Frequently Asked Questions: Offshore Wind and Whales

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Version 3.0

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 energy. 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 encompass 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: brief 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.

Version 2.1 represents a minor update from Version 2, published in June 2024, whereby the wording of *Why are baleen whales dying in the Northwest Atlantic and is this a new phenomenon?* was updated to more accurately reflect the causes of recent increases in humpback whale strandings. For the full FAQ version history visit https://www.nyetwg.com/communications-committee

Contents

Anthropogenic Impacts on Whales

What factors influence vessel strike risk for large whales?

- Vessel strikes are a major source of mortality and injury for large whales around the world.
- The chance of a vessel strike occurring depends on the co-occurrence or overlap of whales and vessels in space and time, with risk increasing as the densities of both ships and whales increase.
- Both the likelihood and severity of a vessel strike vary based on vessel characteristics (e.g., size, speed) and the species and behavior of the whale involved.
- Vessel strike avoidance depends on the ability for a whale to be detected, and the time for a vessel to enact a maneuver to avoid a whale. Thus, current efforts to reduce vessel strike risk in the U.S. depend on both relocating shipping lanes away from key whale habitat (i.e. reducing co-occurrence of whales and vessels) and implementing voluntary or mandatory speed restrictions in key areas. Reduced vessel speeds are known to reduce severity of collisions and also likely reduce the probability of collisions by increasing reaction times and chances for whale detection by boaters.

Broad Answer

Vessel strikes are a primary source of mortality and serious injury for large whales around the world. The risk of a whale getting hit by a vessel is dependent on both whale behavior and vessel characteristics. The severity of vessel strikes varies based on multiple factors including the size, speed, type, and sound level of the vessel. For example, large vessels may be more immediately lethal to whales than small vessels, but any vessel operating at high speeds (e.g., greater than 10 knots or ~12 mph) poses a risk of injury or death to whales. In addition, the sound produced by a vessel may vary depending on vessel type, size, speed, and environment in which it travels (Erbe et al. 2019), which could impact whale behavior. Vessel strike risk also varies based on the behavior of whales. As vessels only operate in near-surface waters, behaviors conducted by a whale near the surface (e.g., feeding, sleeping, nursing) present the risk of vessel strike. Individual characteristics and activities of whales may influence the degree of this risk; for example, calves and juveniles spend more time at shallower depths, increasing their likelihood of interaction with a vessel. Whales may be more solitary or more aggregated based on sex, age, and foraging behavior, and the degree of aggregation behavior can influence risk. Whales feeding near the surface may be at higher risk of vessel strike, but this increased activity at the surface may also make them more detectable by boaters. Similarly, the longer a whale spends at the surface, the higher the chance it is detected by a boater. Ultimately, the risk of vessel strike is dependent on both vessel and whale characteristics that influence their degree of overlap in space and time and the ability of each to avoid the other. Current efforts to reduce vessel strike risk in the U.S. depend on 1) relocating shipping lanes away from areas of high whale density to reduce the overlap of whales and vessels, and 2) reducing vessel speed in areas and during times of importance for whales to reduce the severity of collision while increasing the ability for boaters to detect animals and conduct avoidance maneuvers.

Detailed Answer

Vessel strikes are a major source of mortality for large whales globally, and can lead to population-level impacts at a local scale (Clapham et al. 1999, Laist et al. 2001). Van der Hoop et al. (2013) examined mortality and serious injury for large whales in the Northwest Atlantic, and found that 67% resulted from human interactions, with entanglement in fishing gear and vessel strike as the two main causes. The risk of vessel strike depends on the specific characteristics of both the whale and the vessel. The occurrence of a vessel strike requires that both a whale and vessel co-exist in space and that the vessel protrudes into the portion of the water column where the whale is present. Therefore, vessel strike risk is higher in regions of high vessel traffic (Laist et al. 2001, Vanderlaan et al. 2009), and the probability of vessel strike within the water column is greater towards the ocean surface (Laist et al. 2001, Lammers et al. 2013). The risk and severity of a vessel strike (i.e., likelihood of severe injury or mortality) is influenced by vessel characteristics in the following ways:

- **Vessel Size** – Large vessels such as cargo and shipping vessels commonly have higher severity of lethality to large whales due to sheer size alone, but also are high risk as they are more difficult to maneuver to avoid strikes (Laist et al. 2001). However, small vessels also pose a vessel strike risk and have been documented by the media[1] and in the scientific literature and federal technical reports (Henry et al. 2022). Documented whale deaths and serious injuries have occurred from small vessels including whale-watching vessels, Coast Guard and Navy vessels, and ferries (Kelley et al. 2020). In addition, there is a higher risk of injury to persons onboard smaller vessels that collide with whales.
- **Vessel Speed** – Vessels traveling at high speed have a greater probability of lethality for large whales, as the blunt or sharp force trauma is more severe than that occurring at slower speeds (Conn & Silber 2013). In addition, like driving a vehicle on a highway, the reaction distance decreases with increased speed; thus, risk of strike (e.g., the inability to avoid) increases with vessel speed. Vessel speed has been an important topic of scientific research, and restrictions on vessel speeds are a key management measure currently enacted in the U.S. In addition, although we know the probability of lethality is high for fast, large vessels, collisions with vessels of all sizes—from recreational boats to large ocean-going ships—are one of the primary causes of recent elevated North Atlantic right whale injuries and deaths.[2] Vessel strike is also a main source of mortality for sea turtles (Foley et al. 2019), with vessel speed significantly influencing the degree of risk (Hazel et al. 2007).
- **Vessel Type and Sound Level** – Type of vessel impacts the severity of vessel strikes. While both sailing and motorized vessels are capable of hitting whales at the surface, the risk of sharp force injury by propellors is much higher for motorized vessels. In addition, the sound produced by a sailing vessel may be dramatically different from that produced by a motor vessel, as sound varies greatly depending on propeller characteristics, vessel size and speed, and even the environment in which a vessel is operating (Erbe et al. 2019). Though behavioral responses to noise could include increased vocalizations (Dahlheim & Castellote 2016), or even physical disruption through surfacing (Nowacek et al. 2004) or shallow dives (McKenna et al. 2015), there is no clear detection and response behavior elicited by whales broadly (Erbe et al. 2019). When considering the combination of vessel size, speed, and type, it is also important to consider vessel and operator behavior, which may lead to varying risk of vessel strike occurrence and severity. For example, a tug or tow vessel may operate in a straight line, at low speeds, while in proximity or while attached to a very large vessel and may therefore pose a relatively low vessel strike risk. In contrast, a fishing vessel may operate at high speeds, while passengers may be occupied with tasks that draw their eyes away from the water, and they may target areas where fish are known

[1] Whales in the media: https://www.the-scientist.com/news-opinion/why-did-this-whale-smack-into-a-boat-70267
[2] North Atlantic right whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2024-north-atlantic-right-whale-unusual-mortality-event

to congregate, which may be where whales are also congregating, and therefore lead to increased likelihood of interaction. Though vessel type and behavior are highly variable, these examples illustrate how different vessel types, speeds, sizes, and behaviors inform vessel strike risk.

The characteristics and behaviors of marine mammals may also influence the risk and severity of vessel strikes. The probability of a vessel strike occurring may vary based on species or individual behaviors. For example, vessel strikes are infrequently reported for dolphins as they are inherently nimble and can move at fast speeds to avoid being struck. In contrast, a large baleen whale is less capable of maneuvering quickly to avoid contact and has a greater surface area to strike. Individual behavior is also important, as vessel strike risk may be higher for individuals that are foraging or resting near the sea surface compared to those traveling at depths below the typical draft of vessels (Silber et al. 2010, Parks et al. 2012).

The overlap in space and time of large whale and vessel densities drives the risk of vessel strike (Laist et al. 2001, Vanderlaan et al. 2009), and is influenced in part by habitat use and behavior of the whales (Friedlaender et al. 2009, Parks et al. 2012, Blair et al. 2016, Stepanuk et al. 2021). For example, the coastal waters of the U.S. east coast tend to be areas where large whales are observed foraging, and also have dense vessel traffic, leading to areas of high overlap in space and time. Changes in food and habitat due to climate change can also lead to an increase in overlap. For example, due to shifting prey distributions, North Atlantic right whales shifted their distribution north into the Gulf of Saint Lawrence, resulting in increased vessel strikes (Davies & Brillant 2019). Variations in habitat use and foraging behavior within species and populations are based on a number of factors that influence the risk of vessels strike:

- **Demographics** – Age, sex, and reproductive status influence vessel strike risk (Craig et al. 2003, Whitehead & Rendell 2004, Teloni et al. 2008, Valsecchi et al. 2010). For example, while adult humpback whales may forage in larger groups that are active at the sea surface (and therefore are easily detected by boaters), juvenile humpback whales tend to be more solitary and exhibit more erratic behaviors than older individuals (Clapham 1994, Stepanuk et al. 2021), making both detection and avoidance more difficult. In the case of North Atlantic right whales, pregnant females, female-calf pairs, and lactating females spend more time at, or near, the surface than other demographic groups (e.g., < 3.5m; Dombroski et al. 2021), increasing their risk of vessel strike (Baumgartner & Mate 2003, Dombroski et al. 2021). Distributions also may differ, with juvenile humpback whales showing more of a preference for coastal habitats (which are generally areas with higher vessel traffic; Clapham 1994, Stepanuk et al. 2021), while adult whales are not regularly sighted in inshore waters. In combination with their smaller size, this behavior in juvenile humpbacks may lead to higher risk of vessel strikes than for larger, adult humpback whales. On the breeding grounds, documented vessel strikes of humpback whales have primarily involved calves and juveniles (Lammers et al. 2013), and humpback whale calves have been documented surfacing or residing at shallow depths and demonstrating high surfacing rates without their mothers (Lomac-MacNair et al. 2018). In addition to these behaviors that may increase risk for calves and juveniles, some researchers also hypothesize that vessel avoidance may be a learned behavior so young whales may not have as much knowledge or awareness of the need to avoid vessels (Laist et al. 2001, Panigada et al. 2006).
- **Foraging behavior type** – Some species vary their foraging behavior based on location, prey type, and/or time of day (Friedlaender et al. 2009, Blair et al. 2016). In the case of humpback whales,

where subsurface foraging is regularly observed in the Stellwagen Bank region, whales are typically foraging near the sea floor on species like sandlance (Hain et al. 1995). In contrast, surface lunge feeding and coordinated bubble feeding are regularly observed in the waters of the New York Bight and Gulf of Maine (Stepanuk et al. 2021, Lomac-MacNair et al. 2022), presumably on schooling fish species (e.g., herring, mackerel, menhaden). North Atlantic right whales employ different foraging strategies depending on prey type and location, utilizing surface or near-surface feeding, as well as feeding at depth (Baumgartner et al. 2017). Importantly, the near-bottom foraging behaviors may put whales at less risk of vessel strike compared to the surface foraging behaviors, as whales at depth are likely not within the range of the draft of a vessel. In addition, some whale species forage at the surface at night, but deeper in the water column during the day (Parks et al. 2012). As it is incredibly difficult to detect whales at the water's surface at night, this nocturnal near-surface feeding behavior may increase the risk of vessel strike.

- Surfacing behavior and morphology – There are multiple surface behaviors that may influence the level of risk of vessel strike. When whales breathe at the water's surface, their breath results in a visible blow that is more readily visible to boaters. Some individuals take multiple breaths during each surfacing event, while others may only take a few breaths. The number of possible cues at the surface is directly proportional to how detectable the animal is by human observers (Gende et al. 2019) or by monitoring technologies like thermal imaging. Some species also rest (known as logging) and nurse at the surface, and the amount of time spent in these behaviors influences risk (Gende et al. 2019). In addition, the morphology of species and individuals influences surface detectability, and therefore risk of vessel strike. In particular, North Atlantic right whales lack a dorsal fin, which makes surface detectability more difficult than for other species.

Ultimately, factors that influence the risk of a vessel strike relate primarily to a) overlap in vessel and whale activity, b) the characteristics and behavior of whales, and c) the characteristics and behavior of vessels. The probability of vessel strikes increases when the density of both vessels and whales is high, for example in areas of the New York Bight. Current efforts to reduce vessel strike risk in the U.S. include efforts to relocate shipping lanes away from key whale habitat (i.e. reducing co-occurrence of whales and vessels), as well as implementing voluntary or mandatory speed restrictions in key areas (i.e. reducing severity of collision while increasing reaction times and chances for whale detection by boaters; see *What mitigation measures are available to avoid and or minimize offshore wind effects on marine mammals?* for more information on vessel speed restrictions) and development and use of technologies, such as near-real-time passive acoustic devices and observers to help monitor for marine mammals in the vicinity in order to implement avoidance maneuvers.

Strandings and Unusual Mortality Events

What are strandings and Unusual Mortality Events?

- Whales and other cetaceans (such as dolphins and porpoises) are considered stranded when they are found on the shore (dead or alive), when they are found dead at sea (e.g., if the body is floating in the water), or when found alive at sea but unable to return to their natural habitat (e.g., if trapped in shallow water or injured).
- As defined in the U.S. Marine Mammal Protection Act, an unusual mortality event (UME) is "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response."[3]
- A UME can occur over multiple years and across regions and may affect a single species or various species. Individuals or groups of animals can strand, depending on the species and situation.

Detailed Answer

Whales and other cetaceans (such as dolphins and porpoises) are considered stranded when they are 1) found dead on shore or floating in the water; 2) found alive on shore and unable to return to the water; or 3) are found alive at sea but unable to return to their natural habitat (e.g., if trapped in shallow water or injured).[4] Because healthy pinnipeds (e.g., seals and sea lions) come to land to rest, not all individuals found on land are considered stranded, only those found dead or in need of medical attention (which requires expert assessment to determine). In the United States, pinniped species strand more often than cetaceans.[5] However, strandings of numerous whale species have been documented along the coastline of the United States. These strandings are not confined to one geographic region, though different stranding patterns have emerged in relation to location and time of year. Strandings are often caused by: 1) injuries due to vessel collisions, entanglement or ingestion of active and derelict fishing gear and marine debris, or other human interactions; 2) infectious and non-infectious diseases; 3) malnutrition; 4) unusual weather events or oceanographic conditions; or 5) some combination of these or other factors.

The National Oceanic and Atmospheric Administration (NOAA)'s Marine Mammal Health and Stranding Response Program was established under the U.S. Marine Mammal Protection Act to coordinate emergency responses to sick, injured, out of habitat, or entangled marine mammals, This coordination is achieved through collaborations with federal, state, local, and tribal governmental agencies as well as an extensive network of regional stranding responders involving academic institutions, zoos and aquariums, museums, and non-governmental organizations.

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[3] NOAA Definition of UME: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events#:~:text=Under%20the%20Marine%20Mammal%20Protection,%3B%20and%20demands%20immediate%20response.%22

[4] NOAA Definition of strandings: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/greater-atlantic-marine-mammal-stranding-network

[5] Marine mammal health and strandings report program: https://www.fisheries.noaa.gov/resource/publication-database/marine-mammal-health-and-stranding-response-program-reports

Mass stranding or mass mortality event are broad terms used to refer strandings of multiple marine mammals simultaneously in the same general area.[6,7] An unusual mortality event (UME) is specifically defined in the U.S. Marine Mammal Protection Act as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." A UME can occur over multiple years and across regions and may involve a single species or multiple species.

