Request for an Incidental Harassment Authorization to Allow the Non-Lethal Take of Marine Mammals Incidental to Construction Activities in the Vineyard Wind BOEM Lease Area OCS-A 0501

Phase II

Submitted To:

National Marine Fisheries Service
Office of Protected Resources
Silver Spring, MD

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Introduction

Vineyard Wind 1, LLC (Vineyard Wind) is constructing an 806 megawatt (MW) commercial wind energy project (the Project) in BOEM Lease Area OCS-A 0501 (Lease Area), offshore Massachusetts, also referred to as the Wind Development Area (WDA) in this application. The Project consists of 62 offshore wind turbine generators (WTGs) and one electrical service platform (ESP), an onshore substation, offshore and onshore cabling, and onshore operations and maintenance facilities. As of the date of this application, construction of the onshore substation, offshore and onshore cabling, and ESP are complete and the first nine (9) WTGs are being energized to deliver power to the grid. Overall, construction of the Vineyard Wind project is over 84% complete.

Vineyard Wind began offshore installation of jacket and monopile (MP) foundations in June 2023 in accordance with an Incidental Harassment Authorization (IHA) issued in May 2021 and effective from May 1, 2023, to April 30, 2024, with the expectation that all MP foundations would be installed before December 2023. However, the foundation installation campaign experienced significant and unexpected delays, due to extraordinary weather conditions, including multiple storms and extensive fog caused by the unprecedented heat and humidity throughout June and July[1], as well as logistical and technical challenges associated with being the first commercial scale offshore wind project in the US. As of December 31, 2023, Vineyard Wind has installed 47 MP foundations. As there is a prohibition on pile driving from January 1 to April 30, Vineyard Wind will not be able to complete installation of the remaining fifteen (15) MP foundations before the current IHA expires on April 30, 2024.

Based on discussions with the National Marine Fisheries Service (NMFS), Office of Protected Resources, Vineyard Wind is submitting this new request for an IHA to update the biological data and to account for Vineyard Wind's actual sound field acoustical measurements associated with pile driving. Importantly, under this new request Vineyard Wind is not proposing to materially modify the scope of the activities included for consideration in the original IHA application. Rather, as described in more detail below, Vineyard Wind is proposing to conduct the same pile driving activities using the same installation equipment within a Limited Installation Area (LIA) that is approximately 64.3 square kilometers (km^2) (15,888.9 acres) of the 264.35037 km^2 (65,322.4 acres) Lease Area to install the remaining fifteen (15) MP foundations (Figure 1). Moreover, Vineyard Wind will conduct these activities in accordance with the monitoring and mitigation outlined in Section 11. This application also proposes the same monitoring and mitigation measures already established under the current IHA as modified by NMFS during the 2023 campaign. These monitoring and mitigation measures have proven effective as the activities to date have not resulted in any confirmed takes of marine mammals.

In summary, this application includes updated marine mammal density data, a description of the limited scope of work, and the analysis of the final sound field verification acoustical data collected during the 2023 installation campaign to establish clearance and shutdown zones.

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[1] This summer, the New England region has experienced more days in a row with a dew point above 65 than has ever been recorded.

1. Description of Specified Activity

At its nearest point, the remaining MP foundations to be installed are 29 km (18.1 miles [mi]) from the southeast corner of Martha's Vineyard and a similar distance from Nantucket. Water depths in this area of the Lease Area generally range from approximately 37–49.5 meters (m) (121–162 feet [ft]).

As already established, the WTGs are arranged in a grid-like pattern with spacing of 1.9 km (1 nautical mile [nm]) between turbines. Each WTG independently generates approximately 13 MW of electricity and interconnects with the ESP via the inter-array submarine cable system. The offshore export cable transmission system connects the ESP to the Covell's beach landfall location in Barnstable, MA. As the ESP jacket foundation and all export cables have been installed, this application does not discuss those further. Once the fifteen (15) remaining MP foundations are installed, the associated turbine towers and remaining WTG components will be erected onto the MPs. As such, 15 WTGs may become operational within the LIA during the effective dates of this IHA. Operational noise associated with WTG's is not considered in this application. WTG operational noise is fully considered within NMFS' Biological Opinion, October 2021. Specifically, the Biological Opinion states that given the distance between the turbines and NMFS' determination that operational noise will not disturb or displace whales, any effects of operational noise will be extremely unlikely and insignificant. NMFS further asserted that they do not expect that the physical presence of the foundations will affect the distribution of whales in the action area or affect how these animals move through the area. Additionally, consistent with findings in the 2021 Biological Opinion, any hydrodynamic effects of the 15 turbines within the small footprint of the LIA are not expected to be of a scale that could influence regional physical oceanographic conditions and therefore are not expected to affect the distribution of prey, or conditions that aggregate prey in the local southern New England region.

The Construction and Operations Plan ([COP] Vineyard Wind 2020) provides a detailed description of the Project and its key components. Components that are part of the 2024 construction activities, and therefore relevant to this application, are described in the subsections below. In addition to the COP, the Project's potential impacts are analyzed and described across various Federal Agency Consultations, as illustrated in Table 1.

