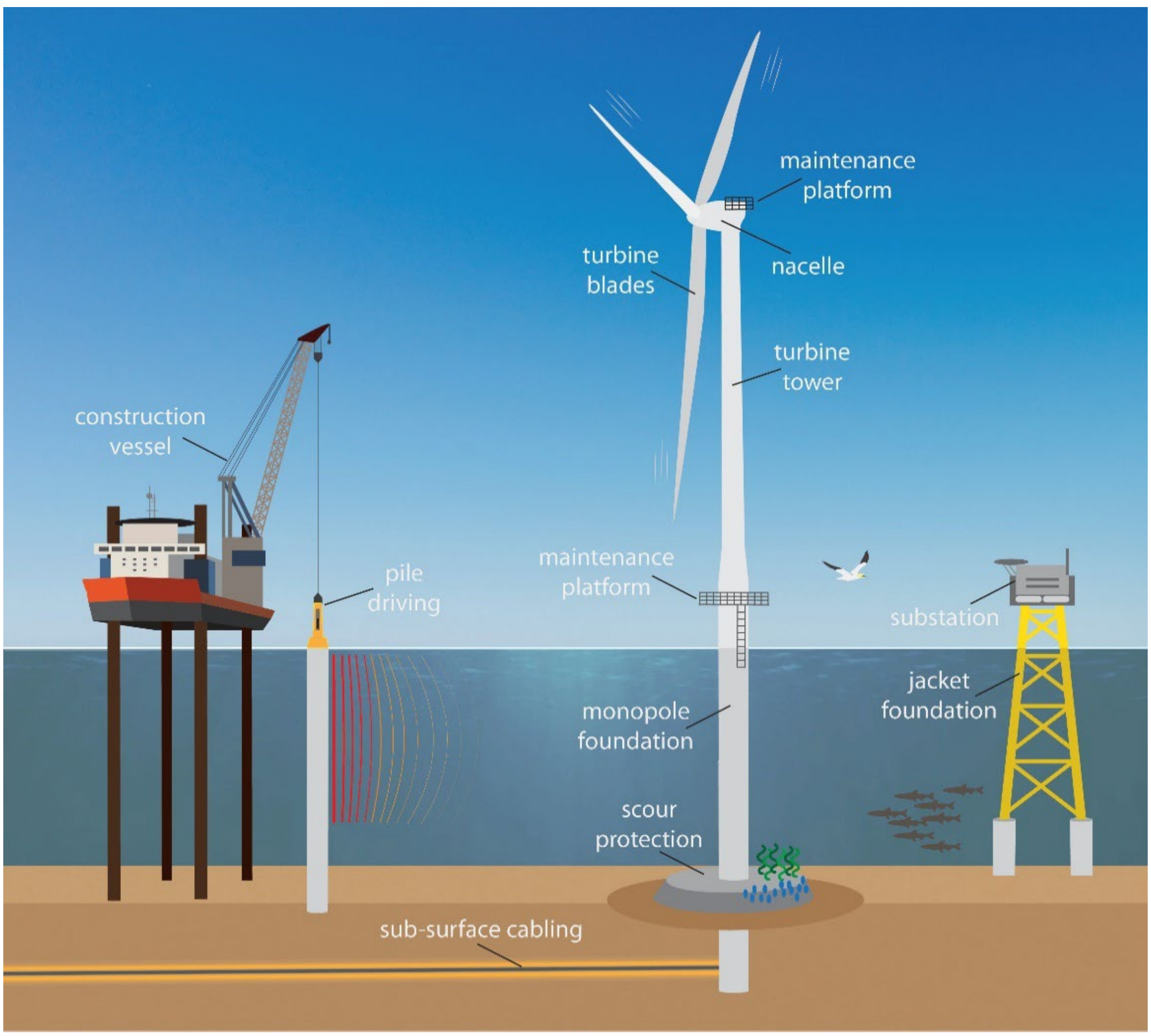
Importantly, turbines and offshore substations have typically been secured to monopile foundations that are installed to the seafloor through pile driving. However, there are a range of other foundation types, such as suction bucket and gravity-based foundations (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?*), whose use typically depends on the seabed substrate, water depth, supply chain availability, and other factors. Floating offshore wind turbines are much newer, and there are several designs in use at pilot projects around the world; currently, the largest floating offshore wind farm consists of 5 turbines in Scotland.[3] Floating turbines include in-water structures of various kinds that support the tower and are connected to large cabling systems that are anchored to the seafloor. While traditional turbine designs can be installed in <50 m (164 ft) of water, and are typically installed in <30 m (98 ft) of water, floating wind turbines can be deployed in deep water

[2] www.wind-energy-the-facts.org/offshore-support-structures-7.html

[3] www.equinor.com/energy/hywind-scotland

regions up to about 300m (984 ft) in depth (Lin et al. 2021) that would otherwise be inaccessible (e.g., most of the Gulf of Maine and West Coast of the United States, as well as areas of the U.S. Atlantic Continental Shelf).[4]

OSW farm footprint and turbine sizes can vary greatly. As turbines increase in size, the energy capacity per unit of footprint is increasing (Wiser et al. 2023). Turbine capacity, blade diameter, and height of the structures have all increased steadily in the last 20 years, both on land and in marine environments, which increases efficiency of energy generation and influences the potential effects on wildlife and the marine environment. In addition, the cost per unit of energy typically decreases as the OSW farm size increases, driving expansion of OSW farms (Shields et al. 2021). The configuration and design of a particular wind farm will be site-specific, depending on physical characteristics of the site, available technologies and components, and other factors.



[4] http://www.nyserda.ny.gov/offshorewind

Figure 1. Components of an offshore wind farm. Source: Biodiversity Research Institute.

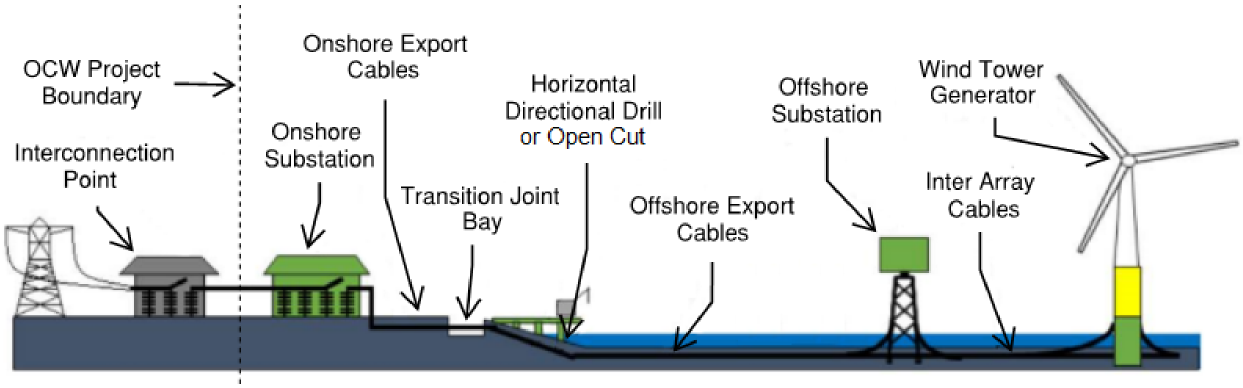


Figure 2. Diagram of main offshore wind project components. Source: HDR (https://media.fisheries.noaa.gov/2022-03/OceanWind1OWF_2022_508APP_OPR1.pdf).

For More Information

NYSERDA Offshore Wind 101: https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/About-Offshore-Wind/Offshore-Wind-101

Ørsted Offshore Wind Farm Construction Video: https://www.youtube.com/watch?v=3bntCXP8Yic

Crown Estate Guide to an Offshore Wind Farm: https://www.thecrownestate.co.uk/media/2861/guide-to-offshore-wind-farm-2019.pdf

What are the potential effects of offshore wind development on whales?

- The main ways that marine mammals may be affected by offshore wind development are via 1) underwater sound; 2) vessel interactions; and 3) changes to habitat and prey. The offshore wind industry follows a stringent federal permitting process to minimize and mitigate marine mammal disturbance.
- The main sources of offshore wind-related sounds are geological and geophysical surveys (during site assessment of wind energy areas) and installation of wind turbine foundations (during construction). Operating turbines are also expected to emit low levels of noise into the water column. Site assessment surveys for offshore wind differ from oil and gas in that they do not employ the deeper penetration sources used by oil and gas for estimating oil reserves. The sources used for offshore wind development are of much lower volume and at high frequencies often above the hearing range of baleen whales.
- All vessels operating on the water pose a potential risk of vessel collisions to whales. Vessel strikes are thought to be the cause of many of the large whale strandings in New York and New Jersey in 2023 and are one of the major drivers of the decline of endangered North Atlantic right whales. Offshore wind development is subject to stringent requirements to reduce risk of vessel collisions for marine mammals, primarily via vessel speed restrictions that require vessels to travel under 10 knots.
- Introducing offshore wind structures into the environment could change the abundance, distribution, and composition of marine mammal prey (e.g., via artificial reef effects), influence hydrodynamic processes, and potentially alter fishing patterns around the structures. These changes may alter where, and how, marine mammals use the habitat in and surrounding OSW farms, though it is unclear the degree to which changes will occur or if they will positively or negatively affect whales.

Broad Answer

The primary factors associated with offshore wind (OSW) development that may affect whales include underwater sound, vessel activities, and habitat change. OSW development introduces a variety of sounds into the environment, particularly during wind farm construction, as well as additional boat traffic during construction, operations, and maintenance activities. In addition, OSW development could lead to changes in the habitats around OSW farms, which may result in either positive (e.g., creating of artificial reefs) or negative change (e.g., effective habitat loss). The potential impacts to individuals and populations from each of these changes will depend on multiple factors, including behavior, life history, population size, and habitat use.

Though there has been substantial research on certain taxa, effects, and stressors, not all taxa and regions have been thoroughly studied. Our knowledge of OSW effects is limited to regions where development has occurred (e.g., Europe) and impacted taxa in those regions (e.g., primarily harbor porpoise and seals). Most of the understanding of OSW effects on baleen whales in the U.S. comes from thorough research on other anthropogenic activities, such as offshore oil and gas exploration and extraction, shipping, and naval activities, but only some components of these activities are relevant to assessing impacts of OSW development. Ultimately, the stressors that could cause death or serious injury to marine mammals during the development phases of OSW (e.g., ship strike or entanglement), are well understood, and mitigation measures are currently in place to help address these stressors. However, we are faced with shifting baselines due to the impacts of climate change and other long-term ecosystem changes. As we begin to understand these climate-driven effects, challenges remain in predicting how climate change influences the distributions, phenology, and abundance of marine mammals and more work is needed to help disentangle potential effects of offshore wind development from climate-related effects.

Acoustic Effects

There is a lot of research into the effects of anthropogenic sound on marine mammals, though it is important to note that impacts may not necessarily be transferrable between regions, species, or types of sound. The ocean environment is noisy, comprised of both natural (biological and physical) and anthropogenic sounds. Marine mammals use sound to communicate, to feed, socialize, and assess their environment, and certain types of anthropogenic sound impact marine mammal hearing and behavior. Marine mammals may suffer acute impacts, such as injury or death, if they are close to a harmful sound source, or may change their behavior or move away from a distant or less harmful sound source. Marine mammal hearing sensitivity and recovery from sound depends on the species, environment, and characteristics of the sound (e.g., volume, frequency, duration). Sound is expected at all steps of OSW development in varying amounts, though due to the above-mentioned factors, only some species or behaviors may be affected.

During pre-construction, underwater acoustic equipment is used to produce high-resolution maps of the seafloor and shallow sediments during the planning and assessment phase of development. While the seafloor mapping process for OSW is somewhat similar to that used for oil and gas exploration, the acoustic equipment used in oil and gas exploration to penetrate deep below the seafloor to search for oil and gas deposits produces much louder, lower-frequency sounds. Oil and gas exploration activities have demonstrated serious impacts to many marine mammal species from use of the deeper penetration sources. In contrast, the sources used for the mapping process for OSW are only to characterize the ocean bottom and shallow sediments. Most sound generated by these OSW activities are not expected to affect large whale species because they are low-volume and high frequency, often above the hearing range of baleen whales. Some sound emitted could also potentially cause behavior changes in small cetacean and toothed whale species, though measures are in place to help mitigate those effects. Furthermore, there is no evidence of injury from OSW mapping activities in any marine mammals.