Some marine mammals strand while alive. This may happen to individuals whose health is compromised (e.g., through nutritional deficiency, Alava et al. 2019, or infection, Cools et al. 2013), who are disoriented (e.g., a dependent young animal who is separated from their mother), or who are experiencing other stressors. The criteria used to decide whether to release, euthanize, or rehabilitate a live stranded individual include the availability of logistical support and resources, number of animals involved, environmental conditions, condition of the animal(s), ease of handling (e.g., size, temperament), and availability of care facilities (Geraci & Lounsbury 2005). However, best practices regarding the decision process for responding to a live stranding require that animal welfare and personal safety of individuals involved take precedence over all scientific data collection (Geraci & Lounsbury 2005, Boys et al. 2022). In the event of a dead stranded marine mammal, examinations and tests may be conducted to help determine the cause of death and other information about the animal's health. The data obtained from dead stranded marine mammals may vary based on the level of decomposition as well as the availability of expertise and resources to conduct a necropsy (see *How are necropsies conducted?*).

What are some of the causes of stranding events for marine mammals?

- Strandings are often caused by 1) injuries due to vessel collisions, entanglement or ingestion of active and derelict fishing gear and marine debris, or other human interactions; 2) infectious and non-infectious diseases; 3) malnutrition; 4) unusual weather events or oceanographic conditions; or 5) some combination of these or other factors.
- Climate change has altered the migration and distribution of whale species and their prey and, in some cases, increased their interaction with vessels and other anthropogenic activities. Climate change also has the potential to contribute to changed patterns of pathogen emergence, distribution, abundance, and transmission, all of which can lead to increased strandings.

Detailed Answer

Marine mammal strandings can occur from both natural causes and anthropogenic factors. Natural causes include old age, weather and oceanographic conditions, navigation errors, or illness, though some of these may also be influenced or exacerbated by anthropogenic activities as well (e.g., stress from anthropogenic interactions could lead to weakened immune systems and therefore increased susceptibility to illness). Marine mammals that are injured or ill may move towards shallow waters and become disoriented, making them susceptible to stranding. Additionally, natural environmental factors, such as strong offshore storms and natural seismic activity (e.g., earthquakes) that disrupt or alter underwater topography, may play a role in strandings. Importantly, the susceptibility of marine mammals to human impacts varies by species and taxon; while large whales are susceptible to vessel strikes and

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[6] NOAA information on strandings: https://www.fisheries.noaa.gov/insight/understanding-marine-wildlife-stranding-and-response#:~:text=Strandings%20of%20multiple%20animals%20(sea,Act%20sets%20out%20a%20process

[7] Marine Mammal Commission definition of mass stranding: https://www.mmc.gov/priority-topics/marine-mammal-health-and-strandings/

entanglements in fishing gear and marine debris, toothed whales like dolphins and pilot whales may be more susceptible to impacts from audible noise and fisheries bycatch.

A number of human activities may cause injury, death, illness, and stress to whales that directly contribute to strandings or mortality events. Hazards from such activities include:

- Vessel strikes
- Entanglement in marine debris and fishing gear such as lines and trawl nets
- Contaminant exposure from oil spills and other chemicals, including from agricultural and industrial runoff
- Ingestion of plastic and other marine debris
- Sound exposure from activities including military sonar operations, seismic surveys (e.g., oil and gas exploration), and construction activities
- Habitat degradation and destruction including increased beachfront development that may impact feeding grounds and breeding areas for species like seals
- Shifting prey distributions and migratory pathways due to changes in oceanographic conditions due to climate change

In recent decades, high-profile stranding and mortality events involving critically endangered North Atlantic right whales and other species, have led to increased public awareness and conservation efforts intended to reduce anthropogenic causes of mortality. Efforts in the U.S. include the expansion of stranding response networks and the formalization of a national stranding response program in 1992, public outreach and education, as well as the establishment of protected marine habitat areas. Additional efforts include the implementation of government regulations and guidelines such as vessel speed limits starting in 2008 and fishing gear modifications starting in the 1990s (e.g., dolphin-safe tuna), increased monitoring, noise attenuation requirements and sound limits for certain activities, and development of species management plans. Public awareness of the factors contributing to stranding events can help support conservation and management efforts.

For More Information

- Understanding Marine Wildlife Stranding and Response: https://www.fisheries.noaa.gov/insight/understanding-marine-wildlife-stranding-and-response#why-do-animals-strand

Why are baleen whales dying in the Northwest Atlantic and is this a new phenomenon?

- Generally, existing evidence suggests that the main anthropogenic causes of death for baleen whales are vessel strike and entanglement in fishing gear. However, the cause varies by species. While we lack information for many whale mortalities (e.g., those that aren't detected or necropsied, or for which cause of death cannot be determined; see *What are the biases and limitations of stranding data?*), data suggest that the greatest risk to humpback whales is vessel collisions (50% of necropsies showed evidence of vessel interaction), whereas 65% of North Atlantic right whales that have been killed or injured were entangled in fishing gear.
- Recent increases in the number of baleen whale deaths in the Northwest Atlantic region relate to a combination of natural and anthropogenic factors. These may include shifting prey and whale

distributions inshore, infectious disease, and changes in the locations and amount of shipping activity leading to increased interactions with vessels.

Detailed Answer

As of April 2024, there were four active "unusual mortality events," or UMEs, for marine mammals in the United States, all of which are in the Atlantic (Table 1).[8] A panel of expert with knowledge and experience in marine science, marine mammal science, veterinary and husbandry practices, marine conservation, and medical science—known as the Working Group on Marine Mammal Unusual Mortality Events—determine when a UME is occurring. UME designation may provide additional financial support for stranding response and investigations into the causes of the event. Of the active UMEs in April 2024, all four are in the Atlantic and three involve whales: humpback whales, minke whales, and North Atlantic right whales. A fifth UME involving grey whales in the Pacific was recently closed.[9]

Elevated humpback whale mortalities have been observed along the U.S. Atlantic (from Maine to Florida) since January 2016.[10] The highest numbers of strandings have occurred off New York and Massachusetts, followed by Virginia, New Jersey, and North Carolina, but strandings have been recorded during this period off all Atlantic coastal states (view the locations). Necropsies were conducted on only about half of the carcasses due to various reasons, including advanced decomposition and carcass accessibility. Of the individuals examined, approximately 40% exhibited evidence of human interaction, either vessel strike or entanglement. Some of the remaining whales had other causes of death. Importantly, the distribution of humpback whales along the U.S. Atlantic has varied in recent years, including some novel habitat use (Aschettino et al. 2020, Brown et al. 2022). Population growth could also influence long-term stranding rates as the population recovers from historical whaling (Stevick et al. 2003), but the drastic increase of stranded humpback whales detected in 2016 onwards was not matched with a similar drastic population increase. Rather, changes in whale habitat use and behavior may be important factors in stranding rates. For example, young humpback whales have been observed foraging close to shore on prey that are aggregated in shallow coastal areas (e.g., Atlantic menhaden in the New York/New Jersey region; Lucca & Warren 2019), where human activity, such as passenger and shipping vessel traffic, is prevalent (Stepanuk et al. 2021, King et al. 2021). The presence of these animals close to shore could increase both the detection of injured, stranded, or dead animals, and the risk of lethal interaction with known anthropogenic threats, such as fixed fishing gear and vessel traffic (Stepanuk et al. 2021). In addition, changes in the density, volume, and speed of vessel traffic and fishing effort could also impact interaction rates with human activities. While 2023 saw an increase in the number of strandings of humpback whales compared to 2021 and 2022, the number and location were similar to observations in 2017 and 2020.[11]

North Atlantic right whales, which currently number around 360 individuals, have experienced elevated levels of mortality and injury in eastern North America (from Newfoundland to Florida) since 2012. A UME

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[8] NOAA Fisheries information on Unusual Mortality Events: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events

[9] Active and closed Unusual Mortality Events: https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

[10] Humpback whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2024-humpback-whale-unusual-mortality-event-along-atlantic-coast

[11] More information on humpback whale strandings: https://e360.yale.edu/features/humpback-whale-strandings-u.s.-east-coast

was declared for this species in the U.S. in 2017, and is still ongoing.[12] An interactive map of these locations can be found on the NOAA website. Mortalities and injuries were first detected in Canadian waters related to the movement of many North Atlantic right whales into the Gulf of Saint Lawrence starting in 2015. In 2017, seventeen right whales were observed killed or injured in the Gulf of Saint Lawrence, a region featuring some of the largest densities of pot and trap fishing in Canada (Davies et al. 2019). The whales were killed by entanglement in snow crab and other fishing gear and blunt trauma from vessel strikes, as well as undetermined causes. Following these events, monitoring and risk reduction regulations were rapidly implemented by the Canadian government, including the closure of the snow crab fishery. Since 2017, Canada has maintained a robust mitigation and monitoring program for North Atlantic right whales.[13] Increased mortalities in U.S. waters started in 2017, prompting the declaration of a UME. The UME has since been expanded to include individuals that are dead, seriously injured, or have a sublethal injury or sickness. The leading causes of the UME are entanglement in fishing gear (65%) and vessel strikes (15%).[14] Remaining cases were birth-related or were dependent calves harmed by injuries to their parent (3%), were not examined (8%), or had undetermined cause of death (9%). The highest number of annual mortalities and injuries occurred in 2017 and 2018, with lower but still elevated numbers since then.

Similar to humpback and North Atlantic right whales, minke whales from Maine to South Carolina have experienced elevated mortalities since 2017. Preliminary findings from necropsies on minke whales have found evidence of human interaction and infectious disease.[15]

The widespread nature of these three UMEs along the Atlantic coast of North America and the temporal scale (2017-present) suggest a range of causes, primarily vessel strikes and entanglement, as well as disease and other factors.

Table 1. Active unusual mortality events (UMEs) for marine mammals in the United States including year declared, name of the UME, species affected, location, and the causes. Source: NOAA website on UMEs.

Year	Name	Species	Location	Cause(s)
2021	Atlantic Florida Manatee	Manatee	Atlantic Ocean, Florida	Malnutrition related to ecological factors (e.g. change in forage)
2018	Atlantic Minke Whale	Minke Whale	Atlantic Ocean	Suspected human interaction (entanglement)/Infectious disease
2017	North Atlantic Right Whale	North Atlantic right whale	Atlantic Ocean, Canada, and U.S.	Human interaction (vessel strike/entanglement)
2017	Atlantic Humpback Whale	Humpback whale	Atlantic Ocean	Suspected human interaction (vessel strike)

[12] North Atlantic right whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2024-north-atlantic-right-whale-unusual-mortality-event

[13] Canadian efforts to reduce north Atlantic right whale mortality: https://www.canada.ca/en/fisheries-oceans/news/2024/03/government-of-canada-announces-the-2024-measures-to-protect-north-atlantic-right-whales.html

[14] North Atlantic Right Whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2024-north-atlantic-right-whale-unusual-mortality-event

[15] Minke Whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2024-minke-whale-unusual-mortality-event-along-atlantic-coast

For More Information

- More information on unusual mortality events: https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events#:~:text=Since%201991%2C%2072%20marine%20mammal,(UMEs)%20have%20been%20declared; https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events
- The humpback whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2023-humpback-whale-unusual-mortality-event-along-atlantic-coast
- The North Atlantic right whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2023-north-atlantic-right-whale-unusual-mortality-event
- The minke whale UME: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2024-minke-whale-unusual-mortality-event-along-atlantic-coast
- The Working Group on Marine Mammal Unusual Mortality Events: https://www.fisheries.noaa.gov/national/marine-life-distress/noaa-fisheries-partners-spotlight-working-group-marine-mammal-unusual-mortality-events
- Marine Mammal Commission 2023 update on strandings of large whales along the East Coast: https://www.mmc.gov/wp-content/uploads/Update-on-Strandings-of-Large-Whales-along-the-East-Coast-2.21.2023.pdf

What can we learn from stranding data?

- Strandings can provide important information on disease, health, and causes of death.
- Stranding data are especially important for learning about susceptible and rare populations/species.
- Stranding and entanglement networks fill a valuable bio-surveillance role, as they are often the first to detect threats to marine mammal populations.

Detailed Answer

Marine mammals are considered stranded when found dead, either on land or floating in the water, or alive on land but are unable to return to the water or are in need of medical attention (see *What are strandings and Unusual Mortality Events?*). The data obtained from stranding events are vital to understanding marine mammal biology, physiology, and health, which allows us to better evaluate the risk factors for both individuals and populations of marine mammals. Stranding events can provide a key set of information that would not otherwise be attainable, as marine mammals spend all or most of their lives in marine environments and are difficult to study. In addition, strandings network partners fill a valuable role related to bio-surveillance, as they are often the first to detect particular threats to marine mammal populations.[16]

Stranding data have been incorporated into scientific analyses for decades and can provide an understanding of marine mammal health and how it varies across space and time (Wiley et al. 1995, Betty

[16] Marine mammal health and strandings response program: https://www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-health-and-stranding-response-program

et al. 2020). These data can inform our understanding of species presence and distributions, population health, contaminant levels, and human interactions with marine mammals. Examples of these include:

- Species presence and distributions: Some rare marine mammal species have never been observed alive and have only been discovered based on the presence of stranded, dead individuals. An example of this is the Perrin's beaked whale in the Pacific, which was only recently recognized as a unique species based on the discovery of just five individuals that stranded over a 20-year period (Dalebout et al. 2002). Changes in the spatiotemporal patterns of strandings can also serve as indicators of underlying changes due to anthropogenic or naturally occurring events in the populations of common species (Byrd et al. 2014).
- Population health: In some instances, it is possible to extrapolate from stranding occurrences to understand broader population health, though there are important caveats (See *What are the biases and limitations of stranding data?*). A study of killer whales in the northeastern Pacific Ocean and Hawaii found that necropsy and pathology results indicated a range of causes of mortality, including infectious disease, trauma, malnutrition, and bacterial infections, and that there was a relationship between cause of death and body condition (i.e. a measure of animal health based on blubber, size, and fatness; Raverty et al. 2020). As another example, necropsy results from gray whales in the Pacific have been used to understand rates of malnutrition, with 26% of stranded gray whales being severely emaciated, likely related to various factors including environmental change and prey shifts (Raverty et al. 2024).
- Contaminant levels: Contaminants in the ocean typically biodegrade (or break down) quite slowly, and therefore can accumulate in animals' bodies, particularly species that are towards the top of the food chain. This is particularly important for toothed whales, due to the higher trophic level of their prey; a study of tissue samples collected from 83 toothed whales found that there were differences in the toxins and contaminants between species, sex, and age classes, and suggested that the toxin levels observed in tissues from stranded animals could lead to health declines, especially when combined with other impacts (Page-Karjian et al. 2020).
- Human Interactions: One of the goals of conducting stranding assessments and necropsies is to determine whether human interactions were the cause of death[17]. Stranding data can also provide insight into novel human interactions with marine mammals, such as recent detections of plastic and debris in stranded marine mammal digestive tracts (Alzugaray et al. 2020).