Table 1. Summary of relevant federal agency actions and consultations since December 2018

Title	Date
Final Environmental Impact Statement	March 12, 2021
Record of Decision	May 10, 2021
COP Approval	July 15, 2021
Final Biological Opinion from NOAA Fisheries	October 18, 2021
Pile Driving Monitoring and Mitigation Plan	May 22, 2023

The Limited Installation Area (LIA) lies within the Atlantic Exclusive Economic Zone (EEZ), waters that support several marine mammal species (Table 5) and is therefore subject to review under the Marine Mammal Protection Act (MMPA) (16 United States Code [U.S.C.] 1362). Section 101(a) of the MMPA prohibits the “taking” of marine mammals except under certain situations. MMPA defines the term “take” as: to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. MMPA regulations define harassment in two categories relevant to pile driving operations. These are:

- Level A: any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild, and
- Level B: any act of pursuit, torment or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing a disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild (16 U.S.C. 1362).

Section 101(a)(5) provides for an exception to the take prohibitions of the MMPA, and allows, upon request, the unintentional incidental take of small numbers of marine mammals by US citizens who engage in a specified activity within a specified geographic region. Incidental take is an unintentional, but not unexpected, take of a marine mammal.

The remaining construction activities in 2024 are installation of fifteen (15) MP foundations, WTG installation, inter-array cable laying, and associated vessel activity. No HRG surveys or seabed preparation activities are planned. Of the 2024 proposed construction activities, only impact pile driving during foundation installation has the potential to result in take.

The energy generated from pile driving activities associated with the installation of the remaining MP foundations has the potential to take marine mammals in the vicinity of the LIA by both Level A and Level B harassment. Based on the activities already conducted, with the approved monitoring and mitigation measures in place, no Level A takes are anticipated, and Level B takes, if any, are expected to be minimal. Sounds from other construction activities, including WTG installation and cable laying, were considered in Volume III of the COP (Vineyard Wind 2020). WTG installation and cable laying are described in Section 1.1.4 below. These activities produce sounds generally consistent with those from routine vessel operations and are not expected to contribute significantly to the Project’s acoustic footprint and are therefore not expected to result in take.

According to the Navigational Risk Assessment, the WDA currently experiences moderate levels of vessel traffic, with some increased vessel traffic during the summer months – see Appendix III-I of Volume III of the COP (Vineyard Wind 2020). However, based on BOEM’s analysis of impact-producing factors (IPFs) for offshore wind’s cumulative impacts scenario (BOEM 2019) and their Final Environmental Impact Statement for Vineyard Wind 1 (BOEM 2021), coastal vessel traffic in the vicinity of the Massachusetts Wind Energy Area (MA WEA) is relatively high, with commercial and recreational fishing being a significant contributor and offshore wind development contributing only a small portion of overall traffic and, thus, having no major impact. In its Biological Opinion for Lease Area OCS-A 0501 construction activities, NMFS assessed marine mammals to be likely to either not respond to vessel noise or respond in a way that would not significantly disrupt their normal behavioral patterns, and therefore any effects would be insignificant (NMFS 2021). Therefore, vessel noise is unlikely to result in the incidental take of marine mammals and is not considered further in this application.

Additionally, takes of marine mammals by vessel collision are not expected, given the robust monitoring and mitigation plans approved for the Project. This IHA application only requests incidental takes of marine mammals that may result from exposure to sounds from pile driving for the remaining fifteen (15) MP foundations in the LIA.