Sound generation during construction will likely have the greatest acoustic impact on marine mammals. Installation of fixed OSW structures on the sea floor (e.g., monopiles; see *What are the major components of an offshore wind farm?*) commonly involves a process called pile driving where a large hydraulic hammer drives piles into the seabed, which emits loud sounds that extends to great distances. If marine mammals are close to the pile driving activity, they could potentially experience temporary or even permanent hearing damage. At greater distances, it is thought that such sounds may interfere with communications during feeding, socializing, and nursery activities or cause animals to avoid the area (e.g., displacement) which may be temporary or longer-term. Effects of sound vary by species (based on hearing capabilities) as well as the characteristics of the sound. However, a range of mitigation measures are available to reduce the effects of sound produced by pile-driving (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?*).[5]

During the 30-year operational period, the sound produced by turbines is unlikely to reach levels that would significantly impact marine mammals but could result in a behavioral response for individuals close

[5] Specific measures being used in the U.S. OSW industry will also be detailed in an upcoming FAQ response.

to turbines. As turbine size increases, so does operational sound which may increase the distance by which sound is detected by large whales. It is important to point out that we presently lack evidence on the effects of operational sound on large whales because existing studies from Europe have focused primarily on harbor porpoises and seals, and different marine mammal groups use and communicate with sound in very different ways.

Finally, all stages of OSW development and operations result in increased vessel traffic, which will increase vessel sound in the area, which could contribute towards masking of sounds produced by marine mammals by other vessel traffic. Technologies to quiet vessels are on the horizon, which may help mitigate this problem.

Vessel Strike Risk

Vessel strike risk is a great concern for marine mammals globally. Vessel traffic is increasing, in large part driven by the shipping industry. OSW is expected to further increase vessel traffic, though it contributes a small part of total vessel activity globally, with offshore wind vessel activity currently accounting for about 2% of tracked vessel traffic in U.S. Atlantic waters from North Carolina to Southern New England.[6] Vessels operating at high speeds (> 10 knots, or 11.5 mph) have a significantly higher risk of causing death or injury to marine mammals upon colliding, and most current restrictions for vessel traffic operate based on the premise that "speed kills". OSW development is subject to stringent requirements to reduce the risk of vessel strike, including vessel speed restrictions, observers on vessels, passive acoustic monitoring, reporting when whales are sighted in an area, and other measures to reduce risk of collisions for marine mammals (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?*). Vessel strikes are thought to be the cause of many of the whale strandings that occurred in New Jersey and New York in 2023, with recent federal data indicating that generally, high-density vessel traffic areas in approaches to major commercial ports pose the greatest risk of vessel strike mortalities.[7] Vessel strikes are also a leading driver of the decline of North Atlantic right whales.

Habitat Change

Marine mammals have large food requirements for migration, reproduction, and thermoregulation in cold ocean environments, and are therefore sensitive to changes in their habitats and prey. Introducing OSW structures into the environment could change the abundance, distribution, and composition of prey (e.g., reef effects), influence hydrodynamic processes, and potentially alter fishing patterns around the structures. Cabling introduces electromagnetic fields which may also influence prey distributions near the seafloor. These changes may alter where, and how, marine mammals use the habitat in and surrounding OSW farms, though it is unclear whether changes would positively or negatively affect whales. There are other threats to marine mammals in busy coastal ocean environments, such as entanglement in fishing gear and risk of vessel strikes from other industries, so OSW-related changes to where and when marine mammals occur could also lead to secondary impacts from other stressors. Marine mammals also face changing conditions due to climate change, with regime shifts occurring in the Northwest Atlantic resulting in shifting resources. Disentangling the effects of offshore wind development on resource availability and habitat from climate-induced changes will be challenging.

[6] https://cleanpower.org/wp-content/uploads/2023/02/ACP_WhaleFactSheet_230222.pdf

[7] This topic will be discussed in further detail in an upcoming FAQ response.

Understanding and Avoiding Population–level Effects

OSW development may introduce risks to marine mammals, but the overall importance of any effects depends on whether large whale populations are negatively impacted (e.g., through reduced birth rates or juvenile survival, or increased death rates). In general, anthropogenic effects may vary in spatial and temporal scale, so impacts occurring locally may not translate into population-level impacts. In addition, rare species and those with small population sizes (e.g., North Atlantic right whales) will be more sensitive to small changes in survival and reproductive success than more abundant species (e.g., humpback whales).

From the perspective of current federal regulations (e.g., Endangered Species Act, Marine Mammal Protection Act), the goal is to maintain viable populations by reducing anthropogenic impacts. Although a small amount of lethal or non-lethal impact to marine mammals may be permitted in certain circumstances, no impact that would jeopardize a population is currently allowed under the Marine Mammal Protection Act and no lethal take has been authorized for the offshore wind industry to date. Therefore, the OSW industry follows a stringent federal permitting process to minimize and mitigate marine mammal disturbance. Scientists understand the general impacts of sound, vessels, changes to prey, and other effects on marine mammals, though they are still working to understand the specific effects of OSW on large whales. The current scientific understanding is used to inform OSW development and mitigation planning.

Detailed answer

OSW development may impact whales differently depending on their behaviors, life history, population size, and habitat use (Bailey et al. 2014). The current understanding of possible impacts to marine mammals includes acoustic harm or disturbance, vessel collision risk, and habitat alteration, with the potential for cumulative effects from offshore wind development and from existing sources. The ocean is heavily impacted by human activities already, including recreational and commercial vessel traffic, fishing, seismic surveys, and oil and gas development (Bailey et al. 2014), and it is important to consider OSW development in the context of an environment that is already under stress (NYSERDA 2019). The addition of OSW development to the marine environment could potentially result in minimal effects to marine mammals, as these species are already accustomed to habitats that are under substantial stress from other human activities. Alternatively, effects from various stressors could be cumulative, wherein marine mammal populations that are already vulnerable may become more vulnerable due to compounding causal factors (e.g., fishing gear entanglements, vessel strikes, and OSW impacts; Williams et al. 2015).

The existing research on OSW impacts on marine mammals has been primarily conducted in Europe. Therefore, research questions have focused on taxa relevant to those regions, such as harbor porpoise and seals that inhabit European waters (Thomsen et al. 2006, Kraus et al. 2019). Initial assessments of OSW risk to large whales are primarily drawn from knowledge of effects from other anthropogenic marine activities (naval activities, offshore oil and gas development, marine infrastructure development such as bridges, etc.). However, recently collected data from new OSW construction in the United States is becoming available (Amaral 2021). Additionally, mitigation measures developed for OSW in Europe, such as bubble curtains (which prevent sound propagation during pile driving of turbine foundations), are being increasingly tested and used in the U.S. However, we are faced with shifting baselines due to the impacts of climate change and other long-term ecosystem changes. We have already seen distribution shifts of marine mammals, including the North Atlantic right whale as a result of oceanographic regime shifts (Davies et al. 2019, Meyer-Gutbrod et al. 2021, Thorne et al. 2022). In this case, warming waters in the Gulf of Maine and the western Scotian Shelf resulted in a shift in the distribution of foraging grounds to the Gulf of St Lawrence, which had knock on effects for calving rates and increased exposure to vessel collision and entanglement (Meyer-Gutbrod et al. 2021). As we begin to understand these climate-driven effects, challenges remain in predicting how climate change influences the distributions, phenology, and abundance of marine mammals (Lettrich et al. 2023) and more work is needed to help disentangle potential effects of offshore wind development from climate-related effects.

Acoustics Effects

There is substantial research on the effects of anthropogenic sound on marine mammals, though the results of existing studies are not necessarily transferrable to other regions, species, or sound sources. Studies on large whales and OSW are lacking, because activities associated with OSW are only beginning in areas where large whales typically occur. However, no studies have linked behavioral responses due to OSW sound with any measurable population change in marine mammals (Bailey et al. 2014).

Sound can occur as ambient (i.e., background sound), a single event (e.g., underwater explosion), continuous sound (e.g., vessel sound, operational sound), or pulsed events (e.g., sonar, pile driving). The propagation of sound throughout the marine environment is dependent on sound frequency ("pitch"), duration, regularity, and levels (i.e., volume), as well as habitat features (e.g., water depth or substrate type). Marine mammals use sound to source food and communicate, for mating purposes, and to understand their surroundings. Marine mammals may be influenced by anthropogenic sound in a number of ways, ranging from no effect to alterations of behavior that may directly or indirectly influence fitness (e.g., survival and reproductive success). Certain sound events may cause a temporary shift in the hearing threshold (TTS) for marine mammals, similar to tinnitus, with recovery to baseline hearing levels within hours to weeks following exposure (Ryan et al. 2016), while continued accumulation of small amounts of sound exposure may be impactful over time. More injurious exposure (louder or accumulating over longer periods of time) can lead to a permanent shift in hearing abilities (PTS) from which the animal does not return to baseline hearing capabilities (Ryan et al. 2016). These sound levels may drive marine mammals to move away from the sound source or alter their behavior to minimize exposure. Many mitigation measures are also in place during OSW development to minimize the risk of exposure to sound levels that could cause either TTS or PTS (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?*). NOAA has developed a set of guidelines for assessing the effects of underwater anthropogenic sound on the hearing of marine mammal species, which identifies thresholds (e.g., received levels), at which different marine mammal species are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater anthropogenic sound sources (NMFS 2018). This guidance is the standard used by the offshore wind industry to assess potential noise exposure impacts.

Sound exposure from offshore wind energy development varies by development phase. During pre-construction, underwater acoustic devices are used to characterize the seafloor (and sometimes fish and zooplankton distributions) to inform siting of OSW turbines. These systems use relatively quiet sound to obtain high-resolution imagery of the composition of the seafloor, as well as some shallow geological features. They are much smaller in scale and less impactful than the low frequency, loud technology used to explore deep below the ocean crust for oil and gas deposits, which have notable measurable effects on many marine mammal taxa (Figure 3; Gailey et al. 2007, Castellote et al. 2012, Cerchio et al. 2014, Blackwell et al. 2015). Most of the sound frequencies emitted by equipment used in OSW geophysical and geotechnical mapping surveys are low volume and outside the frequency range where large whales have demonstrated impacts, so it is not expected that these systems will have any measurable effect on large whales. Some sound emitted could also potentially cause behavior changes in small cetacean and toothed whale species, though measures are in place to help mitigate those effects. Furthermore, there has been no evidence of injury of any marine mammal associated with the sound systems used in OSW mapping and studies.[8]

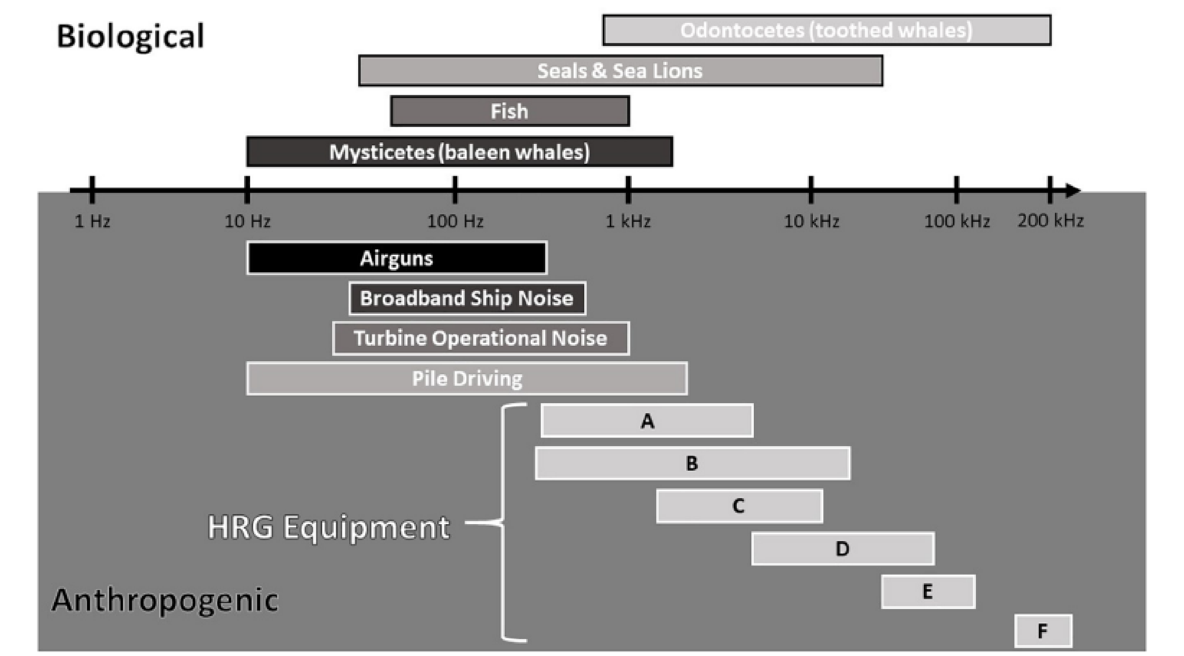


FIGURE 3 | This figure shows the frequency ranges over which groups of marine animals call (top) and the primary frequency ranges over which some anthropogenic sound sources (bottom) overlap. The frequency scale is on a logarithmic scale, expanding from 1 to 200,000 Hz. Mysticetes (baleen whales), such as the North Atlantic right whale, fin, sei, blue, humpback, and minke whale, produce low-frequency sounds, while odontocetes (toothed whales), such as the sperm whale, produce higher frequency sounds. Anthropogenic sound sources and primary frequency ranges are displayed on the bottom of the figure, with the bracketed boxes corresponding to the following high resolution geophysical (HRG) equipment sound sources: (A) Sparkers/boomers; (B) Non-parametric sub-bottom profilers; (C) Acoustic corers; (D) Acoustic positioning systems; (E) Parametric sub-bottom profilers; (F) Multibeam echosounders and sidescan sonar.