Ultimately, stranding data are incredibly useful to better understand the health, biology, and risks for marine mammal species. These data can support other forms of monitoring and assessment, such as shipboard or plane-based surveys and field-based health assessments (e.g., biopsy collection, photogrammetry). However, it is important to understand that some scientific questions are difficult to address or answer due to biases and limitations of stranding data (see *What are the biases or limitations of stranding data?*).

What are the biases or limitations of stranding data?

- Detecting strandings and determining their causes is challenging.

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

- Many factors influence stranding occurrences and rates. This means it is difficult to understand whether observed changes in the timing, location, or rate of strandings reflect changes in actual mortality in a population.
- Availability of stranding data depends on the strandings being detected by people (e.g., some animals never wash ashore), knowledge of how to report the stranding, and stranding network partners that are able to further investigate an event when it detected and reported.

Detailed Answer

It can be hard to draw definitive conclusions from stranding data when asking certain scientific questions, such as whether the timing, location, or annual rate of strandings have changed over time for a given population. This is because a variety of factors influence the detection and reporting of strandings to the appropriate agencies (Figure 1). If those sources of variability are not accounted for when interpreting the data, the resulting interpretation could be misleading or, in statistical terms, "biased." Statistical bias refers to something that does not represent the true state of nature. Factors that affect numbers of reported strandings include:

- **Actual number of strandings** – Multiple factors influence the true number of strandings that occur over time, including 1) population abundance (e.g., an increase in the size of the population may lead to an increase in the number of stranded animals); 2) changes to mortality and serious injury rates due to natural or human-related factors (e.g., changes in the type, number, severity, and/or duration of human interactions); and 3) habitat and behaviors that may influence likelihood of beaching and/or increased susceptibility to human impacts.
- **Number of stranded marine mammals detected –** While ideally all stranded marine mammals are detected, known or detected strandings only represent a fraction of the true or actual number of strandings. This unobserved number of strandings has been termed "cryptic mortality." There are multiple factors influencing the likelihood of detection, including 1) abundance and distribution, as detection likelihood is higher for marine mammals who typically use habitat that is closer to coastlines and are more likely to strand on shore (rather than sink or get carried out to sea) or those with larger populations; 2) environmental conditions and habitat, including ocean currents that may affect the speed and path that a carcass will travel at sea, ocean temperature and salinity (which affect the buoyancy and decomposition rates of dead marine mammals), and scavenging of carcasses by predators; and 3) human population density, as there are higher detection rates in areas with higher concentrations of people.
- **Number of stranded marine mammals reported** – Accurate stranding rates rely on the consistent reporting of stranded marine mammals and consistency of network partners, who maintain records. Factors that influence reporting include the presence of local active stranding networks and public awareness, so people know how and why to report strandings. Gaps in reporting can also occur when stranding network partner organizations close or restructure their priorities.

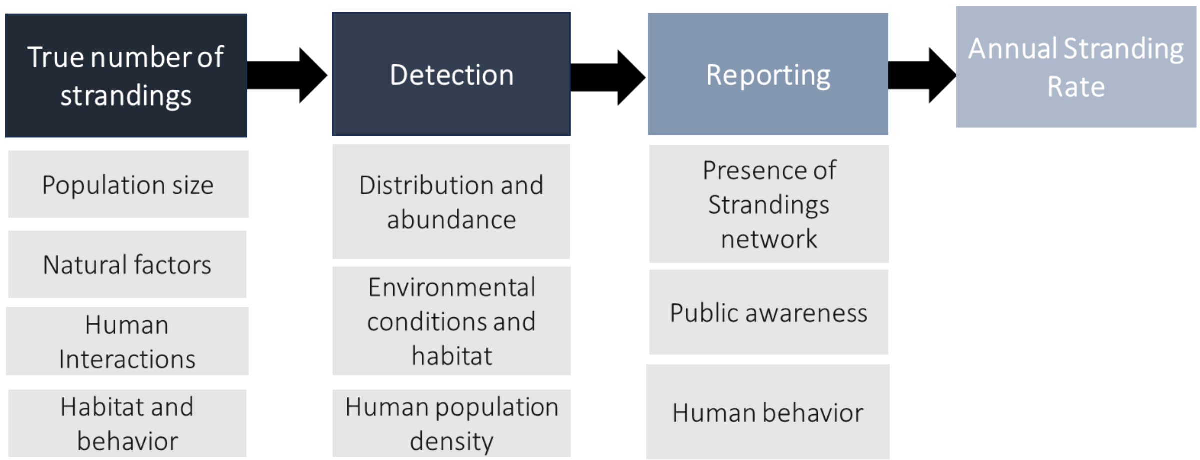

Figure 1. Potential factors influencing annual marine mammal stranding rates. Factors can influence the true number of strandings, the likelihood of detecting strandings when they occur, and/or the likelihood of detected strandings being reported to the proper authorities.

Detecting strandings and detailing the causal factors that lead to a stranding is complicated. Simple examination of the number of strandings may be misleading (Faerber & Baird 2010). Marine mammal annual stranding rates (e.g., the number of strandings reported per year) can be influenced by the true number of seriously injured or dead animals, the ability to detect stranded animals (the number of known or observed strandings represents only a fraction of the true number, with unobserved mortality termed "cryptic mortality"; Pace III et al. 2021), and the likelihood that detected strandings are reported. The true number of strandings is influenced by marine mammal population size: if a constant proportion of the population is stranding over time, yet the population is growing, then a larger number of individuals will strand as the population increases (Woodhouse 1991, Pyenson 2011). In addition, changes to mortality and serious injury rates may occur due to changes in natural or human interactions (including type, severity, location, and duration). Finally, species or individual behavior may impact stranding rates. Hypotheses for behavioral impacts on strandings include possible disruption of strong social networks (Oremus et al. 2013), or age- or sex-based behavioral differences that influence stranding risk, such as juvenile humpback whales occurring disproportionately close to shore (Stepanuk et al. 2021), or female humpback whales occurring closer to shore than males in Hawaiian waters (Craig et al. 2014), thus leading to a higher probability of strandings.

Detection factors that influence observed marine mammal stranding rates include habitat, distribution, abundance, oceanographic conditions, and human population density and amount of monitoring or reporting effort. A species' distribution and its proximity to coastlines could influence observed stranding rates, as strandings that occur farther offshore are less likely to be detected (Norman et al. 2004, Faerber & Baird 2010, Stepanuk et al. 2021). If the typical habitat of individuals is close to shore, the probability of stranding along a shoreline, and therefore being detected, is higher (Geraci & St Aubin 1979, Faerber & Baird 2010). In addition, if the distribution of a population shifts closer to shore, the probability of detecting strandings will increase, even when the population is experiencing constant rates of mortality (Norman et al. 2004, Faerber & Baird 2010, Stepanuk et al. 2021). Oceanographic drivers including ocean currents, sea surface salinity, and sea surface temperature may also influence stranding rates. The drift and movement of floating carcasses and weakened live animals at sea is primarily driven by ocean currents, either increasing stranding rates by driving more individuals towards land (e.g., Cape Cod –

Pugliares et al. 2016) or decreasing rates by pulling carcasses and weakened animals away from shore (e.g., Hawaii- Faerber & Baird 2010). In addition, lower sea surface salinity could reduce buoyancy, and sea surface temperature influences both decomposition rate and buoyancy (Faerber & Baird 2010). The probability of detection is also consistently higher in areas with higher concentrations of people, due to the distribution of homes, accessible coastlines, recreational vessels, and vacation hotspots (Norman et al. 2004, Faerber & Baird 2010). Similarly, there may be seasonal variation in detections, with higher rates during warmer summer months when more people are spending time on coastlines (Norman et al. 2004). Warmer summer months may also correspond with oceanographic drivers and seasonal species distribution shifts to compound the probability of detecting strandings (Norman et al. 2004). To properly understand and analyze stranding data, particularly when assessing changes in stranding rates in space or time, it is important to account for these influences.

Variation in reporting of strandings can lead to biases that make it difficult to effectively incorporate stranding data into analyses. First, the presence of an official and active stranding network influences the rate of reporting, as does general public awareness of why and how to report stranded marine mammals (Norman et al. 2004). There may also be variability in human behavior when reporting, as some individuals may be more likely to report than others.

The research questions that can be addressed with this type of data and the ways in which biases need to be accounted for must be carefully considered during analysis and reporting. Despite these limitations, ultimately, stranding data are incredibly useful to better understand the health, biology, and risks faced by marine mammals, especially for rare species, and stranding data can support other forms of standardized monitoring and assessment, such as surveys and in-field biological sampling.

How are necropsies conducted?

- Similar to an autopsy in humans, a necropsy is the examination of a deceased animal to identify cause of death and collect other information on the health of the individual, the species, and the marine environment.
- In the United States, whale necropsies are conducted by organizations that are members of the National Marine Mammal Stranding Response Network. All reported strandings are documented, but it is not possible to conduct necropsies in many cases due to human safety, the state of carcass decomposition, stranding location, or other reasons.
- Necropsies can provide valuable information but cause of death cannot always be determined. Complicating factors include the level of decomposition, inability to collect or process samples due to limited accessibility or resources, inconclusive test results, and difficulty identifying multiple factors that may contribute to the cause of death.

Detailed Answer

Similar to an autopsy in humans, a necropsy is the examination of a deceased animal to identify cause of death. It may include the collection of biological samples from a deceased animal and/or the synthesis of known history of the animal, particularly during the time leading up to the stranding. For cetaceans and other marine mammals, necropsies provide an important, rare insight into the physiology and health of these species that spend their lives at sea and are therefore difficult to study. In the United States, necropsies are conducted by members of the National Marine Mammal Stranding Response Network. The

Network is overseen by the Marine Mammal Health and Stranding Response Program (MMHSRP) at NOAA Fisheries' Office of Protected Resources; the MMHSRP was formalized as part of amendments to the U.S. Marine Mammal Protection Act in 1992.[18] Network members include nonprofit organizations (e.g., zoos and aquaria), museums, universities, and state, federal, local, and tribal governments who have personnel experience and are trained in marine mammal stranding response activities.

Stranding network members are required to document all reported strandings as is feasible for both live and dead stranded animals, and at a minimum must report basic animal information (e.g. date, location, species, etc.) and external observations of the animal, including morphology, life history, and general health (this is called "Level A data").[19,20] The opportunity to conduct a full necropsy and investigation of a dead stranded animal, however, is dependent on a number of factors, including condition of the carcass, stranding location, weather, and financial, scientific, and logistical resources. For partially decomposed carcasses, it may not be possible to obtain comprehensive information. If animals strand in unsafe locations (e.g., rocky coastlines, slippery intertidal regions) or die at sea, additional resources may be needed to relocate the animal (if possible) to a location where personnel can safely operate around the animal, such as a beach or dock. In addition, necropsy completion may be complicated by inclement weather and environmental factors. For example, because some necropsies may require over 10 hours to complete, winter months may limit the ability to conduct a thorough investigation. Many resources are required to effectively conduct necropsies, including highly trained and experienced personnel, including a designated safety officer, and in many cases, industrial machinery such as backhoes and excavators. Trained necropsy coordinators and staff may need to travel long distances on short notice to conduct high priority necropsies. The resources required to conduct a full necropsy of large whales are also much greater than for small marine mammals, as the amount of machinery and number of trained personnel required to conduct a necropsy typically scale with animal size.

Preliminary necropsy data collection

Before any necropsy begins, it is important to document baseline information about the animal, including the time, date, and location of stranding, environmental conditions, any behavior documented prior to stranding and/or previous documented stranding history (which can help inform understanding of body condition and possible causes of death), and if the animal was euthanized. The history of some stranded animals can be determined from documentation of individuals (e.g., humpback whales have natural markings on the underside of their tail, or fluke, that can be used for individual identification; North Atlantic right whales have unique patterns of callosities on their skulls that can allow for individual identification), or from repeated reports of an individual in distress or in novel habitat (e.g., rare toothed whales occurring in harbors and rivers, entangled whales).

Importantly, it is necessary to document any initial signs of human interaction, such as rope, gear, or debris on the animal, or sharp lacerations indicative of interaction with a vessel propeller. This process is called human interaction evaluation. The detailed process to assess and evaluate stranded animals for human interaction is documented in the "Handbook for Recognizing, Evaluating, and Documenting Human Interaction in Stranded Cetaceans and Pinnipeds" (Barco & Touhey 2006). This document outlines

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[18] Marine mammal health and stranding response program: https://www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-health-and-stranding-response-program

[19] More information on Level A data collection: https://www.fisheries.noaa.gov/national/marine-life-distress/level-data-collection-marine-mammal-stranding-events

[20] Level A data form: hdtps://media.fisheries.noaa.gov/2021-07/Level%20A%20form_2024%20Fillable.pdf?

the standardized reporting and data collection process required to eventually determine whether death occurred due to human causes, which is vital to determining population sustainability and acceptable levels of "take" under the U.S. Marine Mammal Protection Act (see *What federal and international environmental laws protect whales?*). In addition, determining whether death was caused by human interaction can inform our understanding of the causes of unusual mortality events (see *What are strandings and Unusual Mortality Events?*), as well as guide effective responses to those events. The examination for human interaction could include documentation of:

- **Scars and lacerations on the body:** Scars are observed on many marine mammals, and it is often possible to determine whether they are due to human interaction. For example, when entanglements occur, there are regions of the body where gear tends to accumulate, including around the pectoral fins (fins on the side of the body), across the blowholes or top of the back, and around the spine just before the tail begins. Marks and scars in these regions, especially if they look like rubs or abrasions, are almost always due to entanglements in fishing line. If a vessel strike involves a propeller, it can be easy to determine if the skin is broken. The scar looks similar to an accordion fold along the body of the animal. Scientists are sometimes able to use the distances between propeller scars, the angle of intrusion, and the depth of cut to infer the size and possibly the speed of the vessel that struck the animal. Importantly, scientists can also sometimes determine if scarring occurred before or after death, based on internal examinations and bruising.
- **Internal injury:** If a full necropsy is conducted (see biological sampling, below), biological samples and professional assessments are typically conducted that focus on areas of suspected human interaction. This could include regions of the body with evidence of blunt force trauma (e.g., bruising or pooling blood, cracked or broken bones), material in the body (e.g., embedded lines, plastic or other debris), or areas identified by external scarring and/or lacerations. If a full necropsy is not conducted, some samples in these regions may still be taken to support the analysis in determining whether human interaction was a cause of death.

Measurements and documentation are a key part of the preliminary analysis. Photographs supplement the descriptions written in necropsy reports and can allow further analysis of any notable marks on the carcass. In addition, measurements are taken at standardized locations on the body, including measurements of blubber thickness along the body, estimated weight, and both length and width measurements. This initial external analysis, investigation of human interaction, and measurement protocol comprise the "Level A" data reporting; more details can be found in the Level A Examiner guide. The Level A data reports may be supplemented with further analyses, such as analyzing biological samples of the animal.