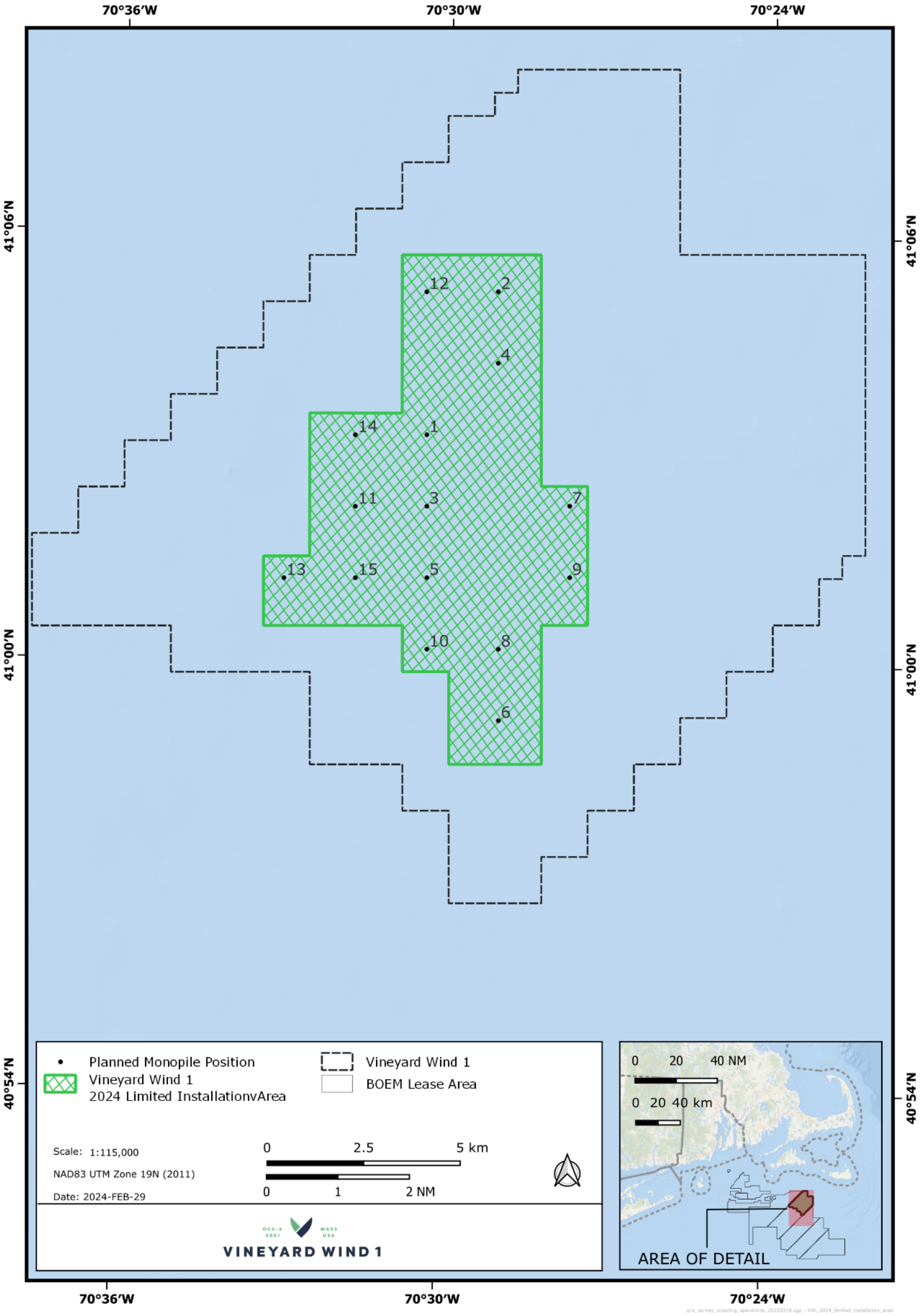


Figure 1. Location of the remaining MP foundations to be installed for the completion of the Project within the LIA, Lease Area OCS-A 0501. Numbers indicate the order in which the piles will be installed.

1.1. Offshore Project Elements and Construction Activities

The Project's key offshore elements are described in detail in Section 3.1 of Volume I of the COP (Vineyard Wind 2020). The remaining offshore elements to be installed for the Project include fifteen (15) MP foundations, WTGs, and inter-array cables. WTG installation is ongoing with expected completion in 2024. The anticipated schedule for the remaining MPs to be installed is summarized below in Section 2 of this request. A description of the remaining offshore elements is provided in subsections 1.1.2 through 1.1.4 below.

1.1.1. Construction Vessel Activity

Overall, construction vessel activity is described in Section 7.8.2.1 of the COP (Vineyard Wind 2020), Volume III, and the remaining vessel activity expected for the 2024 construction is described here. Based on construction activities to date, an average of approximately 20 vessels operate during a typical work day. The same level of activity is expected within the LIA. Many of these vessels would remain in the LIA for days or weeks at a time (e.g., HLV Orion), making only infrequent trips to port for bunkering and provisioning, as needed. The types of vessels operating during a typical pile driving day as well as their estimated number of transits per month are shown in Table 2. For the purposes of this IHA, only those vessels supporting monopile installation are relevant and therefore included in this table. All project vessels carry a visual observer or trained lookout to monitor for protected species.

Table 2. Estimated number of vessels operating within the WDA during a typical impact pile driving day.

Project Vessel Transits (2024 Estimate)					
Vessel Type	Maximum # of Vessels	Vessel Role	Activity Support	Estimated # of Transits per Month	Port
HLV	1	Pile Driving	Monopile Installation	2	Halifax, Canada
TSV	2	Bubble Curtain	Monopile Installation	4	New London, CT
F/V	2	PSO Support Vessel	Monopile Installation	3	New Bedford, MA
F/V	1	Service Operations Vessel	Monopile Installation	4	New Bedford, MA
M/V	2	Crew Transfer Vessel	Monopile Installation	12	New Bedford, MA
F/V	4	Safety Vessel	Monopile Installation	2	New Bedford, MA
GPO	2	Heavy Transport Vessel	Monopile Transport	2	Halifax, Canada

While an average of ~20 vessels are involved in construction activities on any given day, fewer vessels transit to and from New Bedford Harbor or a secondary port each day. The estimated number of vessel trips per MP Batch during the 2024 construction is provided in Table 3. The 15 MP's will be transported to the LIA in batches (MP Batches). Each MP Batch will consist of approximately three (3) to six (6) MP's, therefore, it is anticipated that a maximum of three (3) MP Batches will be transported to the LIA. The vessel activity associated with the limited scope of pile driving for which an IHA is requested is assumed within the Biological Opinion analysis.

Table 3. Estimated maximum number of vessel trips per MP Batch during the 2024 construction.