Figure 3. Frequency ranges of major human-caused sound sources in the marine environment and their overlap with the hearing ranges of marine animals. Source: Van Parijs et al. 2021 (https://www.frontiersin.org/articles/10.3389/fmars.2021.760840).

The construction phase will likely have the greatest acoustic effects on marine mammals. A process called pile-driving is commonly used to secure fixed OSW structures to the sea floor, which produces impulsive, low frequency, and broadband sound (Madsen et al. 2006) that travels across large swaths of the ocean. The sound produced by driving the piles into the sea floor propagates through the water, sediment and air. The average pile takes between 1-2 hours to install (Nedwell & Howell 2004, Siddagangaiah et al. 2022), though the process may occur over several weeks (Dähne et al. 2013). Since pile-driving requires very specialized vessels and equipment, and many offshore wind projects include dozens of turbines, pile driving activity for a single wind project will occur intermittently over periods of months or even years.

[8] https://www.noaa.gov/sites/default/files/2023-01/Transcript-011823-NOAA-Fisheries-Media-Teleconference-East-Coast-whale-strandings-508.pdf

Potential impacts from pile-driving could include permanent or temporary hearing damage for marine mammals in close proximity to the sound source, depending on the species (Thomsen et al. 2006, Bailey et al. 2014), behavioral avoidance, which could lead to displacement of animals from the location where sound is emitted (Bailey et al. 2014), or masking of calls (i.e. where sound is strong enough to interfere with detection of other sounds; Thomsen et al. 2006). It is possible that the same sound source impair hearing near the source of the sound and disrupts behavior farther away from the sound source (Thomsen et al. 2006, Bailey et al. 2010). Disruptions have also been determined for other marine mammal species from pile driving activities of different industries (Bottlenose dolphins, offshore wind development- Bailey et al. 2010, Beluga whales, port infrastructure- Castellote et al. 2019, Hector's dolphin, wharf construction- Leunissen et al. 2019). Much of what we know about the effects of offshore wind related sound to marine mammals comes from Europe where harbor porpoise is a key study species, however we can also learn from other industries the potential effects to large whales.

- *Effects to hearing:* Traditional pile driving involves multiple strikes over a given period of time, which amounts to a cumulative exposure for marine mammals, assuming their hearing does not fully recover between strikes and they remain in the area (Bailey et al. 2014). For example, for harbor porpoises, this could cause temporary hearing damage within about 10-50 m (33-164 ft) of the sound source, and permanent hearing damage within 5-20 m (16-66 ft) of the source (Thomsen et al. 2006, Bailey et al. 2014), though use of various mitigation measures (as well as potentially animals' own avoidance responses) will likely prevent animals from being present this close to pile driving activity, and other marine mammals species will have different distance thresholds (see NOAA 2018).
- *Behavioral responses:* One of the primary responses of marine mammals to sound is avoidance behavior. Pile driving sounds played, simulated, and conducted in real time in proximity to harbor porpoises indicate that there may be a behavioral response at distances of 20 km (12.4 mi) or more, though responses are variable (Carstensen et al. 2006, Tougaard et al. 2009). Documented displacement has been observed immediately after pile driving commences (Brandt et al. 2011) and can be long-lasting, with demonstrated avoidance effects of OSW areas for up to a decade or more in harbor porpoises (Teilmann & Carstensen 2012). In another study of harbor porpoises around OSW farms in the north Irish Sea, however, the number of harbor porpoise in the OSW area decreased during construction, but the abundance before and after construction was the same (Vallejo et al. 2017). While we lack evidence of response distances to OSW development sound-generating activities for large whales, evidence from other industries suggest these species respond as well. For example, humpback whales exhibited avoidance behavior from seismic airguns up to 4 km (2.5 mi) away (Dunlop et al. 2016). The response of animals at certain distances depends on a variety of factors, including the species' hearing capabilities, what behavior the animal is engaging in at the time of exposure, the sound level, sound propagation (i.e. how sound is dispersed throughout the environment as it moves away from the source), ambient sound levels, demographic characteristics such as sex, age, and presence of young, and individual-level variation among animals, among other factors (National Research Council (US) Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals 2003, Madsen et al. 2006, Southall et al. 2008, Ellison et al. 2012). Avoidance of OSW project areas can lead to effective habitat loss, which may negatively affect foraging success. Other

behavioral responses may also occur in relation to sound from OSW development, including the changes in diving, feeding, and movement patterns (Gomez et al. 2016).

- *Masking:* Pile driving sound, vessels, or other sounds that raise ambient sound levels in the ocean environment may "mask" or drown out important biological sounds such as whale calls. Sound increases could impact communication (Videsen et al. 2017) or could cause sublethal stress responses (Rolland et al. 2012). Pile driving sound occurs in the frequency range regularly used for communication for large whales (Kraus et al. 2019).

In addition to construction sound during turbine installation, vessels and operational turbines also produce underwater sound. Vessel traffic increases substantially over baseline levels during OSW construction, and to a lesser degree during pre-construction (e.g., survey vessels) and operations (e.g., maintenance vessels). This sound is not different in nature than that produced by other vessel activity in marine systems but will add to existing sound levels from other anthropogenic activities. The sound produced from OSW turbine operations, once construction is completed, is unlikely to reach dangerous levels for marine mammals (Tougaard et al. 2009),but could disrupt behaviors for individuals within close proximity of the pile (Koschinski et al. 2003, Thomsen et al. 2006, Madsen et al. 2006). Based on measurements from relatively small (maximum power 2 megawatt) single turbines, sound produced during operations is of much lower intensity than during construction, though the duration of sound is expected to be almost continuous for the 30-year lifetime of OSW projects (Madsen et al. 2006, Amaral et al. 2020). The amount of operational sound scales with the size of the turbine, and larger turbines (on the order of 10 megawatts) are expected to be louder than small turbines, increasing the distance at which sound is detectable by marine mammals, and therefore may lead to a stronger behavioral response (Stöber & Thomsen 2021). The technological configuration of the gearing in newer turbines technologies could help offset some of these increases sound levels (Stöber & Thomsen 2021).

Vessel Collision Risk

The construction phase will likely have the greatest risk of vessel collision for marine mammals (Dolman & Simmonds 2010). Vessel strike risk has been documented as a primary causal factor for whale mortalities globally (Laist et al. 2001, Neilson et al. 2012, Schoeman et al. 2020), and has been specifically demonstrated for humpback and North Atlantic right whales in recent years (Rockwood et al. 2017, Brown et al. 2019, Garrison et al. 2022). Vessel strikes may occur with large vessels such as tankers and cargo vessels, as well as with smaller vessels (<65 ft in length; Stepanuk et al. 2021, NOAA 2022). Risk of lethality of collisions increases with increasing vessel speeds (Vanderlaan & Taggart 2007, Currie et al. 2017). Federal rulemaking to reduce the risk of vessel strikes of North Atlantic right whales sets a threshold for traveling at speeds of 10 knots (11.5 mph) or less to reduce collision risk and likelihood of serious injury or mortality if interactions occur (Vanderlaan & Taggart 2007, Wiley et al. 2011b, Conn & Silber 2013, NOAA 2014a). The current North Atlantic right whale vessel speed rule applies to vessels 65 feet in length or greater (NOAA 2014a); however, NOAA issued a proposed rule in 2022 that would apply the ten knot speed reduction to vessels that exceed 35 feet in length, with some exceptions (NOAA 2022).

In addition to these non-OSW specific rules, OSW development is subject to more stringent requirements to reduce risk of collisions for marine mammals, including additional situations in which the 10 knot (11.5 miles/hour) vessel speed restrictions apply, the use of observers on vessels transiting above 10 knots, passive acoustic monitoring, reporting of sightings, among other measures (BOEM 2021, 2022, 2023). OSW vessel fleet information is typically provided to the public by individual OSW developers as part of outreach to fishing communities and other mariners (for example, Vineyard Wind: www.vineyardwind.com/offshore-wind-mariner-updates; Ørsted: https://us.orsted.com/renewable-energy-solutions/offshore-wind/mariners, U.S. Wind: https://uswindinc.com/mariners/).

Habitat Alteration

Marine mammals, especially large baleen whales, require substantial consumption of densely schooling prey, such as krill and shrimp, or schooling fish such as herring, sand lance, or anchovy (Kenney et al. 1997, Smith et al. 2015). Prey species may be affected by OSW development, including potential avoidance or attraction of prey to OSW structures (Bailey et al. 2014), as refugia could be developed if ocean life adheres to subsurface structures (e.g., mussels, tunicates) which could support locally dense regions of biomass, similar to artificial reef development. During operation of wind farms, the subsurface cables that transmit energy also emit electromagnetic fields, and some fish species are sensitive to these emissions. It is possible that these changes could impact the distribution and behavior of prey that inhabit sediments or water near the sea floor (Bailey et al. 2014, Nyqvist et al. 2020, Copping et al. 2021). In close proximity to cables, some animals have demonstrated behavioral responses, such as increased foraging and exploratory movements, though there is no evidence to date that these changes negatively affect animals.

It may be infeasible for some fisheries (e.g., large trawls) to operate in OSW areas, which could result in a refuge for fish species that would otherwise be subjected to fishing pressure (Bailey et al. 2014, Kraus et al. 2019). OSW areas may likewise serve as safer areas for marine mammals, if some types of fishing and vessel traffic become less common (Kraus et al. 2019). Seals have been observed preferentially foraging around OSW foundations (Russell et al. 2014). Because marine mammals have high caloric requirements, as warm-blooded highly migratory animals, they may be negatively or positively impacted by the possible alterations to habitat that may occur with OSW operations. However, marine mammals are highly mobile and are typically capable of relocating or seeking alternative sources of food (Wiley et al. 2011a, Smith et al. 2015). Though it is possible these factors could affect marine mammals, any habitat alteration would need to occur at a scale that is relevant to impact marine mammals at both an individual and population level (e.g., by affecting animals' survival rates or reproductive success).

Interactive and cumulative effects

The impacts of the potential effects listed above depend on their cumulative, or overall, risk to large whale populations and the conservation status (e.g., abundance) of those populations. Individuals within a population may experience some level of disturbance, but the OSW industry must obtain permits through detailed federal processes, and there are mitigations in place to avoid lethal and sublethal damage to individuals and prevent any population-level effects (see *Offshore Wind Mitigation Measures* section of this document). When assessing the potential effects of OSW development on marine mammals, it is important to also consider potential compounding or interactive effects, particularly across regions and industries. For example, fishing exclusion zones have led to substantial increases in fishing pressures at the boundary of the protected region, which can influence the distribution and accumulation of fishing gear (Nillos Kleiven et al. 2019). If OSW development leads to changes in fishing patterns, this has the potential to also change the risk of whale entanglement with fishing gear. Though the understanding of the effects of OSW development on large whales is still being studied, scientists have a good understanding of the general effects of sound, vessels, and prey shifts, and other effects on marine mammals, all of which are being considered in OSW development and mitigation planning.