Biological Sampling

A necropsy comprises the cumulative measurements, observations, and samples obtained throughout the investigative process that aims to provide a comprehensive set of results to determine the cause of a marine mammal mortality. The successful collection of these data is highly variable and depends on many factors. Importantly, the ability to conduct a thorough investigation is primarily dependent on the amount of decomposition of the animal. For example, many large whale species float after death due to the interior buildup of gases from decomposition, and can be subjected to rough weather and waves, predation from scavengers (e.g., sharks), and substantial sun exposure. Further, some animals may sink below the surface and begin decomposing and are only detected once emitted gas causes the animal to re-float, further influencing the rate of decomposition. Dead animal condition is determined by four codes (code 2 through code 5) that inform the type of sampling and analysis that is valuable and feasible for varying levels of decomposition. For example, an individual that is a Code 5 is essentially mummified or a skeleton, and the only valuable samples would include life history and genetics. In contrast, a fresh carcass, assigned a Code 2, can provide valuable samples for virology, histology, contaminants, and biotoxins.

Sampling options include the following, though this is not a comprehensive list:

- Histopathology: the microscopic examination of tissue for disease detection. Tissue samples are taken from multiple locations along and throughout the body.
- Virology: Testing for viruses is ideally conducted on the serum, lung, liver, spleen, lymph nodes, and brain, but additional samples are possible as well.
- Microbiology: These samples can be obtained with swabs or from tissue samples. These analyses provide information on bacteria and microbes.
- Parasitology: Any parasites can be sampled and stored for future identification and documentation. Parasites can also contain information vital to virology.
- Contaminants: Both human-produced toxic substances and natural toxins can be consumed by marine life and incorporated into their tissues. Marine mammals may have high levels of some contaminants, which can affect behavior or cause immune and endocrine issues. Contaminants can be sampled from blood, blubber, muscle, organs, skin, keratinized tissue, and bone.
- Biotoxins: These are naturally occurring toxins produced by marine algae (similar to the harmful algal blooms that affect bivalves), which can accumulate in marine mammal tissues and have been attributed as the causes of a number of unusual mortality events in the past.
- Life History and Genetics: Information on age estimation, genetics, sex, reproductive status, trophic status, and habitat use can help inform changing trends or baseline physiological information, especially for species that are rarely sighted (e.g., beaked whales). Samples can include teeth, skin, stomach contents, gonads, blood, and bone.

Taxon-specific necropsy information

Best practices for conducting necropsies vary across different species of marine mammals, including specific delineations of where to take measurements and collect samples. Information specific to small odontocetes, which includes dolphins, porpoises, beaked whales, pilot whales, and other similarly sized species, includes the types of stress-induced lacerations, bruising, and hormonal changes that may impact individuals that have stranded on shore. In addition, there are specific descriptions for internal sampling of organs such as the thyroid, lymph nodes, gall bladder, and reproductive tract for both male and female individuals. Information on determining body condition is provided in the marine mammal necropsy guide for strandings responders and field biologists, as this can be difficult to assess for different types of marine mammals. The specific locations for sampling and measurements are given, as well as descriptions of typical and atypical markings on the outer body.

Large whale necropsies and mass strandings require substantial coordination, planning, and personnel management. Some strandings response organizations require federal training on the Incident Command

System[21] typically used by multiple branches of the government for emergency planning and response and recovery efforts. Typically, the ability to fund such substantial and thorough necropsies in a timely manner (ideally within 48 hours of a stranding) is species-specific and depends on the status of the species under the Endangered Species Act, as well as whether an unusual mortality event is in process for the species/location where the stranding occurred. Ultimately, the ability to conduct such a massive operation depends on funding, personnel, location, and timing. Waste disposal can also be an issue, as animals may be large; options include surface decay, beach burials, offshore dumping, land filling, composting, and incinerating.

Key personnel for large whale necropsies include off- and on-site coordinators, necropsy team leaders, photographers, cutting crews, sampling teams, and scribes to record all information. Site safety is the most important component of large whale necropsies. All personnel meet prior to the necropsy to cover personnel safety issues, which may include operating around large equipment, knives, chemicals, large body parts, and uneven shorelines, and use of proper personal protective equipment. More details on responding to large whales and mass strandings can be found in the MMSHRP Best Practices.

Post-necropsy analysis

Though necropsy teams may have a comprehensive understanding of the causes and drivers of strandings, the results of specific cases are rarely immediately available. Preliminary information based on visual examination may provide some insight, but after samples are collected and the individual is disposed of, samples are sent to respective diagnostic laboratories and results can take weeks or months to obtain. In addition, whether a mortality was caused by anthropogenic impacts will be based on elicitation from multiple individuals who are experts in marine mammal strandings. Once the necropsies are complete, reports are finalized and if there are determinations of anthropogenic causes of mortality, these may be used to inform estimates of population-level impacts and unusual mortality event determinations. The outcomes of necropsies are also used in conjunction with other datasets such as federal, academic, and public reporting to determine levels of mortality and serious injury under the U.S. Marine Mammal Protection Act and are reported in marine mammal stock assessment reports.[22] Level A data is considered public information and may be released upon written request from NOAA Fisheries, whereas sharing of necropsy results and diagnostic testing data (also known as Level B data) is at the discretion of individual Stranding Network participants that collected and analyzed the data.[23,24]

For More Information

- NOAA frequent questions on necropsies: https://www.fisheries.noaa.gov/national/marine-life-distress/frequent-questions-necropsies-animal-autopsies-marine-mammals
- Marine mammal necropsy: An introductory guide for strandings responders and field biologists: https://darchive.mblwhoilibrary.org/entities/publication/7701ada6-8af9-5c36-923b-bc44bc718183

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[21] More information on the Incidental Command System: https://training.fema.gov/is/courseoverview.aspx?code=IS-100.c&lang=en

[22] NOAA marine mammal stock assessment: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock

[23] NOAA FAQs: https://www.fisheries.noaa.gov/national/marine-life-distress/frequent-questions-necropsies-animal-autopsies-marine-mammals#how-long-does-it-take-to-get-results-from-necropsies?

[24] Additional FAQ *Why can't the public see necropsy reports?* forthcoming

- Information on the Marine Mammal Health and Stranding Response Program: www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-health-and-stranding-response-program
- NOAA FAQ on strandings and stranding response: www.fisheries.noaa.gov/insight/understanding-marine-wildlife-stranding-and-response
- NOAA examiner's guide: https://media.fisheries.noaa.gov/2021-07/EXAMINERS%20GUIDE_2024%20FINAL.pdf

Who funds necropsies?

- Necropsy costs are typically covered by the individual Stranding Network organization that conducts the necropsy (e.g., non-profit organization, academic institution, local, tribal, state or federal government agencies). However, such organizations may be eligible for monetary support through the competitive John H. Prescott Marine Mammal Rescue Assistance Grant Program through the federal government.
- The federal government distributes several million dollars per year to support recovery and data collection of marine mammals, including necropsies. In 2023, over $4 million was distributed through the Prescott Grant Program (the total amount varies annually as appropriated by Congress). As of 2023, Congress limited these grants to a maximum of $150,000 per organization per 12-month period (the average award in 2023 was $81,425). There is a supplementary federal fund distributed during Unusual Mortality Events (UMEs), when necropsies may be conducted more frequently or thoroughly. There are also non-federal funding sources, such as states, non-federal grants, and private individual or organization donors.

Detailed Answer

The cost of necropsies, specifically large whale necropsies and response to mass stranding events, can be very high, and includes costs of personnel, heavy machinery, and carcass disposal, among other things (see *How are necropsies conducted?*). Necropsy costs are typically covered by the individual Stranding Network organization that conducts the necropsy, and organizations may include non-profit organizations, academic institutions, or local, tribal, state, or federal government agencies. These organizations can apply for federal funding to help support necropsy activities and as members of the NOAA Stranding Network, organizations are eligible to apply for annual federal funding through NOAA Fisheries from the John H. Prescott Marine Mammal Rescue Assistance Grant Program.[25] This program was established as an amendment to the Marine Mammal Protection Act in 2000 and recently has provided approximately $2.7-3.8 million annually (2016-2022) for the recovery or treatment of marine mammals, as well as the collection of data from living or dead-stranded marine mammals, including conducting necropsies[26]. From 2001-2023, NOAA Fisheries awarded more than $75.4 million in funding through 839 competitive grants to Stranding Network organizations[27]. In 2023, NOAA Fisheries made 50 awards of funding to 21 organizations. As of June 2024, funding for future years is uncertain.[28]

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[25] John H Prescott Marine Mammal Rescue Assistance Grant Program: https://www.fisheries.noaa.gov/grant/john-h-prescott-marine-mammal-rescue-assistance-grant-program
[26] The amount of money allocated per fiscal year is subject to change per legislative actions including appropriations.
[27] Stranding Network organizations: https://repository.library.noaa.gov/view/noaa/50149
[28] Congressional budget: https://www.commerce.gov/sites/default/files/2024-03/NOAA-FY2025-Congressional-Budget-Submission.pdf

Supplemental federal funding is available during active Unusual Mortality Events (UMEs; see *What are strandings and Unusual Mortality Events?*) through the Marine Mammal Unusual Mortality Event Contingency Fund,[29] established in 1992. This fund permits the federal Marine Mammal Health and Stranding Response Program to acquire private donations to support the response and investigation into active UMEs. This fund may be distributed to stranding network partners as a reimbursement for responses during UMEs and specifically covers caring for and treating live-stranded animals, the collection and processing of live-animal and necropsy samples, analyses by diagnostic laboratories, and the collection of marine mammal health data.

In addition to federal funds, response organizations are also typically funded by non-federal sources, including state funding, local government funding, and contributions from private donors or organizations. For example, the state of Massachusetts has funded multiple organizations to increase support for stranding investigations, rescue and rehabilitation, and to support responses to large whale strandings (which require substantial time, effort, and personnel; see *How are necropsies conducted*?). This funding includes support for longer-term research on topics such as vessel strike avoidance, veterinary interventions, and reduction of marine mammal entanglement in lines, cables, or fishing gear. In addition to direct funding, local governments provide support via local infrastructure and response (e.g., fire departments). State-wide support initiatives such as the Whale License Plate in Massachusetts can support stranding response and necropsies.[30] As many Stranding Network organizations are non-profits and non-governmental, direct donations are also a component of their funding.

For more information

- NOAA Fisheries' Marine Mammal Health and Stranding Response Program: www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-health-and-stranding-response-program
- National Marine Mammal Entanglement Response Networks: www.fisheries.noaa.gov/national/marine-life-distress/national-marine-mammal-entanglement-response-networks

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.

[29] Marine Mammal Unusual Mortality Event Contingency Fund: https://www.fisheries.noaa.gov/national/marine-life-distress/marine-mammal-unusual-mortality-event-contingency-fund

[30] Massachusetts Whale License Plate Program: https://www.marshfield-ma.gov/sites/g/files/vyhlif3416/f/uploads/fy21_met_grants_press_release.pdf

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 2). 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 3).

Fixed foundation turbines comprise a number of important parts (Figure 2), 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.[31] 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.[32] 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 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).[33]

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,

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[31] More information: www.wind-energy-the-facts.org/offshore-support-structures-7.html
[32] Hywind Scotland: www.equinor.com/energy/hywind-scotland
[33] More information: http://www.nyserda.ny.gov/offshorewind

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.

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

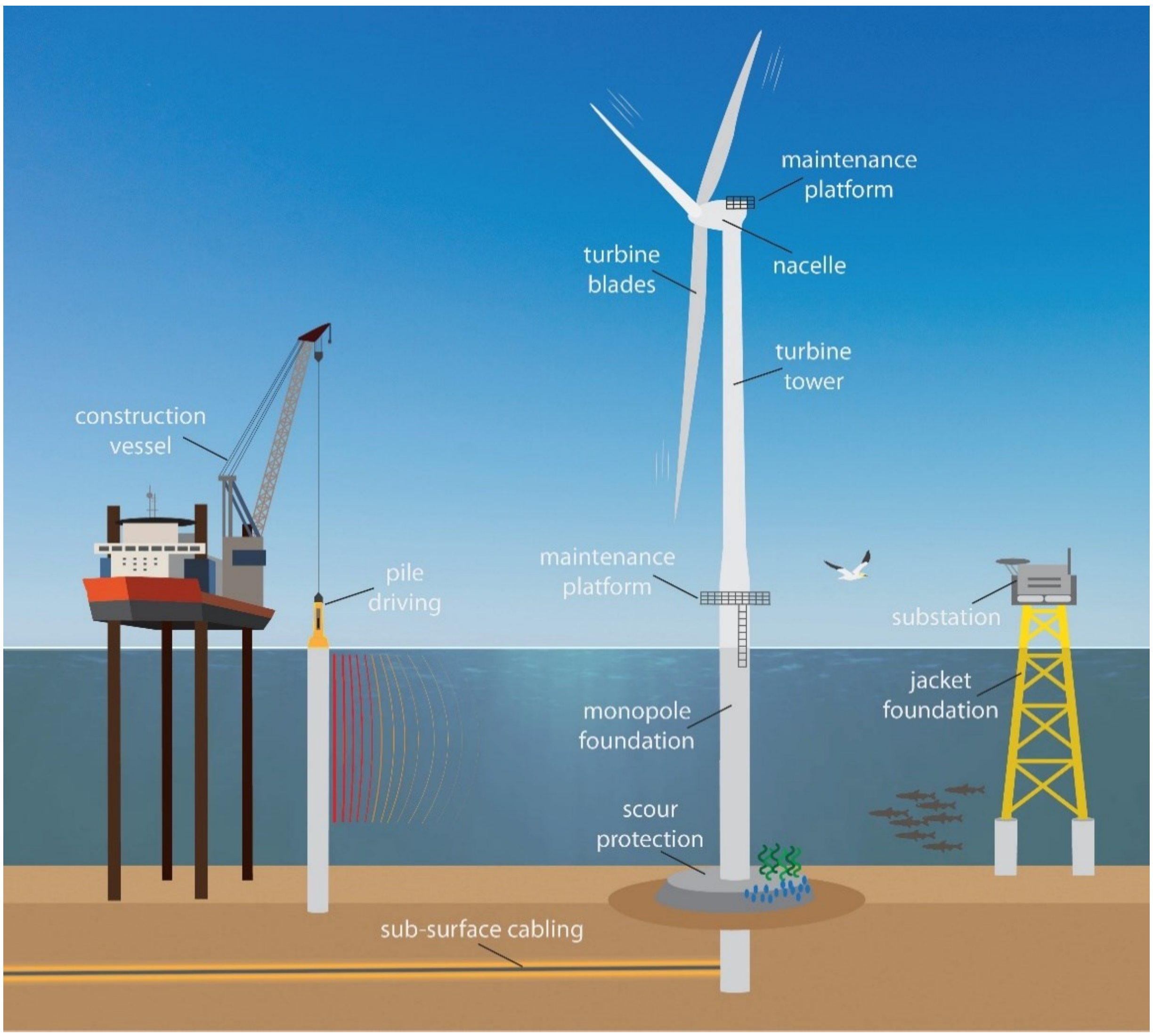

Figure 2. Components of an offshore wind farm. Source: Biodiversity Research Institute.