Origin or Destination	Estimated Maximum Trips per MP Batch
New Bedford (MA)	2
Brayton Point (MA)	1
Montaup (RI)	1
Providence (RI)	1
Quonset (RI)	1
Canada (either Sheet Harbor, St. John, or Halifax)	3
Europe (ports unknown)	NA

Vessel traffic in the vicinity of the Massachusetts Wind Energy Area is relatively high; therefore, marine mammals in the area are presumably habituated to vessel noise and unlikely to react in any significant way (BOEM 2021; NMFS-GARFO 2021). In addition, construction vessels would be stationary on site for significant periods of time and the large vessels would travel to and from the site at low speeds, which would produce lower noise levels than vessel transit at higher speeds. Vineyard Wind did not experience any close encounters with vessels and whales during the 2023 construction campaign. The robust monitoring and mitigation described in Section 11 will reduce the likelihood of vessel strike. Vineyard Wind is not anticipating nor requesting takes for vessel strikes.

As part of various construction related activities, including cable laying and construction material delivery, DP thrusters may be utilized to hold vessels in position or move slowly. Sound produced through use of DP thrusters is similar to that produced by transiting vessels and DP thrusters are typically operated either in a similarly predictable manner or used for short durations around stationary activities. Sound produced by DP thrusters would be preceded by, and associated with, sound from ongoing vessel noise and would be similar in nature; thus, any marine mammals in the vicinity of the activity would be aware of the vessel’s presence (87 FR 79072). Because DP thrusters are not expected to result in take of marine mammals, this sound source is not analyzed further in this document.

1.1.2. Pile Driving Equipment Descriptions

Under this request, fifteen (15) MP foundations will be installed in the LIA to complete the Vineyard Wind 1 Project. A monopile is a single, hollow cylinder fabricated from steel that is secured in the seabed. Monopile dimensions are shown on Figure 2. Monopiles are an equipment type that have been used successfully at many offshore wind energy locations. They currently account for approximately 80% of the installed foundations in Europe, with more than 4,785 units installed as of mid-2021 (Wind Europe 2021).

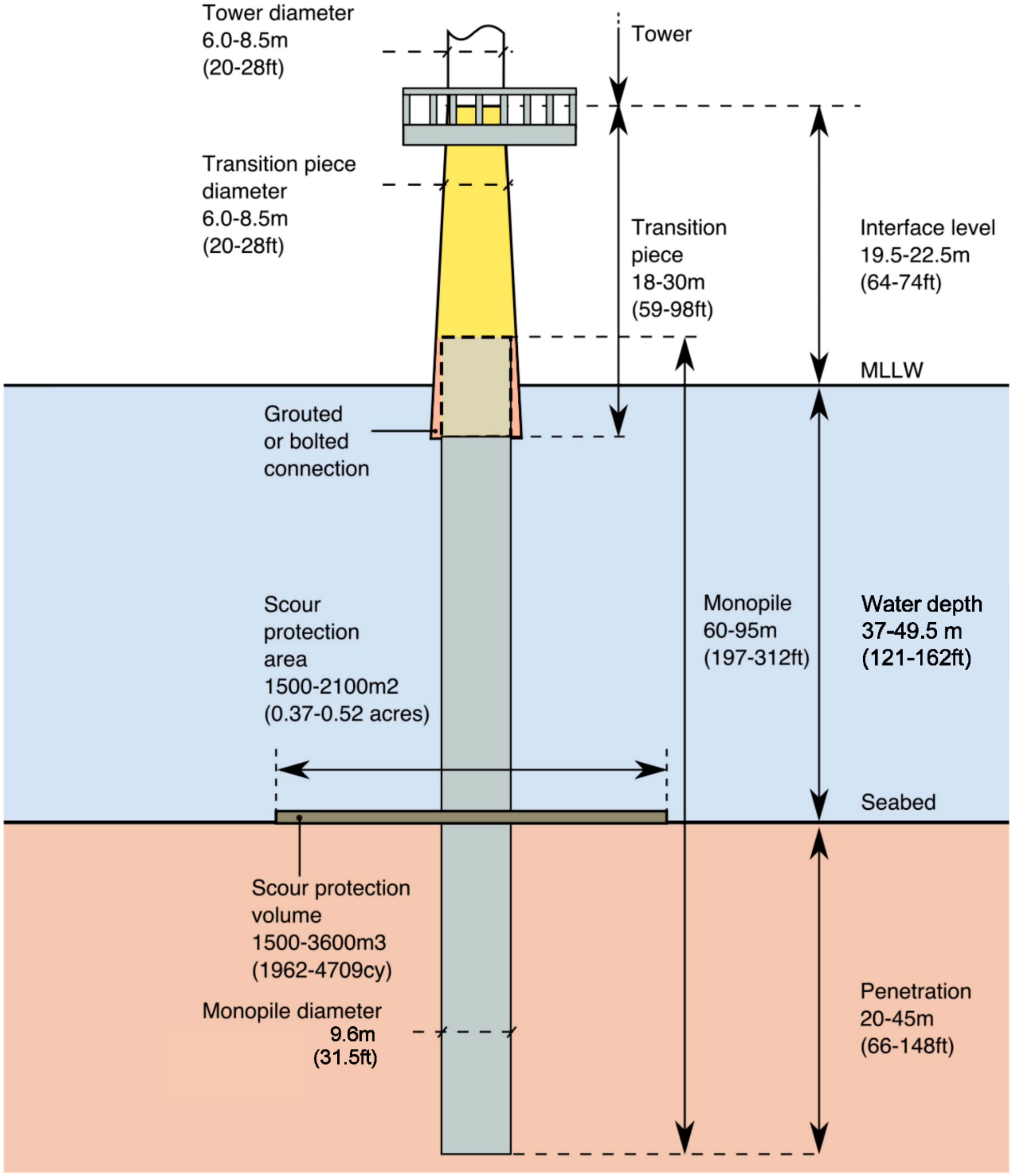


Figure 2. Schematic drawing of a monopile foundation, adapted from Figure 3.1-3 of the COP Volume I (Vineyard Wind 2020) to reflect the final monopile diameter of 9.6 m.