For More Information

Detailed website on underwater sound, including information on how animals use sound and on sound effects to animals: https://dosits.org/

NOAA Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): https://www.fisheries.noaa.gov/s3/2023-05/TECHMEMOGuidance508.pdf

Transcript of NOAA Fisheries Media Teleconference on East Coast Whale Strandings, January 2023: https://www.noaa.gov/sites/default/files/2023-01/Transcript-011823-NOAA-Fisheries-Media-Teleconference-East-Coast-whale-strandings-508.pdf

Research briefs from the Pacific Northwest National Laboratory and National Renewable Energy Laboratory on OSW and vessel collisions, underwater sound, and habitat change: https://tethys.pnnl.gov/summaries/seer-educational-research-briefs

Regulatory Processes

What federal and international environmental laws protect whales?

- The Marine Mammal Protection Act, Endangered Species Act, and National Environmental Policy Act protect marine mammals in United States waters. The International Whaling Commission and the Convention on International Trade in Endangered Species of Wild Fauna and Flora also regulate human activities around marine mammals and endangered species.
- During the offshore wind development process, the Bureau of Ocean Energy Management oversees multi-year, multi-step regulatory processes mandated under the above federal regulations.
- Some number of "incidental takes" of marine mammals may be permitted during the offshore wind development process; take means that there is a disturbance of a marine mammal, however minor in scale. Offshore wind companies are not issued permits for take in which an animal is killed or injured beyond the point of recovery.

Broad answer

The **Marine Mammal Protect Act** (MMPA) established a national policy to prevent at-risk marine mammal populations from "diminishing to the point where they are no longer a significant functioning element in their ecosystem", or if they "fall below an optimum sustainable population size". The MMPA charges the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA NMFS, also known as NOAA Fisheries) with the responsibility to protect whales, dolphins, porpoises, seals, and sea lions. The MMPA also established the Marine Mammal Commission (MMC), a separate federal agency that provides independent oversight of marine mammal-related policies and programs carried out by other federal agencies.

The **Endangered Species Act** (ESA) establishes national regulations for the prevention of harm to endangered species or species likely to become endangered, as well as their habitats. Section 7 of the ESA requires other federal agencies to consult with NMFS if they are proposing an action that may impact ESA-listed marine mammal species or habitats.

The **National Environmental Policy Act** (NEPA) requires federal agencies to consider and assess the environmental impacts of proposed actions. Activities including offshore wind development often require Environmental Impact Statements (EIS) or Environmental Assessments (EAs) to determine the impact on marine mammals.

The International Whaling Commission (IWC) is the international entity created to conserve and manage whales and whaling worldwide. The IWC's work includes coordinating and funding research and conservation efforts directed towards whales, dolphins, and porpoises; analyzing data to estimate population abundance and undertaking technical review of existing abundance estimates; investigating stock structure; maintaining scientific databases; and setting quotas for indigenous subsistence whaling.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates international trade of endangered species and issues trade permits based on certain criteria, including the determination that an export of a specific species will not threaten its survival.

During the OSW development process, the Bureau of Ocean Energy Management (BOEM) oversees multi-year, multi-step regulatory processes, mandated under NEPA, the MMPA, and the ESA. These processes include consultation with other agencies, including NMFS, the assessment of potential effects to marine mammals, and the minimization and/or mitigation of impacts. NMFS may allow some number of "incidental takes" of marine mammals during the offshore wind development process; take means that there is a disturbance of a marine mammal, however minor in scale. NMFS does not issue offshore wind companies permits for take in which an animal is killed or injured beyond the point of recovery. They will allow some level of "incidental harassment," however, in which there is the potential to temporarily injure or disturb a marine mammal.

Detailed answer

There are three federal laws in the United States that protect whales, including the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and National Environmental Policy Act (NEPA). During the OSW development process, a federal agency, the Bureau of Ocean Energy Management (BOEM), oversees multi-year, multi-step regulatory processes that include consultation with other agencies, including NMFS. These regulatory processes require an assessment of potential effects of OSW to marine mammals, as well as minimization or mitigation of impacts. There are also several international entities that manage marine mammals, including the International Whaling Commission and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

NEPA

The National Environmental Policy Act (NEPA), enacted in 1970, requires federal agencies to consider environmental impacts of their proposed actions. NEPA is intended to be "a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation" (42 U.S.C. 4321(a.). Though NEPA does not provide explicit protection for marine mammals, it does establish a framework that ensures federal agencies take environmental considerations into account when making decisions that may impact certain species and their environment.

The cornerstones of the NEPA process are Categorical Exclusions, Environmental Assessments (EAs) and Environmental Impact Statements (EISs). Categorical exclusions are granted to certain types of actions that a federal agency has previously determined do not normally have a significant effect on the human environment. EAs are not as comprehensive as EISs. An agency may prepare an Environmental Assessment (EA) if there is uncertainty about whether the proposed action will have a significant environmental impact and may prepare an EIS only if it is deemed necessary (Vann 2023). If proposed agency actions are expected to significantly affect the environment, the preparation of an EIS is required. An EIS contains a detailed analysis of the project and/or action that is proposed as well as any alternatives. Once an EA or EIS is drafted, there is a period during which the public may comment on the agencies' findings. All offshore wind energy development projects to date have included the preparation of EISs.

The Council of Environmental Quality, established under Section 2, ensures federal agencies meet their obligations under NEPA by 1) overseeing implementation of the environmental impact assessment process, and 2) issuing regulations and other guidance to federal agencies regarding NEPA compliance.

Data and information gathered through the NEPA process can help inform regulatory decisions that can lead to mitigation of impacts to marine mammals. Categories of mitigation measures under NEPA include:

- *Avoiding* the impact altogether by not taking a certain action or parts of an action.

- *Minimizing* impacts by limiting the degree or magnitude of the action or adjusting its implementation.
- *Rectifying* the impact by repairing, rehabilitating, or restoring the affected environment.
- *Reducing* or eliminating the impact over time; and
- *Compensating* for the impact by replacing or providing substitute resources or environments.

MMPA

The U.S. Marine Mammal Protection Act (MMPA) was passed in 1972 as a response to declining marine mammal populations that were in danger of extinction due to human activities. The MMPA established a national policy to prevent at-risk marine mammal populations from "diminishing so they are no longer a significant functioning element in their ecosystem, or so they fall below an optimum sustainable population size" (16 U.S.C. 1361). The MMPA was the first piece of U.S. legislation that focused on an ecosystem management approach. It charged three federal entities with its implementation:

- NOAA Fisheries – Responsible for protection of whales, dolphins, porpoises, seals, and sea lions.
- U.S. Fish and Wildlife Service (USFWS) – Responsible for protection of walrus, manatees, sea otters, and polar bears; and
- The Marine Mammal Commission – An independent, science-based federal agency that provides oversight of the marine mammal-related policies and programs of other federal agencies.

The MMPA requires annual assessments of stocks (i.e., stock assessment reports) that include, but are not limited to, estimates of population size, potential biological removal (PBR) level, and the number of anthropogenic mortalities or serious injuries (M/SI) imparted on stocks by various sources (e.g., commercial fisheries). Guidelines exist for determining human causes of mortality and for defining and determining mortality vs. serious injury to help standardize reporting.[9] The calculation of M/SI is then compared to the value of PBR. If M/SI is lower than PBR, the anthropogenic influence on the stock is judged to not be occurring at a level that warrants federal action. If M/SI is greater than PBR, there are anthropogenic causes of death that are occurring at a level that could impact the stock success, and it is designated as a strategic stock.

If M/SI exceeds PBR due to impacts from fisheries (e.g., bycatch, entanglement in gear), the MMPA requires that a "take reduction team" is formed to recover and prevent future depletion of marine mammal stocks due to fisheries interactions. Within six months of implementation, the goal is to reduce fisheries-induced M/SI to less than the PBR level. In the long term, the goal is to approach a rate of zero fisheries-induced mortality. Teams consist of members of the fishing industry and fishery management councils, state and federal agencies, the scientific community, and conservation organizations.

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[9] https://www.fisheries.noaa.gov/resource/publication-database/marine-mammal-mortality-and-serious-injury-reports and https://media.fisheries.noaa.gov/dam-migration/02-238-01.pdf

Important Definitions Under the Marine Mammal Protection Act (MMPA)

The following definitions under the MMPA are important for understanding how, and when action or intervention is necessary for the protection of marine mammals.

Stock – A group of marine mammals of the same species or subspecies that occupy similar spatial regions and interbreed when mature (e.g., the humpback whales that inhabit the waters off the U.S. east coast and west coast belong to different stocks).

Optimum sustainable population – For any given stock, this is the optimal number of animals to maintain the maximum productivity of the population, where productivity is calculated based on the habitat's quality and carrying capacity (i.e., the maximum number of animals the habitat can support indefinitely without causing permanent damage to the habitat).

Potential biological removal (PBR) - The maximum number of animals that can be removed from a stock due to human causes while still maintaining an optimal sustainable population. PBR is reported as a single number for each stock. It is calculated based on stock size, population growth rate, and a recovery factor that accounts for uncertainty in measurements and decisions based on expert discretion (e.g., recovery is impacted if mortality is differentially impacting female vs. male members of a stock).

Strategic stock – A stock becomes strategic when the level of direct human-caused mortality is greater than PBR (e.g., more animals are removed due to human causes than is sustainable). A stock may also be determined as strategic if it is expected to be listed as "threatened" under the Endangered Species Act or is currently listed as "threatened" or "endangered" (see Endangered Species Act section for more information), or is determined to be "depleted" under the MMPA.

Take – "To harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. 1362). Take can be lethal or nonlethal, and can be intentional (e.g., whaling) or incidental (e.g., unintentionally occurring as a result of some other activity, such as energy development).

Harassment – "Any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal (Level A) or disturb a marine mammal by causing disruption of behavioral patterns (Level B)" (16 U.S.C. 1361-1407).

Negligible – Impacts are not expected to, and are not reasonably likely to, negatively impact the survival and reproductive success of a species or stock.

The abundance estimates published in marine mammal stock assessment reports may be used to determine the number of non-lethal human interactions that a particular activity or project may be permitted to "take". Take means that there is an intended or unintended disturbance of a marine mammal, however minor in scale; it does not necessarily mean that an animal is killed or injured beyond the point of recovery. Importantly, the concept of take is meant to limit harmful effects of human interactions with marine mammals. The MMPA creates a framework for the general prohibition of "take" of marine mammals; however, there are allowances for exemptions via take permits in certain situations (i.e., hunting for indigenous subsistence; harassment from energy infrastructure; intentional and incidental harassment for scientific research and other situations).

Incidental take permits are one of the categories of permits under the MMPA. Incidental takes are defined as unintended (but not unexpected) takes,[10] and may be authorized upon request. This is the category of permits for which OSW developers submit applications to allow a small number of marine mammals to be harassed for select activities in specific places. The authorization of incidental take may be granted if, after public comment, it is found that:

[10] https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act#:~:text=Incidental%20take%20is%20an%20unintentional,certain%20exceptions%2C%20under%20the%20MMPA

- Impacts are small in number;
- Impacts are negligible (to species or stocks);
- Impacts will not cause disruption to the availability of select marine mammals for indigenous subsistence purposes (and/or mitigation measures are proposed to increase the presence of marine mammals for subsistence purposes to offset these effects); and
- NOAA prescribes the permissible method of take, mitigation measures, and requirements for monitoring and reporting.

Take under the MMPA is authorized either through a Letter of Authorization (LOA) or an Incidental Harassment Authorization (IHA). An LOA authorizes Level A or Level B harassment that is planned to occur for multiple years, while an IHA authorizes Level A or B harassment for activities planned for a year or less. (16 U.S.C- 1373). The MMPA was amended in 1992 and 1994. One of the amendments introduced the Marine Mammal Health and Stranding Response Program. This program permits emergency responses to dead or distressed marine mammals, monitoring of health and health trends, and investigation of Unusual Mortality Events (UMEs). In addition, these amendments further delineated the different levels of human impacts to marine mammals (the introduction of Level A and Level B harassment categories; see above), introduced exemptions for harassment for certain human activity including indigenous subsistence hunting and scientific research, and introduced the requirement for federal agencies to prepare reports on the status of each marine mammal stock in U.S. waters (Stock Assessment Reports), among other changes. The issuance of incidental take authorizations under the MMPA, when that take is for endangered species, is a federal action that requires ESA Section 7 consultation, as described below.

ESA

Passed one year after the MMPA in 1973, the United States Endangered Species Act (ESA) protects endangered species and those identified as *likely to become* endangered in the future.[11] The ESA was created with the intention of protecting endangered species as well as the ecosystems they depend on. Species are either listed as endangered (in danger of extinction throughout all or a significant portion of its range) or threatened (likely to become endangered within the foreseeable future; 16 U.S.C. § 1531).