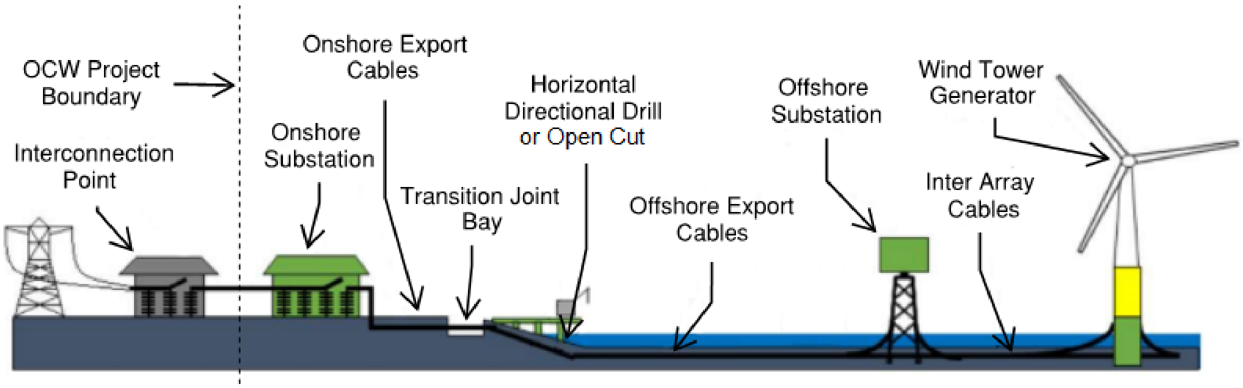

Figure 3. Diagram of main offshore wind project components. Source: HDR (https://media.fisheries.noaa.gov/2022-03/OceanWind1OWF_2022_508APP_OPR1.pdf).

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?* ; *What mitigation measures are being required by regulators in the U.S. for offshore wind?*).

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 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.[34] 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.[35] Vessel strikes are also a leading driver of the decline of North Atlantic right whales.

[34] ACP Whale Fact Sheet: https://cleanpower.org/wp-content/uploads/2023/02/ACP_WhaleFactSheet_230222.pdf
[35] This topic will be discussed in further detail in an upcoming FAQ response.

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.

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 4; 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.[36]

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

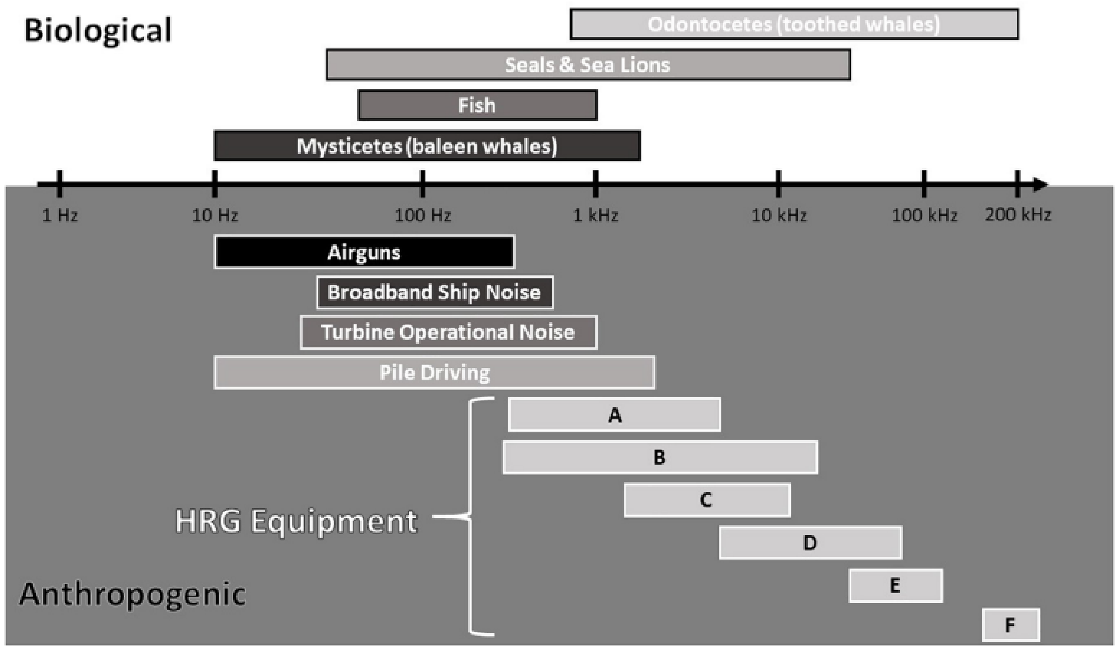

FIGURE 3 | This figure shows the frequency ranges over which groups of marine animals call (top) and the primary frequency ranges over which some anthropogenic sound sources (bottom) overlap. The frequency scale is on a logarithmic scale, expanding from 1 to 200,000 Hz. Mysticetes (baleen whales), such 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 4. 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. 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 Haver et al. 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 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 2014). The current North Atlantic right whale vessel speed rule applies to vessels 65 feet in length or greater (NOAA 2014); 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 2022b).

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 Regulatory Processes and Mitigation* 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

Does offshore wind energy development kill whales?

- There is no documented scientific evidence that offshore wind energy activities kill whales.
- While offshore wind energy development, like any marine development, has the potential to affect whales (see *What are the potential effects of offshore wind development on whales?*), the sounds produced during all phases (i.e., site assessment, construction, and operations) are insufficient to cause direct mortality. However, the sound emitted may impact hearing or behavior, and cumulation of sounds from anthropogenic sources may lead to chronic effects. There are various mitigation measures in place to reduce risk of potential impacts (see *What mitigation measures are being required by regulators in the U.S. for offshore wind?*)
- Collisions are a concern for all vessels in the marine environment across industries. Vessel collisions have the potential to injure or kill whales. However, offshore wind vessels comprise a very small portion of all vessels in the marine environment, and they operate in a more precautionary manner to avoid the types of collisions that occur with other industries, which reduces this risk (see *What mitigation measures are being required by regulators in the U.S. for offshore wind?*).

Detailed Answer

There is no documented evidence that offshore wind energy development activities kill whales. Most offshore wind development activities in the U.S. Atlantic to date have been related to site characterization (pre-construction activities to determine where to place turbines and cables, to identify the types of sediments in the local seabed, etc.). NOAA Fisheries (also known as the National Marine Fisheries Service [NMFS]), which is responsible for managing and protecting whales in the United States, has indicated that, "there is no scientific evidence that sound resulting from offshore wind site characterization surveys could potentially cause mortality of whales. There are no known links between recent large whale mortalities and ongoing offshore wind surveys."[37] The geophysical and geotechnical surveys conducted prior to construction of offshore wind farms do generate sound. Some of these sound sources have the potential to disturb cetaceans, though many of the sound sources used for offshore wind surveys are considered "*de minimis*" and unlikely to do so (Ruppel et al. 2022). The sound from these surveys is very different from the sounds produced by seismic air guns used for activities related to oil and gas and tactical military sonar both in terms of frequency and sound level (see *What are the potential effects of offshore wind development on whales?* for detailed sound frequencies from various anthropogenic activities). Lower levels of sound are emitted during offshore wind site characterization surveys and would not cause mortalities (Ruppel et al. 2022). There have been no strandings of any marine mammal associated with the types of equipment used in offshore wind surveys.[38] This is in contrast to other activities, where the

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[37] NOAA FAQs: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales

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

use of air guns for offshore oil and gas exploration and active sonar used by the military have both been linked to negative impacts to cetaceans (Balcomb & Claridge 2001, Parsons 2017, Bernaldo de Quirós et al. 2019, Mooney et al. 2020, Ruppel et al. 2022). In addition, the offshore wind industry uses various mitigation measures, including observers on vessels[39], to reduce the potential impacts to marine mammals during site characterization surveys (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?*).

Sound is also generated during offshore wind farm construction, particularly during turbine foundation and substation installation (e.g., pile driving). While this sound has the potential to affect cetacean behavior, it is not predicted to occur at levels that would cause mortalities. Additionally, sound could permanently or temporarily affect whale hearing capabilities if an animal is within close proximity to the pile-driving activity and does not move away from the activity. The exact distance at which sound affects marine mammals varies based on numerous factors, including the characteristics of the sound (e.g., duration, frequency, volume) and the environment, along with the species' hearing capabilities and diving behavior; this information is used to define mitigation zones. Odontocetes (i.e., toothed whales) are considered mid-frequency cetaceans and are more sensitive to pile driving sound than low frequency cetaceans (e.g., baleen whales), though both groups have the potential to be affected (see *What are the potential effects of offshore wind development on whales?*). NOAA has produced technical guidance (NMFS 2018) to predict how marine mammal hearing is affected by sound exposure. These characteristics, among other factors, are used to estimate the mitigation and monitoring zones during these sound-generating activities (see *What mitigation measures are being required by regulators in the U.S. for offshore wind?*). Sound from operational turbines is substantially quieter and typically does not significantly exceed background noise levels (Amaral 2020). While it is possible that these sounds could result in behavioral change in some circumstances, the scale of these potential effects is small.

The other main source of concern for whales in relation to offshore wind energy development is vessel traffic, which is a risk across all maritime industries. Vessel collisions can kill baleen whales, especially large vessels traveling at high speeds (Vanderlaan & Taggart 2007, Currie et al. 2017). Recent analyses and documented interactions between large whales and vessels suggest that smaller vessels operating at high speeds may also cause lethal injury (Stepanuk et al. 2021, NOAA 2022b). NOAA Fisheries instituted a vessel speed restriction rule in 2008 to specifically protect North Atlantic right whales, which 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; these locations are termed seasonal management areas (SMAs;[40] NOAA 2014b). Voluntary dynamic management areas (DMAs) and slow zones are also designated when North Atlantic right whales are observed outside of the geographic extent or effective period of SMAs. DMAs are designated specifically when reliable sightings are obtained of three or more right whales within a 75 square nautical mile area (Silber et al. 2012), while the designation of a slow zone happens based on detections via passive acoustic monitoring. Mariners are encouraged to avoid these areas if possible, or to reduce speeds to 10 knots or less while transiting through these areas.

While the vessel speed rule was initially effective in reducing vessel strike risk to North Atlantic right whales, climate-driven shifts in the species distribution outside of the SMAs has caused the number of

[39] Additional FAQ *What are Protected Species Observers and what data do they collect?* forthcoming
[40] Seasonal Management Areas: https://www.fisheries.noaa.gov/resource/map/north-atlantic-right-whale-seasonal-management-areas-sma

vessel strikes to again increase, and more information has become available on the lethal risk posed by vessels less than 65 feet in length (Garrison et al. 2022). These changes led NOAA Fisheries, in 2022, to announce proposed changes to the vessel speed rule to further reduce the likelihood of vessel collisions (NOAA 2022b). In the meantime, BOEM, the federal agency that oversees offshore wind energy development, already made most of these proposed rules mandatory for most offshore wind related vessels, ensuring that the offshore wind industry uses more protective measures for whales than any other anthropogenic activities in marine waters of the United States (see *What mitigation measures are being required by regulators in the U.S. for offshore wind?*). While the focus of these protections is often the endangered North Atlantic right whale, this also serves to benefit other marine mammals.

Offshore wind energy development increases vessel activity during construction activities by 6.82-36.41 vessel hours per month as compared to the preconstruction period (n=3 wind farms; Bishop 2024). During operation, vessel density decreases from the construction period and is only 2.52-4.98 vessel hours per month higher than pre-construction levels (Bishop 2024).

Offshore wind development projects are required to obtain authorizations from NOAA, called one-year incidental harassment authorizations (IHAs) or five-year incidental take regulations (ITRs) that are accompanied by a Letter of Authorization (LOA), for activities that could impact whales. The authorizations are required of any industry or individual that wishes to conduct an activity that could incidentally impact whales, including fisheries and other maritime users. However, these authorizations are only granted if the activities are likely to have no more than a "negligible impact" on the species or stock.[41] Under the U.S. Marine Mammal Protection Act (MMPA), energy infrastructure projects can apply for authorizations for incidental (e.g., non-intentional) harassment of marine mammals, where "harassment" is defined as 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. §1362). Level A harassment only applies to the potential for "non-serious" injury.[42,43] "NOAA Fisheries does not anticipate and has not authorized—or proposed to authorize—mortality or serious injury of whales for any wind-related action. Offshore wind developers have not applied for, and NOAA Fisheries has not approved, authorization to kill any marine mammals incidental to offshore wind site characterization surveys or construction activities."[44] As of March 2024, over a dozen offshore wind projects have active IHAs for site characterization and five have active ITRs and LOAs for construction activities, resulting in a NOAA Fisheries determination of 'negligible impact,' with many additional past issuances for both site characterization and construction.[45] The IHAs and ITRs only consider take from a single activity or project, rather than across projects, when determining a proposed action's negligible impact level. However, NOAA factors into their analysis both past and ongoing anthropogenic activities via their impact on the

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[41] Incidental Take Authorizations under the MMPA: https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act

[42] NOAA FAQs: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales

[43] More information on the MMPA: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act

[44] NOAA FAQs: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales

[45] Active Incidental Take Authorizations: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-other-energy-activities-renewable#active-authorizations

baseline (e.g., as reflected in the density, distribution, and status of the species, population dynamics, and other relevant stressors)[46].

Finally, while there have been recent unusual mortality events for several baleen whale species along the Atlantic coast of the United States (see *What are strandings and Unusual Mortality Events?* and *Why are baleen whales dying right now in the Northwest Atlantic and is this a new phenonmenon?)*, this pattern dates back to 2016, before most offshore wind energy activities began in the U.S. This was after the Block Island Wind Farm was already operational in Rhode Island state waters. The first site assessment plans in the Massachusetts/Rhode Island region were not approved until October 2017.[47] As such, current evidence suggests that these strandings are not connected to offshore wind development activities but rather relate to a combination of natural and anthropogenic factors, including increases in population size (humpback whales) and shifting prey and whale distributions inshore, leading to increased interactions with vessels (see *Why are baleen whales dying right now in the Northwest Atlantic and is this a new phenomenon?*).

For More Information

- NOAA FAQ on offshore wind and whales: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales
- Additional information on right whales and vessel strikes, including vessel speed rules: https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales#proposed-modifications-to-right-whale-speed-rule.

Offshore Wind Regulatory Processes and Mitigation

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

[46] More information on incidental take: https://www.federalregister.gov/documents/2023/07/26/2023-15817/takes-of-marine-mammals-incidental-to-specified-activities-taking-marine-mammals-incidental-to

[47] Site assessment plan approval for OCS-A-0486: https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/RI/SIGNED_BOEM-to-DWW_SAP-Approval-for-OCS-A-0486_101217-%281%29.pdf

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.[48] 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.