1.1.3. Monopile Installation

The MP foundations will be installed by a heavy lift vessel. MP foundations are installed in batches of 5 or 6 which are loaded onto the installation vessel in Canada and transported to the lease area for installation. Under this request, the installation vessel is expected to make only three round trips to Canada. Thus, within the limited scope of work that would be conducted under this request, it is expected that MP foundation installation would be completed within several weeks, conditions permitting.

At the LIA, the installation vessel will upend the monopile with a crane, and place it in the gripper frame, before lowering the MP foundation to the seabed. To seat the MP foundation and protect against damage to the pile gripper and risks to human safety from pile run, there are a number of techniques contractors may use. Under the current IHA, the contractor employs a Monopile Installation Tool (MPIT) that creates buoyancy within the MP foundation using air pressure to control lowering through the pile run risk zone. As the MP foundation is lowered, air is released from the top of the MP foundation above the water surface until the pile is stabilized within the seabed. The duration of the MPIT process prior to pile driving is dependent upon the local soil conditions at each monopile location and can range between 6 and 15 hours. Once the monopile is lowered to the seabed, the crane hook is released, and the hydraulic hammer is picked up and placed on top of the monopile. Figure 4 shows the MP within the pile gripper with the MPIT attached on the top of the MP foundation. Vineyard Wind anticipates using the MPIT tool for MP installation, consistent with the 2023 MP installation campaign, under this IHA.

Pile driving will begin with a 20-minute soft-start at reduced hammer energy to ensure that the monopile remains vertical and allow any motile marine life to leave the area before the pile driving intensity is increased. The intensity (i.e., hammer energy level) will be gradually increased based on the resistance that is experienced from the sediments. The soft-start procedure is detailed in Table 17. The maximum hammer size for MP foundation installation is 4,000 kilojoules (kJ). A typical pile-driving operation has taken less than approximately two hours to achieve the target penetration depth (maximum: 1 h 57 min; average: 1 h 28 min). No more than one MP will be driven into the seabed per day. Concurrent monopile driving will not occur.

Figure 3. Monopile installation vessel (HLV Orion, 2023).

Figure 4. Motion Compensation Pile Gripper (MCPG), green components around monopile, and Monopile Installation Tool (MPIT), yellow components atop the monopile.

1.1.4. Other Construction Activities

After MPs are installed, transition pieces (TPs) and WTGs are installed. TPs contain work platforms and other ancillary structures and WTGs consist of a tower and the energy-generating components of the turbine. These are being installed atop foundations using jack-up vessels. Depending on sequencing, it is possible that some inter-array cable installation within the LIA may occur during the effective period of the IHA. Inter-array cables connect WTGs to the ESP and are buried using a jet trencher after being placed on the seafloor. Details of inter-array cable installation are provided in Section 4.2.3.3.2 of the COP (Vineyard Wind 2020), Volume I. Briefly, this activity would include performing a pre-lay grapnel run to remove obstructions such as fishing gear from the seafloor, followed by cable laying on the seabed, and then burial of the cables using a jet trencher with scour added for cable protection near the TPs/ESPs. These activities produce sounds generally consistent with those from routine vessel operations and are not expected to result in take by harassment. These activities are, therefore, not considered further in this application.

1.2. Project Installation Scenarios

Vineyard Wind is proposing to install 15 MP foundations in the LIA. The MP foundations are 9.6 m in diameter and will be driven to a penetration depth of ~28 to 35 m. Each monopile foundation is designed and fabricated for the specific installation location with lengths ranging from ~71 to 87.4 m to accommodate for the varying depths.

The in-situ data collected during the 2023 sound field verification (SFV) campaign for the installation of the first batches of MPs was utilized to estimate the potential number of incidental marine mammal exposures to sound levels above the Level B threshold. Results of the 2018 acoustic and exposure modeling (Pyć et al. 2018) were used to estimate Level A exposures because the 2023 SFV campaign validated the modeled Level A acoustic ranges (see additional details of the SFV campaign in Section 6.1).

1.3. Activities Resulting in the Potential Incidental Take of Marine Mammals

The remaining Project pile driving could potentially result in incidental take of marine mammals caused by underwater sound produced by impact pile driving. When piles are driven with impact hammers, they deform, sending a bulge travelling down the pile that radiates sound into the surrounding air, water, and seabed. This sound may be received as a direct transmission from the source to biological receivers such as marine mammals, sea turtles, and fish, through the water, as the result of reflected paths from the surface, or re-radiated into the water from the seabed (Figure 5). Sound transmission depends on many environmental parameters, such as the sound speeds in water and substrates, and sound production parameters of the pile and how it is driven, including the pile material, size (length, diameter, and thickness), and the type and energy of the hammer.