Once a species is listed under the ESA, that species receives legal protection, and it becomes illegal to take individuals (where take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct"). As with the MMPA, the ESA defines incidental take as unintentional, but not unexpected, take. Federal agencies are required to consult either USFWS or NMFS if their proposed activities may affect an ESA listed species, including whales. NMFS is the executing agency that aids in the determination of whether certain actions will threaten a specific whale species or habitat. Under Section 7(a)(1), an agency proposing to undertake an action that may impact whales that are listed as threatened or endangered must consult with NMFS to determine whether a listed species is or will be present in the proposed project area.

Additionally, the USFWS and NMFS, acting through the ESA, can determine and designate critical habitat areas for listed species, including marine mammals. Critical habitat has a very specific definition under the

[11] The International Union for Conservation of Nature (IUCN) also maintains a global “Red List of Threatened Species” (www.iucnredlist.org) that categorizes the conservation status of species and population stocks. This is where terms such as “critically endangered” come from. IUCN definitions of these terms do not necessarily match the definitions in the ESA. Likewise, IUCN assessments of the status of individual species may vary from ESA listing status in the U.S.

ESA and may only be formally designated to support the recovery of a listed species following extensive analysis and public comment. Once critical habitat is designated, other federal agencies must consult with either the USFWS or NMFS before completing any actions in that area to ensure no harm is done to the critical habitat.

Offshore wind projects are typically required under the ESA to go through a consultation process between BOEM and NMFS (and the USFWS, as applicable), which must include:

- Information on the proposed action.
- Information about the ecological entities (listed species, critical habitat, etc.).
- An assessment method that integrates this information to produce and support a conclusion; and
- Written record of the interactions, deliberations, or analysis that occurred during the consultation process, the information that was (or was not) considered, and any resolution of disagreement (BOEM, 2018).

The ESA, NEPA, and the MMPA interact during the offshore wind energy development process such that there are multiple periods for inter-agency consultation and coordination to minimize and mitigate effects of the development actions on whales (Figure 4).

International Regulations

There are several international regulations that relate to marine mammals, though these do not always directly inform how marine mammal populations are managed in waters of the United States. The International Whaling Commission (IWC), established in 1946 under the International Convention for the Regulation of Whaling, meets regularly to review scientific, management, and conservation issues that are relevant to whales. The Commission may 1) encourage, recommend, or if necessary, organize studies and investigations relating to whales and whaling; 2) collect and analyze statistical information concerning the current condition and trend of the whale stocks and the effects of whaling activities thereon; and 3) study, appraise, and disseminate information concerning methods of maintaining and increasing whale stocks (e.g., whale populations; 62 Stat. 1716; 161 UNTS 72). A particularly significant action taken by the IWC was the implementation of a moratorium on commercial whaling. Issued in 1986, the moratorium aimed to allow for the recovery of whale populations decimated from commercial whaling throughout the 20th century. All but a few countries in the world (i.e. Norway, Iceland, and Japan) are bound by and comply with this moratorium.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments drafted in 1973. CITES aims to ensure that any international trade of listed flora and fauna does not threaten the survival of the species. A trade export permit will only be granted when certain conditions have been met. NMFS is responsible for the majority of marine species that are listed under CITES. Species covered by CITES are listed in different appendices according to their conservation status. Beaked whales and baleen whales are both listed in Appendix I, which includes species threatened with extinction and provides the greatest level of protection, including a prohibition on commercial trade.

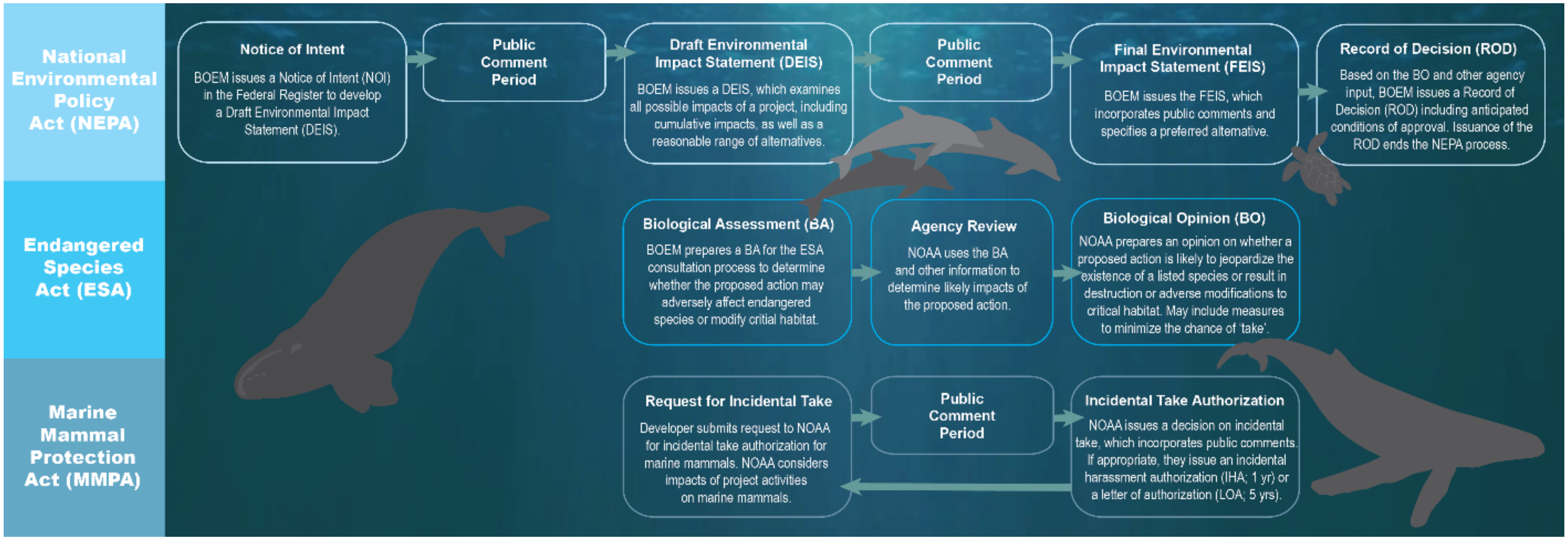


Figure 4. Key U.S. environmental laws protecting whales, and the major steps involved in implementing regulatory assessments and mitigation measures for OSW under each law. The steps described in this graphic focus on the steps in the permitting process following site assessment as well as those during construction of offshore wind developments. The MMPA process will occur multiple times as projects are developed (to include different activities and time periods. Source: Biodiversity Research Institute

For more information

- NOAA Fisheries role under the MMPA: https://www.fisheries.noaa.gov/topic/marine-mammal-protection
- Detailed website on Incidental Take Authorizations under the MMPA: https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act
- ESA terminology: https://www.fisheries.noaa.gov/laws-and-policies/glossary-endangered-species-act
- Factsheet on BOEM's role in the OSW regulatory process: https://www.boem.gov/sites/default/files/documents/about-boem/Wind-Energy-Comm-Leasing-Process-FS-01242017Text-052121Branding.pdf#:~:text=The%20Process,for%20authorizing%20wind%20energy%20leasesThe International Whaling Convention: https://iwc.int/en/
- International Whaling Commission: https://iwc.int/en/
- CITES: https://www.fisheries.noaa.gov/national/international-affairs/convention-international-trade-endangered-species-wild-fauna-and

Offshore Wind Mitigation Measures

What mitigation measures are available to avoid or minimize offshore wind effects on marine mammals?

- There are a range of mitigation approaches that are used by the offshore wind industry and/or other industries in various regions to help avoid and minimize potential effects to marine mammals from sound and vessel collisions.
- Mitigations generally fall into three categories: approaches to reduce the likelihood of marine mammal presence in an area when sound-generating activities occur, reduce the sound that is emitted into the environment, or mitigate risk of vessel strikes.

Broad Answer

Two of the main ways that marine mammals may be affected by offshore wind development is via 1) the generation of underwater sound, and 2) vessel interactions. The main sources of offshore wind-related sounds are generated primarily by geological and geophysical surveys (during site assessment of wind energy areas) and installation of wind turbine foundations (during construction). All vessels operating on the water also pose a potential risk of vessel collisions. There are various mitigation approaches available, some of which are used by the offshore wind industry and/or other industries in various regions to help avoid and minimize these potential effects (Table 1). The effectiveness of mitigation measures depends on many factors including species, specifications/implementation, and compliance. The mitigation plan for each offshore wind project is informed by the species within the area, the geographic and environmental features of the area (such as seabed sediment type, which can influence options for turbine foundations), and the cost of the mitigation measure (Schoeman et al. 2020) and is defined by federal agencies (Bureau of Ocean Energy Management (BOEM), NOAA Fisheries), with additional approval by the International Maritime Organization required for vessel-related mitigation. Increasing our environmental, biological, and technical knowledge can lead to better decision-making and implementation of various mitigation techniques.

Table 1. Mitigation options to reduce potential effects to marine mammals from offshore wind development. Defined based on category (e.g., reducing sound impacts or vessel impacts), mitigation type (mitigation), location where mitigation has been implemented (Loc.), taxonomic focus (focus) and details of the mitigation approach.

Category	Mitigation	Loc.	Focus	Details
Reducing sound impacts	Temporal and spatial restrictions	U.S.	Cetaceans	Reducing or restricting activities that could cause impacts during locations or periods of the year with high presence of certain marine mammal species (ex. during foraging or migration, feeding or social behavior, etc.), or during periods when mitigation monitoring for marine mammals may be difficult to do effectively (e.g., during periods of darkness or poor visibility)
Reducing sound impacts	Mitigation monitoring	U.S.; Europe	All	Monitoring established zones around sound-generating activities and delaying or stopping activities if marine mammals are present. Monitoring can occur visually via protected species observers (PSOs), acoustically via passive acoustic monitoring (PAM), and/or using advanced technology such as infrared imagery and possibly RADAR. Sound propagation modeling is used to inform size of clearance zones and understand potential impacts.
Reducing Sound Impacts	Ramp up/Soft-start	U.S.; Europe	All	Methods that can be used to provide marine mammals the opportunity to move away from the area prior to sound generating activities include ramp-up/soft-start (where there is a gradual increase of sound intensity prior to full operations).
Reducing Sound Impacts	Acoustic deterrents[1]	Europe	All	Acoustic deterrents emit a particular sound to encourage individuals to move away from the area where other sound-generating activities may occur[1].
Reducing sound impacts	Alternatives to impact pile driving	Europe	All	There are alternative turbine installation methods that may be used instead of traditional impact pile driving with a hammer, including vibratory pile driving that uses movement and vibration or blue hammer technology which uses the weight of water. However, many factors influence the feasibility, practicability and efficacy of these alternatives.
Reducing sound impacts	Alternative foundation types	Europe	All	While most turbines to date have been installed using monopiles, other options such as gravity-based foundations (in which much wider foundations are placed on the seabed), suction buckets, and floating foundations are quieter to install. However, many factors influence the feasibility and practicability of these alternatives.
Reducing Sound Impacts	Sound abatement systems	Europe ; U.S.	All	To reduce the amount of sound emitted into the marine environment during pile driving of turbine foundations, there are multiple technologies available including bubble curtains, casings, and resonators that absorb or block some of the sound emanating from the source.
Reducing Vessel Impacts	Reducing vessel activities	Global	Large whales	Reducing the likelihood of interactions between vessels and marine mammals can be achieved by identifying areas of high collision risk and rerouting vessel traffic or implementing vessel exclusion.
Reducing Vessel Impacts	Vessel Speed Restrictions	Global	Large whales	Limiting the speed at which vessels can travel can provide animals and vessel crew with more time to detect and avoid each other and can reduce the severity of injury if a collision occurs.
Reducing Vessel Impacts	Animal Observation on Vessels	U.S.	Large whales	Collisions with marine mammals may be avoided if individuals are detected and appropriate avoidance measures are implemented by the vessel operator. Trained observers or other technologies for mitigation monitoring (e.g., PAM; above) can be used. Reporting observations and sharing observation data with other vessels aids in situational awareness and implementation of avoidance measures by other vessels.

[1]Acoustic deterrents are not currently permitted for use in the United States under the Marine Mammal Protection Act.