[48] More information: 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,[49] 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

[49] NOAA Incidental Take definition: 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

harassed for select activities in specific places. The authorization of incidental take may be granted if, after public comment, it is found that:

- 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.[50] 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

[50] 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.

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 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 5).

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 20^{th} 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.

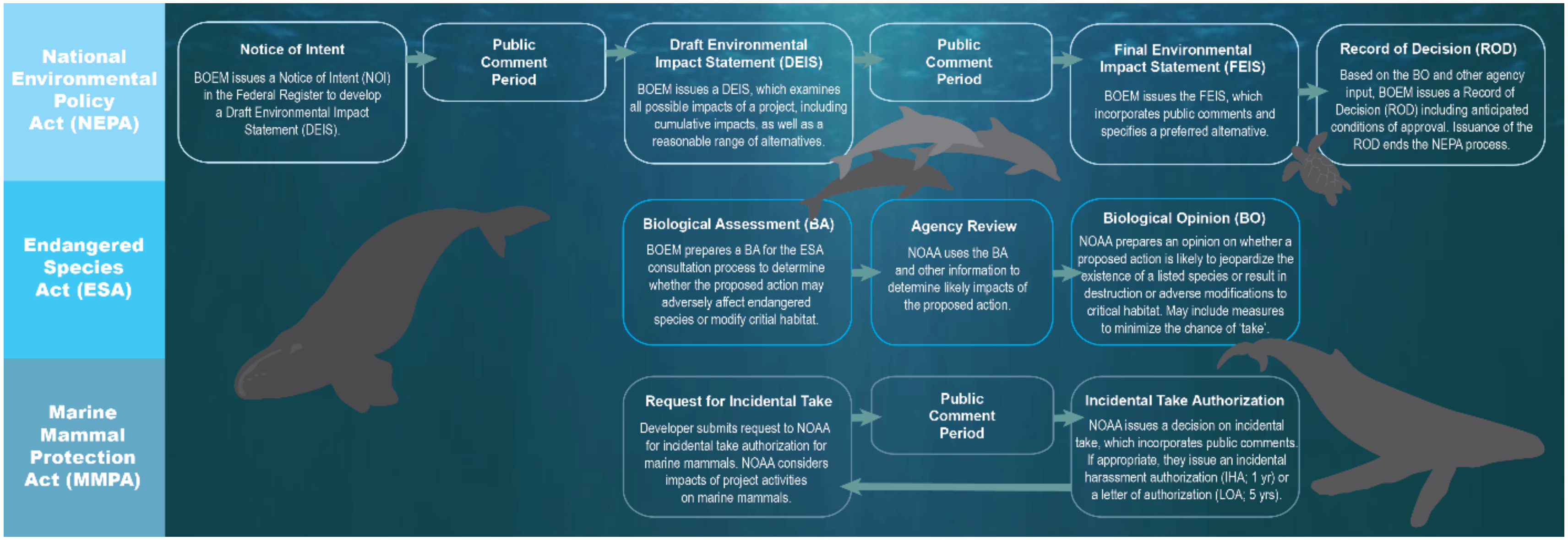


Figure 5. Key U.S. environmental laws protecting whales, and the major steps involved in implementing regulatory assessments and mitigation measures for OSW under each law. The steps described in this graphic focus on the steps in the permitting process following site assessment as well as those during 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

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 2). 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 2. 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

<u>Temporal and Spatial Restrictions</u>

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).

Mitigation Monitoring

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 (NMFS 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 (Compton et al. 2008, Joint Nature Conservation Committee 2017). 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 *What are the potential effects of offshore wind 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 6), 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.

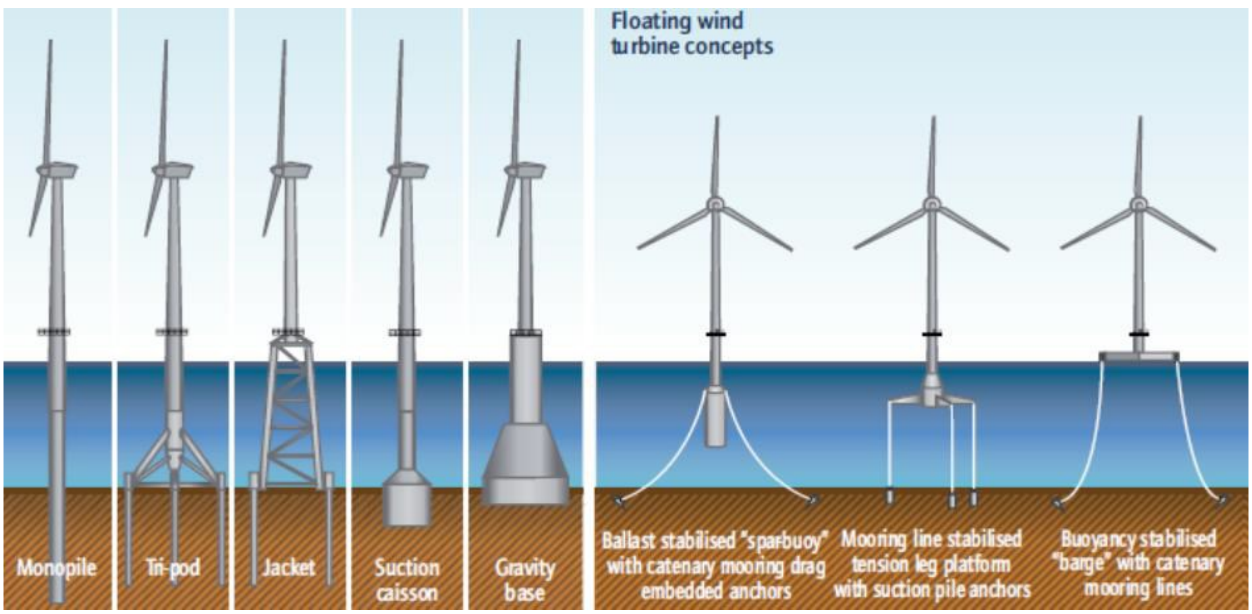
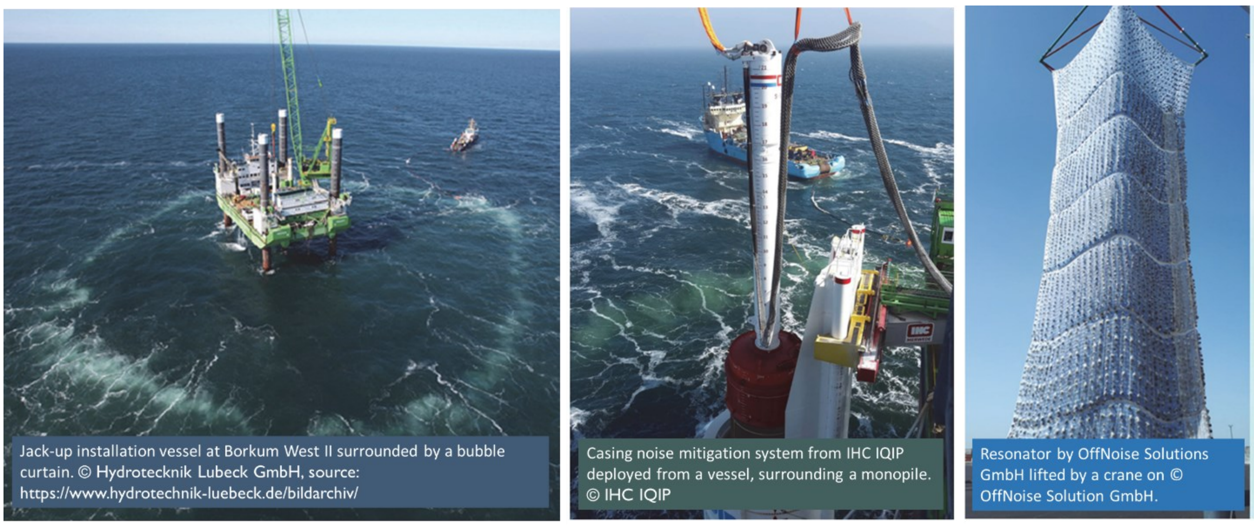


Figure 6. Fixed and floating turbine foundation designs. From Konstantinidis & Botsaris (2016; available via CC by 3.0).

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.[51] (casings are currently not commercially available for the size of turbine currently being installed in the U.S.). 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 7. 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[52] (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

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

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

under the regulatory control of BOEM and NOAA, involvement and approval by the International Maritime Organization[53] 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 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 2022b). 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 (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 2022b). 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.[54] 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

[53] IMO Ship Routing Information: https://www.imo.org/en/OurWork/Safety/Pages/ShipsRouteing.aspx

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

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.

What mitigation measures are being required by regulators in the U.S. for offshore wind?

- The details of requirements for specific offshore wind projects varies based on permit requirements from the Bureau of Ocean Energy Management (BOEM) and can be found in various permitting documents including the Construction and Operations Plan Approval[55] and the Record of Decision.[56] In general, these requirements relate to reducing collision risk from vessels and impacts from sound during construction.
- To reduce vessel-related impacts, requirements generally include vessel speed restrictions (10 knots or less during certain periods of the year) and dedicated observers on vessels (when traveling above 10 knots).
- Generally, requirements related to reducing sound-related impacts during construction activities include temporal restrictions on pile-driving activities, mitigation measures during pile driving (e.g., Protected Species Observers and passive acoustic monitoring), ramp-up/soft start during sound-generating activities, and use of sound abatement systems (e.g., bubble curtains) during pile driving.
- Offshore wind mitigation and monitoring requirements are much more stringent than those for other maritime industries such as shipping.

Detailed Answer

Mitigation for marine mammals at offshore wind facilities is determined on a site-by-site basis through various permitting processes. BOEM, for example, identifies conditions associated with approval of offshore wind farm Construction and Operations Plans (COPs) and these conditions include a range of mitigation measures. Additional information may also be available in the Record of Decision (ROD). NOAA Fisheries also includes required mitigation measures in their Biological Opinions for offshore wind projects (for species listed under the U.S. Endangered Species Act) and incidental take authorizations which authorize the taking of marine mammals, such as by behavioral disturbance, incidental to conducting certain activities for certain specified numbers of marine mammals under the U.S. Marine Mammal Protection Act (MMPA; see *What federal and international environmental laws protect whales?* for the definition of take). The specific mitigation requirements for each offshore wind project are based on multiple factors, including geography and local/regional abundance/occurrence of species, as well as characteristics of the pile installation (e.g., number, size, timing, use of sound attenuation devices; BOEM 2021, 2022, 2023). However, there are types of marine mammal mitigation requirements that apply to all offshore wind facilities, including mitigation measures related to reducing collision risk from vessels and reducing sound emitted during construction activities. Many of the mitigation measures described in "What are the available mitigation measures to avoid or minimize OSW effects on marine mammals?" (this document) are required of offshore wind developers. To reduce vessel-related impacts, requirements

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[55] Example Construction and Operations Plan Approval for Vineyard Wind 1: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/VW1-COP-Project-Easement-Approval-Letter_0.pdf

[56] Example Record of Decision for Vineyard Wind 1: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Final-Record-of-Decision-Vineyard-Wind-1.pdf

include vessel speed restrictio51ns at times of year when North Atlantic right whales may be most at risk, as well as dedicated Protected Species Observers on vessels. Mitigation requirements for reducing sound-related impacts include temporal restrictions on pile-driving activities, mitigation measures via Protected Species Observers and passive acoustic monitoring during pile-driving, ramp-up/soft start during sound-generating activities, and use of noise abatement systems during pile-driving activities.

Reducing vessel-related impacts

Vessel Speed Restrictions

All OSW project vessels, regardless of size, must travel at 10 nautical miles per hour (knots) or less when transiting to, from, or within the project area (with some geographic exceptions) during certain periods of the year when North Atlantic right whales are consider to be most at risk (generally Nov-April/May, but exact dates vary; BOEM 2021, 2022, 2023), with a few exceptions if allowed by permits (see below). In addition to these time windows, project vessels must also travel at a speed of 10 knots or less in Seasonal Management Areas (SMAs) and Dynamic Management Areas (DMAs) when they are in place. The SMAs and DMAs are areas identified by NOAA as part of the implementation of broader vessel speed regulations designed to protect North Atlantic right whales. These rules currently apply to all vessels 65 feet or longer, regardless of vessel type (NOAA 2014). SMAs aim to cover high-risk areas where North Atlantic right whales consistently occur, including migratory routes and calving grounds. In addition, DMAs are designated when right whales are observed outside of the geographic extent or effective period of SMAs, and specifically when reliable sightings are obtained of three or more right whales within a 75 square nautical mile area (Silber et al. 2012). The size of a DMA is commensurate to the number of whales present and is put in place for 15 days. While vessel speed restrictions in DMAs are voluntary for other industries, they are required for OSW development-related vessels.

Recently, NOAA also approved the use of near real-time passive acoustic detections of North Atlantic right whales to designate additional vessel speed reduction areas (North Atlantic Right Whale Recovery Plan Northeast U.S. Implementation Team,[57] Murray et al. 2022). Combined, visually triggered DMAs and acoustically triggered areas are termed “Slow Zones”. Increased vigilance and vessel speed reduction to 10 knots is either encouraged or required (varies by project). Technologies such as WhaleAlert[58] help provide near real-time information on sightings of marine mammals and the location of DMAs and slow zones.

Some projects have exceptions to vessel speed restrictions that are specific to crew transfer vessels, which are vessels that bring operations and maintenance personnel from shore to the offshore wind farm to conduct maintenance activities (BOEM 2021). These exceptions to vessel speed restrictions are only granted with a North Atlantic Right Whale Strike Management plan that has been approved by BOEM and NOAA Fisheries. These plans vary but may require additional observers on vessels to scan for marine mammals in the vicinity, as well as real-time passive acoustic monitoring to detect animals that may be present. If a North Atlantic right whale is observed within or approaching the transit route, vessels must travel 10 knots or less until clearance of the route for one to multiple days (exact timing varies).