Noise generated by impact pile driving consists of regular, pulsed sounds of short duration. These pulsed sounds are typically high energy with fast rise times. Exposure to these sounds may result in Level A or Level B harassment depending on proximity to the sound source and a variety of environmental and biological conditions (Nedwell et al. 2007; Dahl et al. 2015). Vineyard Wind does not anticipate Level A take of any species given the robust nature of the monitoring and mitigation measures summarized in Section 11, as further supported by the lack of Level A take during the 2023 construction campaign. However, as a precautionary measure Level A take is requested for certain species. Level B takes, if any, are expected to be minimal.

To estimate the potential effects to marine mammals of pile driving noise generated during the Project's construction, JASCO modeled pile driving sound output, acoustic propagation, and animal movement using industry standard models (Pyć et al. 2018). Results of that study were used to inform take estimation as well as mitigation and monitoring for the current IHA. During the 2023 construction campaign, SFV was conducted to validate the modeled results. The final SFV report was submitted to regulators in December 2023 (Küsel et al. 2023). A summary of the acoustic assessment results and how they were used to estimate potential Level A and Level B take is provided in Section 6.

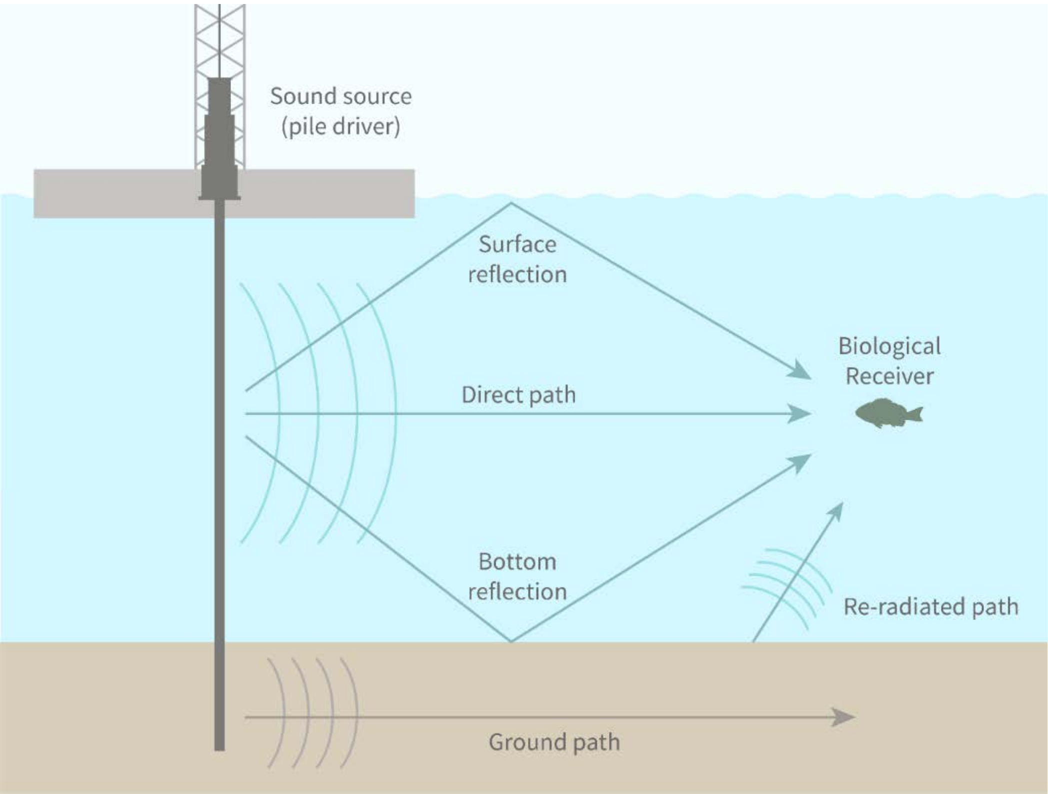


Figure 5. Sound propagation paths associated with pile driving (adapted from Buehler et al. 2015).

Other construction activities proposed for 2024, including installation of WTGs and inter-array cables as well as associated vessel activity, produce sounds generally consistent with those from routine vessel operations and are not expected to result in take by harassment.

2. Dates, Duration, and Specified Geographic Region

2.1. Dates of Construction Activities

Pile driving in the LIA is expected to begin as soon as possible after May 31, 2024 pending IHA issuance and vessel availability. For the purpose of this application, the June–December period was assumed for the installation window. Once pile driving activities commence, they are expected to be completed within several weeks, conditions permitting, and in no event later than the end of 2024. During that time period, the 15 MP foundations will be installed at a rate of one MP per day, for a total of 15 days of MP foundation installation.

2.2. Pile Driving Schedule

Pile driving activities may occur within one (1) month or intermittently over 7 months, depending on weather and logistics; however, piling of a single pile is anticipated to only occur for less than two hours, based on the average pile driving time for the installation of the currently installed MP foundations. This equates to approximately 30 noncontinuous hours of pile driving noise to install the remaining 15 MP foundations, that could potentially result in incidental harassment of marine mammals. As noted, MP foundations are installed in batches of 5 or 6, requiring the installation vessel to travel to Canada to load out a new batch. Pile driving activities will thus pause for approximately 4-7 days while the vessel returns with a new batch. There is also time between each piling activity to mobilize to the next location and prepare for the next installation. Pile driving may occur anytime after an IHA is issued and through the end of November 2024. Vineyard Wind will sequence the installation of the remaining 15 MP foundations in the order that they are numbered in Figure 1 such that the majority of those in the Northeastern portion of the LIA, where NARW density is higher, are installed prior to December.