Detailed Answer

One of the main ways that marine mammals may be affected by offshore wind (OSW) development is via the generation of underwater sound. The main sources of offshore wind-related sounds are generated primarily by geological and geophysical surveys (during site assessment of wind energy development areas) and installation of wind turbine foundations (during construction). Approaches to mitigate, or minimize the impact of, this sound currently fall into two main categories:

1) Reducing the likelihood of marine mammal presence in the area during the activity period, generally using: a) time of year and geographic restrictions to conduct sound-generating activities when marine mammals are less abundant in the area; b) monitoring areas around the sound-generating activity and halting or minimizing efforts when animals are present; c) limiting sound-generating activities during periods when monitoring for marine mammal presence is difficult or ineffective; and d) using ramp-up/soft-start that will give animals the opportunity to move away from the area before sound levels reach full intensity.
2) Reducing the amount of sound emitted into the environment, which is achieved via two fundamentally different sound reduction approaches: a) reducing the amount of sound generated, and b) reducing the radiation of sound by placing sound barriers at some distance from the source (Koschinski & Lüdemann 2020).

Marine vessels also pose a potential risk of vessel collisions with some types of marine mammals, especially large whales. This risk is well-known in relation to the shipping industry; collisions are much more likely to occur and much more likely to kill whales when the ships are large and moving at high speeds (Vanderlaan & Taggart 2007, Currie et al. 2017). While not a risk specific to offshore wind energy development, operating vessels on the water introduces collision risk for marine mammals. The primary mitigation approaches to reduce the risk of vessel strike include: 1) reducing vessel activity in locations and/or time periods of higher risk; 2) vessel speed restrictions, which can be targeted by location, time period, vessel size, or other factors; and 3) using dedicated observation methods to assess whether animals are present near a vessel, and slowing vessel speed when a whale is detected.

The above mitigation measures are discussed in further detail below. Multiple mitigation measures are typically applied during offshore wind energy development. The effectiveness of mitigation measures depends on many factors including species, mitigation design, wind farm design, and the level of compliance. Selection of mitigation measures that are most likely to be effective for a given offshore wind project or situation requires a multi-species approach and active interactions between relevant stakeholders so that individual priorities can be identified and addressed (Redfern et al. 2019). The mitigation plan for each offshore wind project is informed by the species expected to be present, project-specific information such as planned foundation type, the geographic and environmental features of the area (which can influence the type of foundations that are feasible, among other factors), and the costs of the mitigation measure (Schoeman et al. 2020).

Reducing Marine Mammal Exposure to Sound-generating Activities

Temporal and Spatial Restrictions

In some locations, marine mammal research efforts have identified areas of ecological importance based on the presence of endangered species, high marine mammal and/or marine biodiversity, or predictable aggregations of marine mammals exhibiting feeding, breeding, mating, or migrating behaviors (Bailey & Thompson 2009, Sveegaard et al. 2011). Sound-generating activities can be avoided at locations and/or times of the year when aggregations are known to occur (Compton et al. 2008). The extent and duration of these aggregations may change over time, and so it is the responsibility of government agencies and research institutions to continue monitoring to identify effective spatial and temporal resolution of these types of restrictions (Compton et al. 2008). In addition to restricting activities during particular times of the year, restricting activities to certain times of day may also ensure that sound-generating activities are only occurring when adequate monitoring of marine mammal presence can occur (see mitigation monitoring below).

<u>Mitigation Monitoring</u>

Monitoring for the presence of marine mammals within defined zones around sound-generating activities is conducted such that additional action can be taken as needed (Verfuss et al. 2018). The size of the zones varies by geography and likely species, depends on the type of sound-generating activity (e.g., length and timing of activity, sound level and frequency range) and is informed by sound propagation modeling (Faulkner et al. 2018) and NOAA acoustic guidance (NOAA 2018). Monitoring occurs prior to and during activities to ensure the zone remains clear of marine mammals to minimize likelihood of exposure to deleterious levels of sound. Detection of marine mammals within this zone will lead to delays in the start of activities or shut down activities after they have commenced (Joint Nature Conservation Committee 2017). These zones can be monitored in multiple ways:

1. **Visual Monitoring using Protected Species Observers (PSOs)** – Trained marine mammal observers (known as PSOs in the U.S.) act as independent data collectors and scan the sea surface to monitor the presence and behavior of marine mammals within the defined zone of influence for activities such as naval exercises, seismic surveys for offshore oil and gas development, and underwater construction and demolition (Baker et al. 2013). The standard procedure is for each observer to keep watch from a suitable location which allows a clear 360-degree view of the sea surface, beginning no less than 30 min prior to activity commencement. The number of observers used varies between countries and circumstances, including the type of sound-generating activity and the size of the zone being monitored. The range at which observers can detect animals varies by species, viewing altitude, weather conditions, and other factors. Visual detection range should be considered when designing the mitigation monitoring plan. Effective visual detection range should be measured at the start of the activity, and the monitoring protocols should be adjusted, if necessary. An animal must surface within the PSO's visual range in order to be detected; as such, the proportion of time different species spend below the surface influences their detectability. For larger zones, observers can also be deployed from additional vessels or aircraft to facilitate monitoring of a larger area, typically prior to commencement of a sound-generating activity but often during the activity as well. If a marine mammal is detected in the defined zone, it is the responsibility of the PSO to advise the crew what mitigation is necessary (Compton et al. 2008).
2. **Passive Acoustic Monitoring** (PAM)– This approach detects animal vocalizations using underwater microphones (hydrophones). While hydrophones are used in various research and monitoring scenarios, mitigation applications require real- or near real-time detections rather than archiving sound data for later review. This involves a combination of artificial intelligence algorithms to identify possible mammal sounds and biologists who review these data and make decisions about when a mitigation action such as shutdown of pile driving is indicated (Kowarski et al. 2020). PAM systems can be deployed from stationary platforms such as moored buoys or on autonomous

vessels such as ocean gliders (Baumgartner et al. 2020), or can be towed behind crewed or uncrewed platforms. Detection of marine mammals varies greatly with species (for example, the calls of large whales are generally audible at much larger distances than those of dolphins), water depth and salinity, and other factors, but is often in the range of tens of kilometers (Ahonen et al. 2021, Johnson et al. 2022). However, detection of animals via PAM requires those animals to vocalize, and vocalization patterns can vary substantially between species, individuals, and life history stages, among other factors. As such, visual monitoring and PAM are often paired to help maximize the chance of detecting animals if they are present.

3. **Active Acoustic Monitoring** – This involves sending pulses of sound into the water and receiving back acoustic reflections from animals present in the water column. Fish finders often used by fishermen are one type of active acoustics. Sonar target strength is a key determinant of the likelihood of detection, which correlates with body size of the target (Verfuss et al. 2018). The detection range of these systems is dependent on multiple factors including frequency, source level, beam shape, and waveform, but generally ranges from 50 m - 2 km, or 164 ft - 1.2 mi (Verfuss et al. 2018). Some active acoustics are within the hearing range of some marine mammals, so the method must be considered with caution and may not be a permittable form of monitoring under the MMPA (Stein & Edson 2016).
4. **Thermal Infrared Technology** – An electro-optical imaging sensor (e.g., thermal camera) can detect temperature differences between the body of a warm-blooded marine mammal (or its blow, when whales come to the surface to breathe) and that of the surrounding environment (Smith et al. 2020). As with all of these technologies, it is more reliable at detecting animals at closer distances, but in tests with humpback whales appears to be reliable at distances of up to several kilometers (Zitterbart et al. 2020).
5. **RADAR** –RADAR (radio detection and ranging) emits radio microwaves into the air and echoes from the animal are picked up by an array of receivers to determine the range and direction of the animal. While not currently widely used in this context, RADAR can detect marine mammals at the surface from the exposed body of the animal, an exhalation, or from disturbance on the sea surface, and therefore is most effective at detecting larger animals in calm conditions (Verfuss et al. 2018). The ability of RADAR systems to discern marine mammals from clutter at the surface improves with increased bandwidth, power transmission (range), and scan rate. Empirical data are lacking on the detection abilities of specialized systems, but there is some evidence that marine RADAR range in optimal sea state conditions is <1 km, or 0.6 mi (with higher likelihood of detection with larger-bodied species; Verfuss et al. 2018).

Visual monitoring has a number of problems besides human error, including that it is not reliable at night, can be compromised during the day due to adverse weather conditions (increased sea state, precipitation), and many marine mammals spend a large portion of their time underwater. Combining visual monitoring with passive acoustics can help overcome some of these issues, as PAM can operate under most conditions (Verfuss et al. 2019). However, marine mammals, and particularly large whales, do not continuously vocalize meaning that PAM also has its detection limitations. Active acoustics, thermal infrared, and radar technologies may also help with monitoring in poor visibility conditions (Verfuss et al. 2018, Smith et al. 2020). Thermal imaging has undergone substantial testing and research and development activities in recent years (e.g., Zitterbart et al. 2020, Smith et al. 2020). The efficacy of active acoustics and radar for monitoring zones is less well known, though the research on different mitigation measures is evolving rapidly.

Ramp up and Deterrents

The gradual increase of sound intensity prior to full operations, known as 'ramp-up' or 'soft-start,' aims to deter animals away from the site to minimize risk of auditory injury, acting as a warning for marine mammals in the vicinity to move away prior to full sound-level activities (Wensveen et al. 2017). The length of time this ramp-up occurs can range from 20-45 minutes (JNCC 2017; Compton et al. 2008). This approach is used for sound-generating activities across industries, including naval sonar exercises, seismic surveys for oil and gas exploration, geophysical surveys, and pile driving during offshore construction, which vary in methods and sound characteristics (Wensveen et al. 2017; also see *Potential effects of OSW development on whales*).

The type and extent of a marine mammal's response to these initial levels of sound will be affected by a variety of factors, including behavior, experience, motivation, and conditions (Bailey et al. 2014). Much of what we know about potential responses comes from studies during seismic surveys for oil and gas development. A study of short-finned pilot whales observed an avoidance response away from the ramp-up of a 2-D seismic survey that began when they were 750 m (0.46 mi) away from the airgun array (Weir 2008). For migrating humpback whales exposed to ramp-up during seismic surveys, most groups moved away from the source, but the use of ramp-up did not increase the strength of response (e.g., whales moved away similarly for ramp up and higher sound levels; Dunlop et al. 2016). While ramp-up is implemented as a 'common sense' approach, few studies have examined the effectiveness specific to offshore wind related activities, and there may be logistical limitations in the use of these techniques for pile driving of turbine foundations into the seabed, as the design of the hammer used for pile driving must be suitable for these methods.

While not currently permitted in the U.S., it may also be possible to deter animals away from sound sources to distances where the risk of sound-related effects is reduced to acceptable levels. Acoustic deterrent devices (ADDs), such as seal scarers or acoustic pingers, were originally developed to keep seals away from aquaculture and fishing gear and have been effective at deterring harbor porpoises from offshore wind-related activities in Europe (Dähne et al. 2017). These emit sound pulses for 15+ minutes prior to sound-generating activities to encourage animals to move away from the site. There are a variety of devices from various brands that have different acoustic characteristics (Sparling et al. 2015, McGarry et al. 2022). There is evidence that harbor porpoise are deterred to a minimum of 7.5 km, or about 4.7 mi (Brandt et al. 2013) and at least some whale species also appear to respond to ADDs (Boisseau et al. 2021). However, the level and duration of response to these types of devices are species-specific, and possibly individual-specific, as shown in a study on minke whales (McGarry et al. 2017), meaning their effectiveness is not guaranteed. These techniques also introduce additional sound into the environment, have the potential to cause impacts to hearing (either TTS or PTS; Todd et al. 2021) and effectively are a type of intentional harassment of marine mammals, and they are not currently permitted for use in the United States under the Marine Mammal Protection Act.

Sound Reduction

Reducing Sound Production

Reduction in sound emissions can be achieved via low sound alternatives to pile driving for turbine foundation installation. Alternatives to traditional impact piling, which involves hitting the pile with a large hammer to drive it into the seabed, include vibratory piling and BLUE piling. Vibratory hammers work by vibrating the pile and causing a temporary reduction in soil resistance, so that the pile can sink into the seabed. Vibratory hammers can also be used to reduce the time needed for impact piling, and thereby reduce the duration of sound (Koschinski & Lüdemann 2013). Vibratory hammers can also be used to reduce the time needed for impact piling, and thereby reduce the duration of sound (Koschinski & Lüdemann 2013). BLUE Piling Technology, though not currently commercially available, uses the impact of a large water mass to slowly drive down piles over time, which takes longer but emits less sound and vibration than other methods and therefore may represent a future alternative (Verfuss et al. 2019). Vibratory hammers can also be used to reduce the time needed for impact piling, and thereby reduce the duration of sound (Koschinski & Lüdemann 2013).