Dedicated observers on vessels and strike mitigation

Offshore wind vessel operators and crew members must maintain a vigilant watch for marine mammals and reduce vessel speed, alter course, and stop, if necessary, to avoid striking a marine mammal. The

[57] North Atlantic Right Whale Recovery Plan Northeast U.S. Implementation Team: https://www.fisheries.noaa.gov/new-england-mid-atlantic/endangered-species-conservation/north-atlantic-right-whale-recovery-plan-northeast-us-implementation-team

[58] Whale Alert App: https://whale-alert.io/

distance at which these strike mitigation measures are implemented varies by marine mammal species/group. Crew members must be trained in identification, strike avoidance techniques, and reporting of all marine mammals (including live, entangled, and dead individuals) to designated vessel contacts, who in turn handle reporting requirements detailed below. In addition, all project-related vessels traveling at speeds higher than 10 knots must have a dedicated visual observer on duty at all times to monitor a strike avoidance zone around the vessel. Visual observers may be professional Protected Species Observers (PSOs)[59] who conduct these types of observations for a range of industries, or they may be crew members. Regardless, they must be adequately trained in identification and reporting (see below). As part of strike mitigation protocol, at times when vessel speed restrictions (above) are not applicable, vessel operators must reduce vessel speeds to 10 knots or less when "mother/calf pairs, pods, or large assemblages of cetaceans" are observed within the path of the vessel (BOEM 2021). In addition, vessels must maintain certain distances from marine mammals (50-500 m, depending on the species) and implement strike avoidance if animals approach or are detected closer than these distances. There are also requirements related to communication and reporting of sightings, whereby observations of ESA-listed species must be communicated in near real-time across project vessels that are operating concurrently, and North Atlantic right whale sightings must be immediately reported to federal agencies. All stranded, entangled, dead or injured marine mammals that are detected during observations (regardless of whether the death/injury was related to project activities), (see *What federal and international environmental laws protect whales?* for more information on take) any vessel strikes caused by project vessels, or death or non-auditory injury caused by project activities must also be reported to federal agencies immediately (BOEM 2022).

Reducing sound impacts during construction

Temporal and spatial restrictions

There are time-area restrictions for pile driving of turbine and substation foundations to avoid generating large amounts of underwater sound during key periods when North Atlantic right whales are expected to be present. No pile driving can occur during certain months of the year (varies by location, but generally Dec/Jan-April) when North Atlantic right whales are predicted to be most likely to be in or near the construction area. There also may be time-of-day restrictions whereby pile driving cannot commence until at least 1 hour after civil sunrise and 1.5 hours before civil sunset (to minimize the potential for pile driving to continue after civil sunset when visibility is impaired and zones cannot be effectively visually monitored). Time-of-day restrictions may only be relaxed upon approval of an Alternative Monitoring Plan by BOEM and NOAA Fisheries that demonstrates effective monitoring of marine mammals during nighttime conditions. For some projects there are also restrictions related to the number of monopile foundations allowed to be installed per day (BOEM 2023). In addition, if a DMA or Slow Zone is designated in the vicinity of an active construction area, passive acoustic monitoring must be extended to the largest practicable detection zone for North Atlantic right whales (e.g., extending beyond the established clearance and shutdown zones if possible; BOEM 2022). This is required if a DMA or Slow Zone is within a certain distance of pile driving (between 3.2 and 4.1 km, depending on the type of turbine foundation and amount of sound generated when it is driven into the seabed), or if the DMA/Slow Zone overlaps with established clearance and shutdown zones around pile-driving activity (see below).

[59] FAQ forthcoming *What is a PSO and what data do they collect?*

Mitigation measures

Mitigation monitoring of various impact zones around pile-driving activities is required across projects and is detailed in each offshore wind facility's Foundation Installation Pile Driving Marine Mammal Monitoring Plan and Passive Acoustic Monitoring (PAM) Plans. These Plans include both visual monitoring via PSOs and PAM. PAM must demonstrate near-real-time capability of detections within a certain distance from the pile-driving location (5-10 km, varies by project; BOEM 2021, 2022, 2023). In general, there are monitoring, clearance, and shutdown zones that are visually and acoustically monitored for the presence of marine mammals (note the size of visual clearance and PAM clearance zones vary). Monitoring zones may be larger and are often defined by regulatory Level A and B harassment zones (estimated for each project based on acoustic modeling and NOAA-defined sound thresholds and approved by NOAA Fisheries). For the monitoring zone, the presence of animals is recorded to estimate the number of animals that have been exposed to the activity, but pile driving is not necessarily required to stop if animals are detected in the monitoring zone (depending on the incidental take authorization). The clearance zone represents the area where animals cannot be present for 30-60 minutes prior to the commencement of pile driving and overlaps with the monitoring zone. Finally, the shutdown zone is the area within which stoppage of pile driving must occur (if safe to do so) with the detection of marine mammals (E-TWG Marine Mammal Specialist Committee 2020). The size of these three zones is defined by species group (see Table 3 as example). These zones are refined based on field measurements of sound generated during installation of certain piles. There are various requirements related to visual monitoring, including PSO qualifications, number of PSOs, vantage points, and other aspects. In addition, pile driving can only commence when the clearance zones are fully visible for at least 30-60 minutes, and there must be an Alternative Monitoring Plan in place (and approved by BOEM and NOAA Fisheries) for enhanced monitoring if poor visibility conditions unexpectedly arise or if pile driving must continue into the night. In areas with higher North Atlantic right whale activity, there may also be requirements for vessel-based and/or unmanned aerial surveys and additional passive acoustic monitoring to occur for a certain period of time prior to the start of pile-driving activities.

Table 3. Example of clearance and shutdown zones by species for the Southfork Project. The minimum visibility (representing the visibility conditions required for observations to occur, when visibility is reduced below this range due to ambient weather conditions, pile driving cannot occur) is 2,200 m. Sources: NOAA 2022, BOEM 2023

Species	Type of Detection	Clearance Zone (m)	Shutdown Zone (m)
North Atlantic right whale	Passive acoustic monitoring	5,000	2,000
North Atlantic right whale	Visual	Any distance	Any distance
Fin, sei, humpback, minke, and sperm whales	Visual	2,200	2,000
Harbor porpoise	Visual	450	450
Dolphins, long-finned pilot whale	Visual	100	50
Gray and harbor seal	Visual	150	150

Ramp up/Soft-start

All offshore wind energy projects in the United States to date are required to use soft-start procedures during pile driving (construction) and geological and geophysical surveys (site characterization). This is intended to "ramp up" the amount of underwater sound being generated, to allow marine mammals and other wildlife more time to leave the vicinity of the activity. While the exact procedures vary, more recent requirements include a minimum of 20 minutes of 4-6 strikes per minute at 10-20 percent of the maximum hammer energy (BOEM 2023), before both the strike frequency and hammer energy can be raised to full strength. Soft starts are required for each new pile, as well as when pile-driving activities restart after >30 minutes of stoppage.

Sound abatement systems

Use of noise abatement systems are required for most projects that have turbine and substation foundations comprised of monopiles or pin piles (e.g., individual legs of a jacket foundation; see *What are the major components of an offshore wind farm?* for description of foundation types). These systems are deployed during pile driving of turbine foundations to reduce the distance and duration that resulting sound travels through the water and minimize potential acoustic impacts to wildlife. The system proposed and used to date in the United States included a combination of a double bubble curtain with a near-field sound mitigation system based on Helmholtz resonator technology (BOEM 2021, 2022, 2023; for more information, see *What are the available mitigation measures to avoid or minimize offshore wind effects on marine mammals?*). In addition, all projects are required to develop and implement a Pile Driving Source Verification Plan that includes conducting field verification of sound attenuation during pile driving and requires the modification of the initial monitoring, clearance, and/or shutdown zones, if needed, based on the results. As the first commercial-scale offshore wind farms in the U.S. Atlantic complete construction activities, sound verification data from these systems will become available to inform the use of noise abatement systems moving forward.

What are Protected Species Observers and what data do they collect about marine mammals?

- Protected Species Observers (PSOs) are trained professionals who monitor marine animals that are federally protected under the Endangered Species Act (ESA) and/or Marine Mammal Protection Act (MMPA). This monitoring occurs in relation to anthropogenic activities and helps a wide range of entities comply with federal requirements.
- There is a certification process and standards for PSO training, and credentials of individuals are reviewed by NOAA Fisheries for specific projects to ensure they have appropriate training and/or experience to perform the necessary duties.
- PSOs collect data to inform implementation of marine mammal mitigation measures for a variety of activities associated with offshore wind energy development and to enhance the understanding of potential OSW impacts on marine mammals. Data include sightings of live, entangled, or dead marine mammals; marine mammal sightings to inform implementation of a mitigation measure (such as changing a vessel speed/trajectory or shutting down a sound-generating activity when animals are present in the vicinity); a record of PSO observation effort and methods; and offshore wind farm operations data (e.g., project name, location, details about active acoustic sources).
- The federal agencies who receive PSO data and reports from offshore wind projects include NOAA Fisheries, the Bureau of Ocean Energy Management (BOEM), and the Bureau of Safety and Environmental Enforcement (BSEE).

Detailed Answer

Protected Species Observers (PSOs) are trained professionals who monitor for marine animals that are federally protected under the Endangered Species Act (ESA) or Marine Mammal Protection Act (MMPA). The overarching goal for PSOs is to assist in efforts to minimize or eliminate impacts of human activities on protected species for various entities to meet their regulatory compliance needs[60]. PSOs monitor construction, demolition, pile driving, detonations, geophysical and seismic surveys, and military activities, among others. Protected marine species include all species of marine mammals, all species of sea turtles, and species of manta rays, sharks, salmonids, and sturgeon that are ESA-listed.

PSO duties include monitoring during sound-generating activities to detect marine mammals that are in the vicinity (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?* and *What mitigation measures are being required by regulators in the U.S. for offshore wind?*) and direct the implementation of applicable mitigation measures for such activities, when needed. Data from PSOs also help federal agencies evaluate the effectiveness of mitigation and monitoring efforts. The results from PSO data may lead to revised mitigation or monitoring measures for existing projects, assist in the development of mitigation and monitoring measures for future projects, or contribute to efforts to better understand the impacts or benefits of anthropogenic projects in the marine environment (BOEM 2024).

To become a PSO, an individual must undertake specialized training and be approved by NOAA Fisheries (Baker et al. 2013). NOAA Fisheries reviews the credentials of potential PSOs to determine whether they have the appropriate training or experience to perform the necessary project-specific duties. PSO training includes identification of marine mammals, sea turtles, and other protected species; understanding of legislative and regulatory requirements; vessel strike avoidance and reporting protocols; how and when to communicate with the vessel captain; information about the authority of the PSOs to change or halt project operations to protect animals; and how to implement all required mitigation measures effectively. PSOs are independent observers, and therefore are not direct employees of the entity utilizing their service.

The federal agencies that designate PSO qualifications, duties, and other operational and reporting protocols for particular activities related to offshore wind energy include NOAA Fisheries, BOEM, and U.S. Fish and Wildlife Service (USFWS). Detailed information about PSO duties for individual projects are designated in various federally-issued permits, authorizations, and approvals for those projects, such as incidental take authorizations (required under the MMPA), construction and operations approvals, lease requirements, and Environmental Impact Statements (required under the National Environmental Policy Act; for more information about these regulatory and permitting documents, see *What marine mammal-related permits, approvals and authorizations do offshore wind developers get?*)[61]. PSO duties may include:

- Monitoring for marine mammals approaching or within certain distances of activities such as geophysical surveys and impact and vibratory pile-driving. Authorizations typically require a pre-specified clearance and/or shutdown zone around such activities, and the activity will be delayed or will cease if a PSO reports a protected animal within the relevant zone (see *What mitigation measures are available to avoid or minimize OSW effects on marine mammals?* for more details on clearance, shutdown, and vessel-strike avoidance zones).
- Monitoring for marine mammals in the vessel strike avoidance zone.

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[60] More information on PSOs: https://www.fisheries.noaa.gov/national/endangered-species-conservation/protected-species-observers
[61] Central Atlantic Offshore Wind Activities: https://www.boem.gov/renewable-energy/state-activities/central-atlantic

- Reporting sightings of North Atlantic right whales to NOAA Fisheries, US Coast Guard, BOEM, BSEE, and the WhaleAlert app[62].
- Reporting sightings of dead, injured, and entangled marine mammals to the NOAA Fisheries stranding hotline.
- Collecting and reporting data on all marine mammals observed and for which mitigation was implemented.
- Communicating relevant information with project and vessel crews. This includes ordering the crew to shut down activities, if necessary, based on the requirements of the authorizations.

PSOs are used for mitigation monitoring of sound-generating offshore wind development activities (e.g., site assessment surveys, turbine installation; see *What mitigation measures are being required by regulators in the U.S. for offshore wind?*). The types of data that PSOs collect for activities associated with offshore wind development include sightings and detections of all observed marine mammals for mitigation purposes (e.g., date, time, geographic location, species, total number of individuals in a group/pod, age class, behavior, distance and bearing to the sighting), observation effort (e.g., duration and location of monitoring, monitoring method, environmental conditions that may affect detectability), and operations (e.g., details about active acoustic sources, including hours of activity, to provide context for the level of disturbance; mitigation implementation; Ganley et al. 2024). The particular data fields that PSOs need to record and the reporting requirements are specific to each project, and are comprehensively detailed in the project's Construction and Operations Plan Approval letter and in Incidental Take Authorizations. For an example of a comprehensive list of the data types collected by PSOs for OSW construction, see BOEM (2023).

Data collected by PSOs are required to be submitted to federal agencies, including NOAA Fisheries, BOEM, and BSEE. Incidental Take Authorizations require PSO data be summarized in monitoring reports to NOAA Fisheries[63], for example. However, they do not require the underlying data to be made publicly available, an issue that was noted in a recent study that tried to use PSO data to better understand whale distributions (Ganley et al. 2024). Federal agencies receive and archive the data, but inconsistencies in these data make them difficult or impossible to use in broader analyses at present (Ganley et al. 2024). BOEM is currently funding the development of a PSO database[64] to better organize these data for use in broader research and analysis efforts.

What marine mammal-related permits, approvals and authorizations do offshore wind developers get?

- The Bureau of Ocean Energy Management (BOEM) is responsible for permitting offshore renewable energy development in federal waters under the Outer Continental Shelf Renewable Energy Program (authorized by the Energy Policy Act of 2005). Offshore wind project federal permitting and authorizations relating to marine mammals are under the purview of BOEM, NOAA Fisheries, and the Bureau of Safety and Environmental Enforcement (BSEE).

[62] Whale Alert: https://www.fisheries.noaa.gov/resource/tool-app/whale-alert
[63] Available at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-other-energy-activities-renewable
[64] Protected Species Database and Information Management (boem.gov)

- The permitting process includes separate approvals for site assessment activities, construction and operation activities, Endangered Species Act (ESA) consultations, and incidental take authorizations under the Marine Mammal Protection Act (MMPA). All of these approvals and/or consultations aim to assess the level of impact of project activities and identify required mitigation measures (including avoidance and minimization efforts).
- Incidental Take Authorizations (ITAs) granted by NOAA Fisheries under the MMPA and Incidental Take Statements granted under the ESA, are required for activities such as site assessment surveys and construction activities that could impact marine mammal species or stocks. Authorizations are only granted if the activities would:
    - MMPA: take “small numbers” of marine mammals and be likely to have no more than a “negligible impact” on the species or stock. In the authorization, the agency prescribes permissible methods of taking and other means (e.g., mitigation measures) of effecting the least practicable adverse impact on the affected species or stocks and their habitat
    - ESA: either not be likely to adversely affect the species or critical habitat, or if there are expected to be adverse effects, that the activity would not Jeopardize the species or critical habitat.