2.3. Specified Geographic Region of Activity

Pile driving will occur in the LIA within Lease Area OCS-A 0501, which includes a limited portion of the southwesterly corner of the overall WDA (Figure 1). The WDA is just over 23 km (14 mi) from the southeast corner of Martha's Vineyard and a similar distance to Nantucket. The LIA lies within the Mid-Atlantic Bight Northeast Shelf marine ecosystem (NOAA Integrated Ecosystem Assessment Northeast Region, https://www.integratedecosystemassessment.noaa.gov/regions/northeast/mid-atlantic-bight). The sea to shore transition points include three trips to Canada by the installation vessel and support vessels from New Bedford and nearby ports. No take is anticipated or requested for vessel transits.

3. Species and Number of Marine Mammals

3.1. Species Present

There are 38 marine mammal species comprising 39 stocks under NMFS jurisdiction in the Western North Atlantic Outer Continental Shelf (OCS) Region that are protected under the MMPA and whose ranges include the Northeastern US region where the WDA is located (BOEM 2021; Hayes et al. 2023). This includes two different stocks of the common bottlenose dolphin (offshore and migratory coastal) as well as four different species of beaked whale that are often pooled together when estimating abundance. The marine mammal assemblage comprises cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals). There are 34 cetacean species, including 28 members of the suborder Odontoceti (toothed whales, dolphins, and porpoises) and six of the suborder Mysticeti (baleen whales) within the region, as well as four phocid pinniped species (true seals) that are known to occur in the region (Hayes et al. 2023). Five of the species known to occur in the Western North Atlantic are listed as endangered under the Endangered Species Act (ESA); these are the fin whale (*Balaenoptera physalus*), sei whale (*B. borealis*), blue whale (*B. musculus*), North Atlantic right whale (*Eubalaena glacialis*), and sperm whale (*Physeter macrocephalus*).

Of these 38 marine mammal species (39 stocks) with geographic ranges that include the Western North Atlantic OCS, eight of these species are not expected to occur within the WDA because, although they occur in the wider North Atlantic OCS region, their known preferred habitats and distributions (Kenney and Vigness-Raposa 2010; Kraus et al. 2016; Roberts et al. 2016; 2022; Hayes et al. 2023) do not overlap with the WDA. These are – the northern bottlenose whale (*Hyperoodon ampullatus*), false killer whale (*Pseudorca crassidens*), pygmy killer whale (*Feresa attenuata*), melon-headed whale (*Peponocephala electra*), Fraser's dolphin (*Lagenodelphis hosei*), Clymene dolphin (*Stenella clymene*), spinner dolphin (*Stenella longirostris*), and rough-toothed dolphin (*Steno bredanensis*). Additionally, the northern limit of the northern migratory coastal stock of the common bottlenose dolphin (*Tursiops truncatus*) does not extend as far north as the WDA and thus only the offshore stock occurs in the WDA. These eight species are not considered further in this request.

Table 5 provides the protection status, habitat preference, expected occurrence and seasonality in the Massachusetts Wind Energy Area (MA WEA), and NMFS stock name and abundance estimate of each of the remaining 30 marine mammal species with geographic ranges that overlap with the WDA. As shown in Table 5, the occurrence of these species in the MA WEA can be categorized as common (i.e., occur consistently in moderate to large numbers), uncommon (occur in low numbers or on an irregular basis), or rare (i.e., range includes the MA WEA but due to habitat preference and based on sighting information they are unlikely to occur there even though records may exist for adjacent waters). Information on occurrence in the MA WEA is based on NMFS stock assessments (Hayes et al. 2023), a data review (Kenney and Vigness-Raposa 2010) and aerial surveys (Kraus et al. 2016; O'Brien et al. 2020; 2021, 2022; 2023) focused on the WEAs, Atlantic Marine Assessment Program for Protected Species (AMAPPS) annual (NEFSC and SEFSC 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022) and final (Palka et al. 2017; 2021) reports, as well as PSO data gathered during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Vineyard Wind's 2017 site characterization campaign was focused on the export cable routes, not the WDA, and therefore information from 2017 is omitted from this assessment.

Table 4 shows the monthly visual and acoustic PSO/PAM effort from the 2023 construction campaign along with the number of visual and acoustic detections for each marine mammal identified to species as well as for unidentified marine mammals.

Table 4. Number of days of effort and number of marine mammal visual and acoustic detections per month during the 2023 construction campaign.