There are also multiple types of foundations that can be installed without pile driving, including gravity-based foundations (in which much wider foundations are placed on the seabed), suction buckets, and floating foundations (Figure 5), all of which produce less sound during installation. However, there are technical and cost considerations that may preclude use of certain foundation types in certain seabed substrates and water depths.

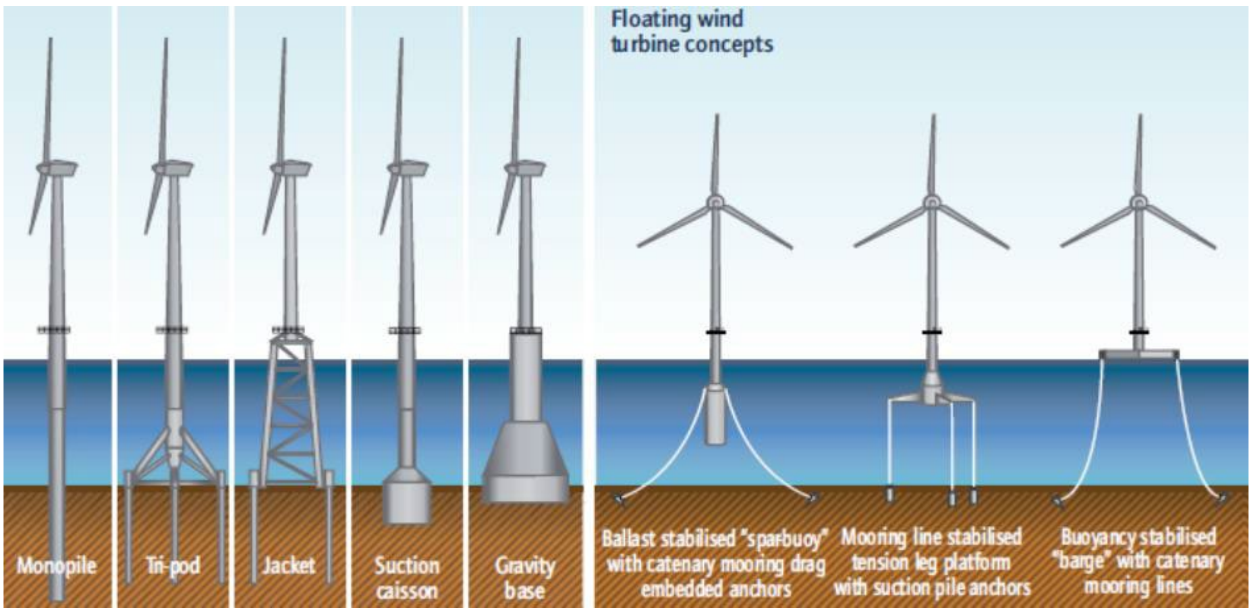


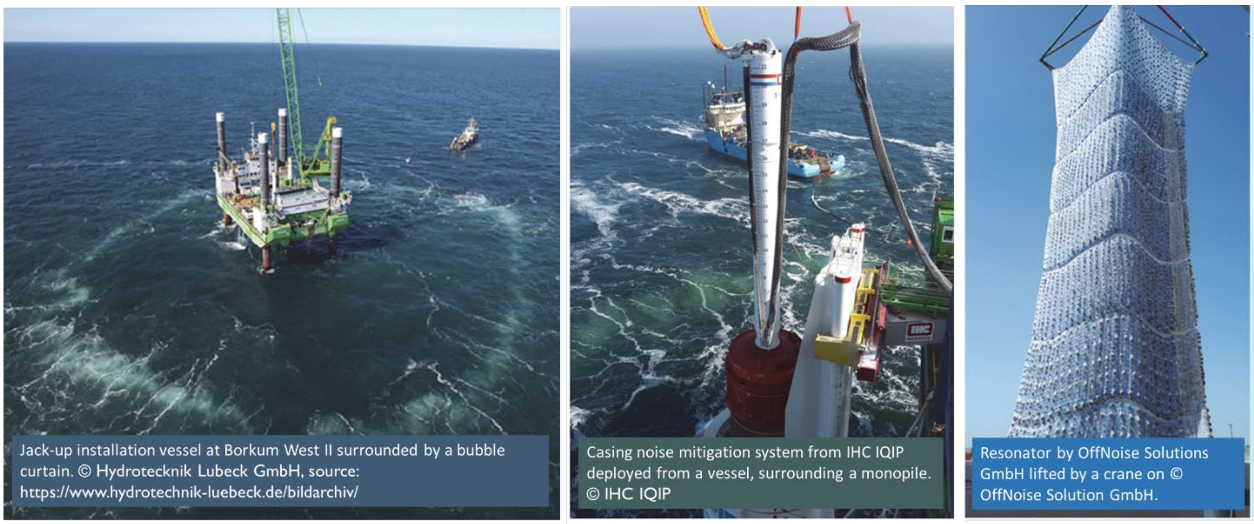
Figure 5. Fixed and floating turbine foundation designs. From Konstantinidis & Botsaris (2016; available via [CC by 3.0](CC by 3.0)).

Reducing Sound Propagation

There are multiple sound-dampening technologies that can be used to reduce the amount of sound energy that is released into the surrounding environment, particularly during turbine foundation installation. These sound abatement systems include bubble curtains, casings, and resonators (Figure 7). Bubble curtains and casings provide a sound barrier around the piling position that prevents sound at certain frequencies from spreading. Bubble curtains consist of a nozzle hose that releases air bubbles in a radius of tens to hundreds of meters, and the bubbles block a portion of the sound being emitted. Casings enclose the pile at close distance with double-walled steel casing or sound-absorbing foam (Verfuss et al. 2019). Resonator systems surround the foundation during pile driving with sound-absorbing or reflective material. Bubble curtains and casings have been used for mitigating sound during offshore wind construction in Europe (Verfuss et al. 2019) and bubble curtains are also being used in the U.S.[12] (casings are currently not commercially available for the size of turbine currently being installed in the U.S.).

[12] https://maritime-executive.com/article/vineyard-wind-tries-bubble-curtain-system-to-cut-pile driving-sound

Implementation of bubble curtains at offshore wind farms during monopile installations has resulted in a 75-95% decrease in the sound-affected area for harbor porpoises (Nehls et al. 2016, Dähne et al. 2017). There are many factors that affect the efficacy of these technologies, however, including configuration, turbine diameter, deployment depth, and the frequencies of sound that are targeted for reduction (e.g., to better protect different marine mammal taxa with varying hearing capabilities), and often combined approached may provide the best sound attenuation (Bellmann et al. 2020). Verfuss et al. (2019) and Bellmann et al. 2020 provide in-depth description of the different technologies that have been used by the offshore wind industry or are promising for future application.



Jack-up installation vessel at Borkum West II surrounded by a bubble curtain. © Hydrotecknik Lubeck GmbH, source: https://www.hydrotechnik-luebeck.de/bildarchiv/

Casing noise mitigation system from IHC IQIP deployed from a vessel, surrounding a monopile. © IHC IQIP

Resonator by OffNoise Solutions GmbH lifted by a crane on © OffNoise Solution GmbH.

Figure 6. Examples of sound abatement systems including a bubble curtain (left), casting (middle), and resonator (right), figures adapted from Verfuss et al. 2019.

Vessel Strike Mitigation

Reducing Vessel Activity

If areas of high collision risk are identified, it is possible that vessel traffic can be re-routed provided that these routes do not compromise safe marine navigation (Schoeman et al. 2020). This approach has been successfully implemented to protect North Atlantic right whales in Boston Harbor and the Bay of Fundy, for example[13] (Vanderlaan et al. 2008, Van Der Hoop et al. 2015). In addition to re-routing, this type of approach may also include the establishment of vessel traffic exclusion zones to reduce the number of vessels in an area. As with temporal and spatial sound restrictions described above, this requires an understanding of the spatiotemporal distributions of marine mammals. Rerouting vessel traffic around areas with known concentrations of whales is an effective mitigation measure (Vanderlaan et al. 2008, Van Der Hoop et al. 2015). While mitigation requirements specific to the offshore wind industry in the U.S. are under the regulatory control of BOEM and NOAA, involvement and approval by the International Maritime Organization[14] would be needed in cases related to changes in vessel routes and exclusion zones.

Vessel Speed Restrictions

Vessel speed restrictions have been implemented in multiple industries and locations to provide animals

[13] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales#vessel-routing

[14] https://www.imo.org/en/OurWork/Safety/Pages/ShipsRouteing.aspx

and vessel crew with more time to detect and avoid each other as well as to reduce the severity of injury (Schoeman et al. 2020). Higher speed and larger vessels pose greater risk as collisions result in more serious injuries due to the higher force of impact (e.g., blunt force trauma) and the probability of deeper and more lethal lacerations from vessel bows and propellers (e.g., sharp force trauma (Wang et al. 2007, Schoeman et al. 2020), though the relationship between speed and severity of injury is species-dependent (Kite-Powell et al. 2007, Vanderlaan & Taggart 2007, Schoeman et al. 2020). However, recent analyses and documented interactions between large whales and vessels suggest that smaller vessels operating at high speeds may cause lethal injury as well (Stepanuk et al. 2021, NOAA 2022). In addition to a higher probability of lethal injury, high vessel speeds result in a decreased probability of detection of marine mammals by vessel operators, which in turn can result in higher probability of collision (Gende et al. 2011). In 2008, the was implemented by NOAA to specifically protect North Atlantic right whales, and states that all vessels 65 feet or longer must travel at 10 nautical miles per hour (knots) or less in certain locations along the U.S. east coast, and at certain times of year, as designated by NOAA; these locations are termed seasonal management areas (SMAs; NOAA 2014). SMAs aim to cover high-risk areas where right whales consistently occur, including migratory routes and calving grounds. In addition to mandatory SMAs, voluntary dynamic management areas (DMAs) are also designated; mariners are encouraged to avoid these areas if possible, or to reduce speeds to 10 knots or less while transiting through these areas.

In 2022, continued vessel collisions with North Atlantic right whales since the 2008 rule, was implemented (Garrison et al. 2022), strikes that have been linked to climate change-driven shifts in right whale distribution (Meyer-Gutbrod et al. 2021) led NOAA Fisheries to announce proposed changes to the North Atlantic right whale vessel speed rule to further reduce the likelihood of vessel collisions (NOAA 2022). These changes, if adopted, will expand the spatial boundaries and timing of seasonal speed restriction areas in the U.S. Atlantic and also expand mandatory speed restrictions of 10 knots or less to include most vessels 35–65 feet in length. Additional information on right whales and vessel strikes, including vessel speed rules, are available on the NOAA Fisheries website.[15] It’s important to note that while the vessel speed rule confers vessel slow down benefits to other large whale species, it is tailored to North Atlantic right whales and so gaps in protection for other east coast whale species remain.

Animal Observation

Collisions with marine mammals may be avoided if individuals are detected and appropriate avoidance measures are implemented by the vessel operator. Vessel crew are generally not trained to detect and identify marine animals and are likely focused on other aspects of the voyage; thus, placing a trained, dedicated observer onboard a vessel (such as a Protected Species Observer or dedicated, well-trained crew member observer) has been suggested to help increase the detection rate of whales along a vessel's route during day-light hours (Schoeman et al. 2020). Some of the technologies described above related to monitoring mitigation zones (e.g., infrared cameras, active sonar) could be used to augment visual observations. Reporting observations in the United States is mandatory for protected species. Reporting aids in management decisions related to vessel speed restrictions (see above) and adds to situational awareness of all vessels in the region to avoid potential interactions with marine mammals.

[15] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales#proposed-modifications-to-right-whale-speed-rule

Glossary of Terms

This glossary defines and provides additional details on terms used in the Whale Communications FAQ document.

Anthropogenic – Anthropogenic effects, processes, objects, or materials are those that are derived from human activities.

Bias – Statistical bias is the difference between an estimate of a parameter (e.g., estimated population size from survey data) and the true underlying value of the parameter (e.g., true population size). Statistical bias can arise during data collection, analysis, or interpretation. For example, if a boat-based survey is unable to collect observational data in a portion of a study area, the resulting abundance estimate could be statistically biased if appropriate analytical methods were not used to account for the unequal survey coverage.