Detailed Answer

Under the Outer Continental Shelf Renewable Energy Program, authorized by the Energy Policy Act of 2005, the Bureau of Ocean Energy Management (BOEM) is responsible for permitting offshore renewable energy development in federal waters (which include ocean waters from 3-200 nautical miles from shore for U.S. Atlantic states). Under this Act, BOEM is responsible for ensuring that projects are developed in environmentally responsible ways and to consider other uses of the Outer Continental Shelf. BOEM is also required to coordinate with relevant federal agencies, as well as state and local governments. Within three miles of the shoreline, states control marine waters and have their own environmental permitting processes for marine industries. The development of offshore wind energy in the U.S. is thus guided by both federal and state permitting processes, which require years of data collection and stakeholder engagement and multiple opportunities for public comment. Permitting and authorizations relevant to marine mammals fall under the purview of BOEM and NOAA Fisheries[65] (Table 4), with a range of additional permits from other federal agencies for aspects not relevant to marine mammals (e.g., U.S. Coast Guard approval for navigation lighting). Project components located within state boundaries (e.g., on land and within three nautical miles from shore) must also abide by state laws and regulations (but state law does not supersede federal authority under the MMPA and ESA). State authorizations and consultations are state-specific but typically include permits related to transmission landing, coastal environmental impacts, and underwater cables in state waters.

The permitting process for an individual wind project begins once a lease has been obtained from BOEM and includes site assessment and construction and operations plans (SAP and COP, respectively). In addition to the SAP and COP process, developers must also apply for and receive incidental take authorizations from NOAA Fisheries under the Marine Mammal Protection Act (MMPA) for potential take resulting from activities during either of these phases that could impact marine mammals, and Section 7 consultations occur under the Endangered Species Act (ESA) for protected species and critical habitat.

[65] The U.S. Fish and Wildlife Service, rather than NOAA Fisheries, is responsible for the protection of certain marine mammal species such as sea otters that are relevant to offshore wind energy development in some geographic regions (such as the U.S. Pacific).

While not specific to marine mammals, the Facility and Design Report (FDR) and Fabrication and Installation Report (FIR) delineate any measures required as a result of these earlier consultations and must be submitted by the developer and approved by the Bureau of Safety and Environmental Enforcement (BSEE) before construction is allowed to commence.

Table 4. Permitting and consultation requirements for offshore wind developers that are specifically applicable to marine mammals. Modified from NYSERDA (https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Permitting)

Permitting/Consultation Requirement	Federal Regulatory Agency
Receive approval for a Site Assessment Plan (SAP)	BOEM
Receive approval for a Construction and Operations Plan (COP)	BOEM
Consultations under the Endangered Species Act. Resulting Biological Opinion includes an incidental take statement (ITS), when applicable	NOAA Fisheries
Apply for/receive an incidental take authorization (ITA) under the Marine Mammal Protection Act	NOAA Fisheries

The steps in this process relevant to marine mammals are detailed below (Figure 8). The National Environmental Policy Act (NEPA), MMPA, and ESA processes are all interdependent and require much of the same information for a particular project to ensure that both BOEM and NOAA Fisheries meet their regulatory requirements under these statues. As such, this process requires a high level of coordination among federal agencies and the offshore wind energy developer.

Site Assessment Plan (SAP)

Offshore wind developers may be required to submit a Site Assessment Plan to BOEM that provides a description of proposed site assessment data collection activities, including details related to the construction and installation of a meteorological tower on the site, as well as planned geophysical and geotechnical surveys of the ocean bottom, and any other 'site assessment activities', which are defined as "those initial activities conducted to assess an area on the OCS, such as resource assessment surveys (e.g., meteorological and oceanographic) or technology testing, involving the installation of bottom-founded facilities" (30 CFR 585.600(a)(1))[66]. BOEM reviews and approves, approves with conditions, or disapproves the SAP. As of April 2024, 20 offshore wind projects have received SAP approval.[67]

Construction and Operations Plan (COP)

The Construction and Operations Plan (COP) is a detailed plan for the construction and commercial operation of a wind energy project submitted to BOEM by the developer. The COP provides a description of all proposed activities and planned facilities (onshore and offshore) for the lease area. The COP includes data and results from survey investigations (including those conducted to support the SAP) and provides the analysis of direct and indirect environmental and socioeconomic impacts resulting from the offshore

[66] Note: Prior to the Renewable Energy Modernization Rule, passed in July 2024, SAPs were required for all commercial leases. Under previous regulations, a lessee could not progress to site assessment activities without an approved SAP. Now SAPs are only required for certain activities, as described.

[67] Northeast Ocean Data Portal: https://www.northeastoceandata.org/offshore-wind-projects/

wind farm project. The submission of the COP starts the NEPA process (detailed in Fig. 5 in *What federal and international environmental laws protect whales?)*, which includes publication of a Notice of Intent, the draft and final Environmental Impact Statements, and the Record of Decision, with public comment periods and input from consultations with NOAA Fisheries. Publication of the Record of Decision for the Construction and Operations Plan marks the end of the NEAP review process (see *What federal and international environmental laws protect whales?*). As of April 2024, eight offshore wind projects have received COP approval.

Environmental Impact Assessment

The submission of the COP to BOEM initiates the Environmental Impact Assessment (EIA) process under NEPA (see *What federal and international environmental laws protect whales?*). BOEM develops the Environmental Impact Statement (EIS), a document containing detailed analysis of the project as proposed, as well as other alternative project designs/locations, with consideration of potential environmental impacts, as well as impacts on aesthetics, cultural resources, socioeconomics, and air and water quality. This process starts with the development of a Draft EIS (DEIS) which goes through a public comment period and consultation with other federal agencies before the development of the Final EIS (FEIS), which incorporates comments and identifies a preferred final project design. This process ends with the issuance of a Record of Decision (ROD), which specifies terms and conditions, such as environmental mitigation measures, that must be met by the OSW developer.

Incidental Take Authorizations (ITAs)

With certain exceptions, under the MMPA, it is illegal to “take” a marine mammals without proper authorization from NOAA Fisheries or the US Fish and Wildlife Service, where take is defined as “ to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal.” NOAA Fisheries shall issue a requested incidental take authorization (see *What federal and international laws protect whales?*) if take would be of small numbers, would have a negligible impact on the species or stock, and would not have an unmitigable adverse impact on the availability of the species or stock for subsistence use. Most incidental take authorizations have been issued for activities that produce underwater sound, including, but not limited to, military readiness, offshore wind development, coastal construction, and oil and gas activities (note commercial fishing is covered separately under the Marine Mammal Authorization Program)[68]. Several offshore wind developers have applied for incidental take authorization for marine mammals for offshore wind survey and construction activities. As NOAA Fisheries has stated explicitly, “NOAA Fisheries does not anticipate and has not authorized—or proposed to authorize—mortality or serious injury of whales for any wind-related action. To date, offshore wind developers have not applied for, and NOAA Fisheries has not approved, authorization to kill any marine mammals[69]. All active and proposed offshore wind-related incidental take authorizations can be found on NMFS’s website.

Endangered Species Consultations

In addition to NOAA consultation under the MMPA and the ITA authorization process, the COP approval process includes Section 7 consultations with NOAA Fisheries under the ESA for listed (e.g., endangered or

[68] More information on ITAs: https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act
[69] NOAA FAQs: https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales

threatened) species. For marine mammals in the U.S. Atlantic, this includes North Atlantic right whales, fin whales, and sei whales as well as other marine species. The Section 7 consultation process begins with a determination that a listed species or designated critical habitat may be present in the action area (16 U.S.C. § 1536(c)(1); 50 C.F.R. § 402.12(c)). If determined that it may be present, BOEM must develop a Biological Assessment (BA) to determine whether the proposed action may adversely affect endangered species or modify critical habitat. The BA considers all proposed federal actions associated with construction, operation and maintenance, and decommissioning, including BOEM COP approval, U.S. Army Corps of Engineers permits, Environmental Protection Agency permits, and MMPA take authorizations[70], including proposed actions to avoid, minimize or otherwise mitigate effects to marine mammals. If there is a determination of potential adverse effects, NOAA Fisheries uses the BA, DEIS, and proposed MMPA ITA authorization to develop a Biological Opinion (BO; formal consultation). The BO includes a detailed analysis of the effects of the action and determines whether the proposed action is likely to jeopardize the species or destroy or adversely modify its critical habitat. The BO also includes the incidental take statement (ITS) delineating the number(s) of takes and measures to minimize the amount or extent of take. BOEM utilizes the BO and other agency input (related to other resources) to issue a Record of Decision (ROD) including anticipated conditions of approval.

[70] Endangered Species Act Information Needs for Offshore Wind Energy Projects in the U.S. Atlantic: https://media.fisheries.noaa.gov/2022-02/ESA-InfoNeeds-OSW-GARFO.pdf

Figure 8. Overview of permitting and authorization process for offshore wind developers under the purview of the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries. Colors indicate the key agency/organization for each step in the process (blue= NOAA Fisheries, green=BOEM, black=developer).

Glossary of Terms

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

Annual stranding rate – The number of strandings reported per year. It is important to note that the number reported may not accurately reflect the true number of strandings occurring each year.

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

Authorization – permit or approval from the federal government to conduct a specified action, which includes strict limits and requirements that must be complied with when conducting the action. For example, the NOAA Fisheries Office of Protected Resources issues Incidental Take Authorizations (ITAs) to U.S.-based entities under the Marine Mammal Protection Act for actions that unintentionally affect marine mammals (assuming the effect is on a small number of animals and leads to negligible impacts to the species or stock). The ITA includes requirements for how the entity is expected to ensure the least practicable impact, as well as monitoring and reporting requirements.

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.

Construction and Operations Plans (COPs) – Plan that an offshore wind energy developer submits to BOEM for approval to request a permit to build an offshore wind project. Includes substantial detail on project components and specifications, baseline survey efforts, and other data to inform BOEM's permitting decision.

Demography – statistical study of populations. At the population level, demographic parameters may include characteristics such as a population's growth rate or age structure. Demographic parameters for individual animals include characteristics such as its age and sex.

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.

Federal waters – water controlled by the U.S federal government. Typically, this area extends from the boundary of state waters (3 nautical miles from the shoreline in the Atlantic Ocean) to about 200 nautical miles from shore (or to the boundary of other countries' waters).

Foraging – spending time searching for food or eating.

Geophysical surveys – Surveys conducted during offshore wind site assessment in which vessels collect information on the ocean floor, including its geologic makeup and the features (shape and conditions) of the seafloor. Geophysical survey data inform planning of offshore wind farms, including plans for cable routes, pile driving, and anchor/mooring plans. Surveys can include a variety of different tools, such as high-resolution multi-beam or towed side-scan sonars, dual magnetometers, and high-resolution/shallow-penetration subbottom profilers, among others. Geophysical surveys are sometimes called "non-intrusive" because they do not involve physical sampling of the seabed, unlike geotechnical surveys (see below).

Geotechnical surveys – Surveys that physically sample or test characteristics of the seabed to inform the placement of offshore wind farm turbines, substations, and cables. Generally conducted after geophysical surveys, these physical samples and in-situ measurements of the seabed help create a geological model of the seabed to inform the engineering plans for an offshore wind farm.

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.

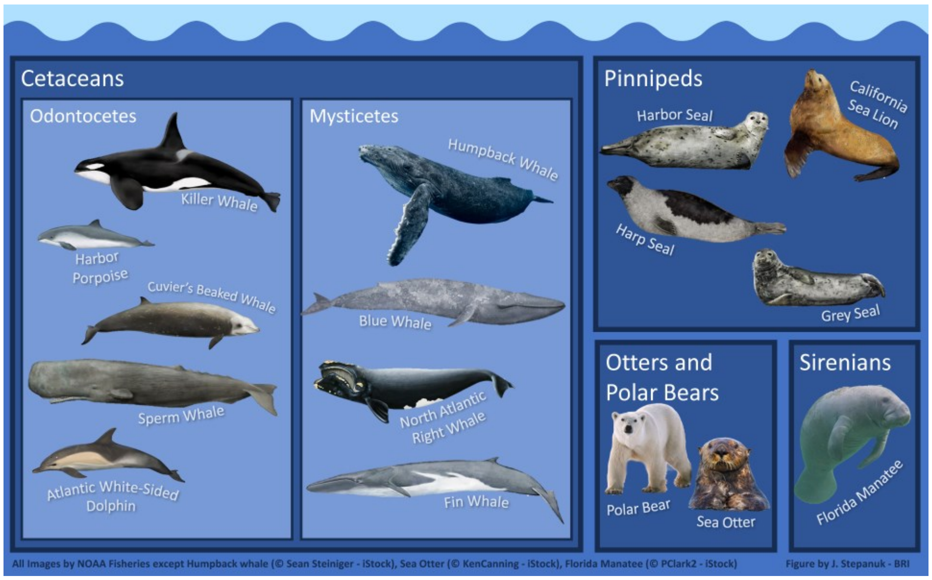
- **Level A harassment –** Any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild.
- **Level B harassment –** Any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the 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.

Human interaction evaluation – Process conducted during necropsies to assess and evaluate stranded animals for signs of human interaction, such as rope, gear, or debris on the animal, or sharp lacerations indicative of interaction with a vessel propeller. The process is documented in the “Handbook for Recognizing, Evaluating, and Documenting Human Interaction in Stranded Cetaceans and Pinnipeds” (Barco & Touhey 2006).

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.



Marine Mammal Health and Stranding Response Program – Program within the National Oceanic and Atmospheric Administration (NOAA) that was established under the U.S. Marine Mammal Protection Act to coordinate emergency responses to sick, injured, out of habitat, or entangled marine mammals. This coordination is achieved through collaborations with federal and state, local, and tribal governmental agencies as well as an extensive network of regional stranding responders involving academic institutions, zoos and aquariums, museums, and non-governmental organizations.

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).

Morphology – the physical characteristics and structure of an animal. Morphological measurements may include body length, weight, or other information.

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.

Noise abatement systems – Technologies implemented during pile-driving activities intended to reduce the distance and duration that sound travels through the water, and thus to minimize potential acoustic impacts to wildlife. Examples include bubble curtains and acoustic resonators that are deployed underwater around pile-driving activities to absorb sound.

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.

Protected Species Observer (PSO) – trained professional biologists who monitor aquatic animals that are federally protected under the US Endangered Species Act (ESA) or Marine Mammal Protection Act (MMPA). This monitoring occurs during anthropogenic activities to help a wide range of industries comply with federal regulations.

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.

Seismic airguns – A technology that blasts the seabed with sound to find and explore offshore oil and gas reserves. The reflected waves or "echoes" from the airgun extend into the seabed and can be used to form a scan of the subsurface to locate fossil fuel reserves. Because the sounds must penetrate far below the surface of the seabed, airguns are substantially louder than the geophysical surveys used for offshore wind energy development (which do not need deep subsurface data).

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.

State waters – waters controlled by a U.S. state. Atlantic coast states control areas within three nautical miles of the nearest ocean shoreline (including shorelines of islands). Beyond this boundary, waters are controlled by the federal government, though states may maintain some degree of authority via their NOAA-approved state Coastal Zone Management Plans.

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.

Vessel strike – when a vessel collides with marine animals such as whales.

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