Cetacean – The scientific name for the taxonomic subset of mammals that includes whales, dolphins, and porpoises. See "Marine Mammals" below.

Distribution – A species' distribution refers to its arrangement in 3-dimensional space (e.g., latitude, longitude, and depth) within a particular time frame.

Dynamic Management Areas (DMAs) – A type of "slow zone" defined by NOAA Fisheries to help protect North Atlantic right whales from collisions. Mariners are encouraged to avoid these areas if possible, or to reduce speeds to 10 knots or less while transiting through these areas. NOAA Fisheries establishes DMAs based on visual sightings of three or more right whales within an area of 75 square nautical miles. Recently, NOAA has also identified "slow zones" based on passive acoustic detections of North Atlantic right whales; similar voluntary vessel speed slowdowns are encouraged in these areas, though these zones are not technically designated as DMAs.

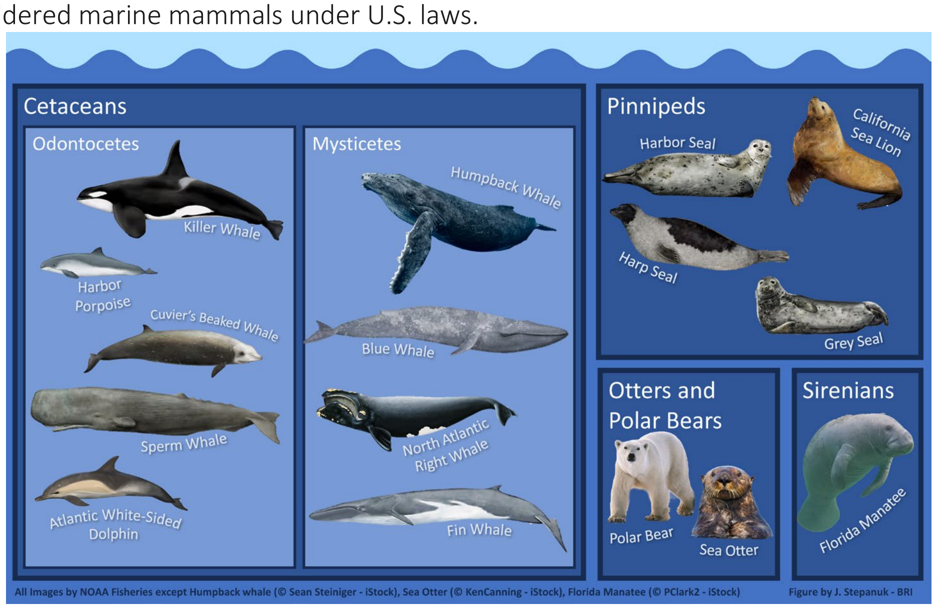
Habitat – A species' habitat is the manifestation of its ecological niche. Habitat comprises the physical, biological, chemical, and acoustical parameters that support the specific needs for a species' survival and reproduction. The values of habitat parameters may be constant or variable across space and time. For example, humpback whales undergo seasonal migrations from foraging grounds in the North Atlantic during spring through fall, to winter breeding grounds in equatorial waters. During these different stages, the properties of their habitat varies, as it is supporting different stages of the life cycle of the species.

Harassment – Type of incidental take under the U.S. Marine Mammal Protection Act (MMPA) that is authorized by the National Marine Fisheries Service either through a Letter of Authorization (LOA) or an Incidental Harassment Authorization (IHA). Harassment authorizations are required for many types of anthropogenic marine activities, including aspects of offshore wind energy development. Also see "take," below.

- **Level A harassment –** Any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild.
- **Level B harassment –** Any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, feeding, or sheltering. Changes in behavior that disrupt biologically significant behaviors or activities for the affected animal are indicative of take by Level B harassment under the MMPA.

Marine mammals – Marine mammals retain all of the characteristics of mammals (they breathe air through lungs, are warm blooded, have hair for at least part of their life, and produce milk to nurse their offspring). However, they are unique from other mammals because they live most or all of their lives in or near the ocean. Marine mammals comprise four taxonomic groups:

- **Cetaceans:** Whales, dolphins, and porpoises. Cetaceans are carnivores who spend their entire lives in aquatic environments. They have streamlined bodies designed for swimming and diving, with appendages designed for aquatic environments. Cetaceans are comprised of two subgroups, odontocetes and mysticetes. Odontocetes are cetaceans with teeth, including all dolphins and porpoise, as well as killer whales, beaked whales, and pilot whales, for example. These species are typically fast-swimming animals who pursue one or a few prey items at a time, such as fish or squid. Mysticetes are cetaceans with no teeth. Mysticetes have vertical plates called baleen (made of keratin, the same material that comprises human hair and fingernails) that hang from the upper gum line of the mouth, used for filter-feeding of small prey. Mysticetes feed by either skimming the sea surface or by gulping huge amounts of prey and water, and then filtering the water out of the mouth. Species in this taxonomic group include the largest whale species, such as blue and fin whales, as well as species such as the bowhead and North Atlantic right whale.
- **Pinnipeds:** Seals, sea lions, and walruses. Pinnipeds are carnivores who have modified flippers to move on both land and in water. Though pinnipeds primarily forage and migrate in the water, they return to land or ice to breed, rest, and molt.
- **Sirenians:** Manatees and dugongs. Sirenians spend their entire life in the water and are herbivores. Though the fossil record suggests that there were once many species of sirenians, only four species exist today.
- **Marine fissipeds:** Polar bears and sea otters. Polar bears and sea otters are also considered marine mammals, though they are more closely related to terrestrial carnivores like weasels. They lack the types of adaptations seen in the other marine mammal taxonomic groups, but portions of their lives are associated and reliant on the marine environment. Therefore, they are considered marine mammals under U.S. laws.



Mitigation – Efforts to avoid, minimize, restore, or offset environmental impacts caused by a human activity. Mitigation of offshore wind energy-related effects to marine mammals could involve a wide range of approaches. Common mitigation methods for whales in relation to offshore wind energy development include vessel speed restrictions, observers on vessels, and noise reduction approaches such as bubble curtains.

Monitoring – Repeated, systematic observations of marine mammals or their habitat and ecosystems. Monitoring can be conducted for several purposes, including as part of scientific research, management, or to inform and enact mitigation measures (see "mitigation," above).

Mysticetes – cetaceans with baleen instead of teeth, including large whale species such as fin, humpback, and blue whales. Also see "Marine Mammals" above.

Necropsy – The examination of an animal after death (essentially an autopsy on an animal), usually to determine the cause of death. A necropsy can involve observation, dissection, or sample processing. Resulting data may be used as a basis for interpreting and documenting cause of death. For marine mammals, necropsies provide opportunities to learn about the physiology, biology, and threats (e.g., disease, toxins) to individuals and populations, since many marine mammal species inhabit regions far from human activity and may be rarely seen when alive and healthy.

Odontocetes – Cetaceans with teeth, including all dolphins and porpoise, as well as killer whales, beaked whales, and pilot whales. Also see "Marine Mammals" above.

Passive Acoustic Monitoring (PAM) – Study or monitoring method in which equipment is deployed in the ocean to record underwater sounds. The device is considered "passive" because it does not produce any sounds itself, but rather listens and records sounds. These sounds can be classified by source (e.g., are sounds generated by animals, waves, weather, vessels, etc.), and in the case of animal sounds, identified to species. PAM is an important method for studying cetaceans because it can be deployed for long periods of time (e.g., years), and can be used at night, during poor weather, underwater, and in other cases where direct visual observation is not possible or ineffective.

Pile driving – The process of installing structural columns into the seabed via a large hammer located on a barge. This process is used across a range of industries including for the installation of some types of offshore wind turbine foundations. These monopile foundations (in which a single steel tube comprises a large part of the turbine foundation) are the most common type of offshore wind turbine foundation globally, since they are relatively inexpensive and easy to install in shallow waters. However, there are multiple turbine foundation types that do not involve monopiles (e.g., jacket foundations, floating foundations), and several newer pile-driving technologies that do not involve the use of a hammer (to reduce noise generation during turbine construction).

Pinniped – Seals, sea lions, and walruses. Also see "Marine Mammals" above.

Population – A marine mammal "population stock" or "stock" is the fundamental unit of conservation under the U.S. Marine Mammal Protection Act (MMPA). The MMPA uses the terms "population stock" and "stock" interchangeably to mean "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature." The term "population" is also sometimes used to mean a smaller geographic subset of a species that is being separately considered for research, management, or mitigation purposes.

Seasonal Management Areas (SMAs) – A type of "slow zone" defined by NOAA Fisheries to reduce vessel collision risk to endangered North Atlantic right whales (per the Vessel Speed Restriction Rule of 2008; 50

CFR 224.105). SMAs occur in defined locations at specific times of year based on expected species presence or behavior. During these periods, vessels of 65 feet or greater in length are required to travel at a speed of 10 knots or less in these areas.

Slow zone – Areas defined by NOAA fisheries to help protect North Atlantic right whales from collisions via avoidance and vessel speed restrictions. Types of slow zones include dynamic management areas (see definition), seasonal management areas (see definition), and slow zones similar to dynamic management areas but defined based on passive acoustic detections of North Atlantic right whales (as opposed to visual sightings).

Sonar – The use of sound propagation to understand the positioning and characteristics of underwater objects. Passive sonar involves only "listening", where underwater sounds are heard and characterized (for example, some listening devices in military applications measure and characterize the frequency and vibrations of nearby vessels to determine nationality). For marine mammals, passive recordings of sounds produced by animals can be identified to species in many instances (see "Passive Acoustic Monitoring"). Active sonar involves sound that is purposefully emitted from a source, which is then reflected or returned by measured objects. Active sonar can be used to obtain a variety of information on objects underwater, including distance from the sound source, density of the object (which can assist with object identification), and object speed. For example, echosounding emits a sound beam from a vessel directly downward to the seafloor, and the depth of the sea floor (e.g., water depth) can be estimated based on the amount of time it takes for the sound to return to the surface. Fishfinders are used to characterize the location (e.g., depth) of schooling fish, which work because the swim bladders of fish are of different density than water, which reflects sound in a unique way. For scientific purposes, more advanced versions of this technology rely on multiple frequencies of emitted sound and can be used to identify species or taxa, school size, and density of schooling animals including fish, shrimp, and zooplankton. Passive sonar does not contribute noise to the marine environment, as it just requires listening devices. Active sonar does add sound to the marine environment, which can vary in volume, pitch (i.e., acoustic frequency), and regularity (e.g., regular pulses vs. random noise introduction), depending on the intended application of the sonar technique.

Sound – Mechanical vibrations transmitted through an elastic medium (e.g., air, water). The ability of an animal to detect a sound depends on characteristics of the sound (e.g., frequency, intensity, duration), the proximity of the animal to the sound, and their hearing capabilities.

Stock – See "Population".

Stranding – Marine mammals are considered stranded when found dead, either on land or floating in the water, or alive on land but unable to return to the water or in need of medical attention. Strandings can be caused by many factors, including disease, injury (such as from vessel strikes or entanglement with fishing gear), or other factors.

Take – As defined in the U.S. Marine Mammal Protection Act, to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. Take can be lethal or nonlethal, and can be intentional (e.g., whaling) or incidental (e.g., unintentionally occurring as a result of some other activity, such as energy development, fishing, military exercises, etc.).

Unusual Mortality Event (UME) – Defined under the Marine Mammal Protection Act as a stranding event that is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response. A working group of scientific experts use specific criteria to determine when a UME is occurring or has ended. Common causes of UMEs include infectious diseases, biotoxins, and human interactions.

Vessel speed restrictions – NOAA has implemented several management approaches to help protect endangered North Atlantic right whales from vessel collisions. These include designating locations where vessel speeds are restricted to reduce the risk of lethal collisions. Some restrictions on vessel speed are required (e.g., mandatory) in the same geographic locations and time periods every year (see "Seasonal Management Areas (SMAs)," above). Others are suggested (e.g., voluntary) and are designated based on known presence of animals in an area (see "Dynamic Management Areas (DMAs)," above). The 2008 vessel speed restriction rule requires vessels >65 feet to reduce speeds to 10 knots in SMAs and suggests voluntary speed reduction in DMAs. In 2022, NOAA proposed an amendment to the current vessel speed restriction rule, which would 1) modify current SMAs, 2) apply speed restrictions to most vessels 35 feet or longer, and 3) create a new framework for implementing mandatory speed restrictions outside of active SMAs.

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