	June	July	August	September	October	November	December
	Number of Vessel Days* of Effort per Month						
	14	16	18	16	13	10	27
Species	Number of Visual and Acoustic Detections per Month						
Marine mammals identified to species							
Fin whale	12	10	-	4	24	14	31
Humpback whale	19	4	3	-	26	-	1
Minke whale	3	1	2	-	-	-	-
Bottlenose dolphin	-	15	4	-	-	-	-
Common dolphin	26	120	443	257	130	-	122
Gray seal	2	-	-	-	-	-	11
Unidentified marine mammals							
Unidentified baleen whale	2	-	-	-	1	-	-
Unidentified non-NARW	8	-	-	1	-	-	1
Unidentified dolphin	54	34	39	25	69	38	14

*Number of vessel days per month is the sum of the number of days for each vessel where PSO/PAM operations were being conducted.

Based on a review of the available information, including sightings from 6 years of Vineyard Wind's PSO data within the WDA, no take is being requested for the 16 marine mammal species listed as "Rare" in Table 5. Vineyard Wind is only requesting take for the remaining 14 species (shown in bold in Table 5), which are: fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), minke whale (*Balaenoptera acutorostrata*), North Atlantic right whale (*Eubalaena glacialis*), Sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), long-finned pilot whale (*Globicephalus melas*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common bottlenose dolphin (*Tursiops truncatus*, Western North Atlantic Offshore Stock only), Risso's dolphin (*Grampus griseus*), harbor porpoise (*Phocoena phocoena*), gray seal (*Halichoerus grypus*), and harbor seal (*Phoca vitulina*). Additional details on the 14 species for which take is being requested are provided in Section 4. The remaining species are not considered further in this application.

Table 5. Marine mammals that could be present in the Wind Development Area. Those shown in bold are the species for which take is being requested.

Common Name (Species Name) and Stock	ESA/MMPA Status[a]	Habitat[b]	Occurrence in MA WEA[c]	Seasonality in MA WEA[c]	Abundance[d] (NMFS best available)
Mysticetes					
Blue whale (*Balaenoptera musculus*) Western North Atlantic Stock	Endangered/ Strategic	Pelagic and coastal	Rare	Mainly winter, but rare year-round	402
Fin whale **(*Balaenoptera physalus*)** **Western North Atlantic Stock**	Endangered/ Strategic	Slope, pelagic	Common	Year-round, but mainly spring and summer	6,802
Humpback whale **(*Megaptera novaeangliae*)** **Gulf of Maine Stock**	Not Listed/Not Strategic	Mainly nearshore and banks	Common	Year-round, but mainly spring and summer	1,396
Minke whale **(*Balaenoptera acutorostrata*)** **Canadian East Coast Stock**	Not Listed/Not Strategic	Coastal, shelf	Common	Spring, summer, and fall (March to September)	21,968
North Atlantic right whale **(*Eubalaena glacialis*)** **Western North Atlantic Stock**	Endangered/ Strategic	Coastal, shelf, offshore	Common	Winter and spring (December to May)	338
Sei whale **(*Balaenoptera borealis*)** **Nova Scotia Stock**	Endangered/ Strategic	Mostly pelagic	Common	Spring and summer (March to June)	6,292
Odontocetes					
Atlantic spotted dolphin (*Stenella frontalis*) Western North Atlantic Stock	Not Listed/Not Strategic	Continental shelf, slope	Rare	NA	39,921
Atlantic white-sided dolphin **(*Lagenorhynchus acutus*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Offshore, slope	Common	Year-round	93,233
Common bottlenose dolphin **(*Tursiops truncatus*)** **Western North Atlantic Offshore Stock[e]**	Not Listed/Not Strategic	Coastal, shelf, deep	Common	Year-round	62,851
Cuvier's beaked whale (*Ziphius cavirostris*) Western North Atlantic Stock	Not Listed/Not Strategic	Pelagic	Rare	NA	5,744

Common Name (Species Name) and Stock	ESA/MMPA Status[a]	Habitat[b]	Occurrence in MA WEA[c]	Seasonality in MA WEA[c]	Abundance[d] (NMFS best available)
Dwarf sperm whale (*Kogia sima*) Western North Atlantic Stock	Not Listed/Not Strategic	Deep, shelf, slope	Rare	NA	7,750[f]
Harbor porpoise **(*Phocoena phocoena*)** **Gulf of Maine/Bay of Fundy Stock**	Not Listed/Not Strategic	Shelf	Common	Year-round, but less abundant in summer	95,543
Killer Whale (*Orcinus orca*) Western North Atlantic Stock	Not Listed/Not Strategic	Offshore and mid-ocean	Rare	NA	Unknown
Mesoplodont beaked whales (*Mesoplodon densitostris, M. europaeus, M. mirus, and M. bidens*) Western North Atlantic Stock	Not Listed/Not Strategic	Slope, offshore	Rare	NA	10,107[g]
Pantropical spotted dolphin (*Stenella attenuata*) Western North Atlantic Stock	Not Listed/Not Strategic	Pelagic	Rare	NA	6,593
Pilot whale, long-finned **(*Globicephalus melas*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Continental shelf edge, high relief	Uncommon	Year-round	39,215
Pilot whale, short-finned (*Globicephalus macrorhynchus*) Western North Atlantic Stock	Not Listed/Not Strategic	Pelagic, high relief	Rare	NA	28,924
Pygmy sperm whale (*Kogia breviceps*) Western North Atlantic Stock	Not Listed/Not Strategic	Pelagic	Rare	NA	7,750[f]
Risso's dolphin **(*Grampus griseus*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Shelf, slope	Uncommon	Year-round	35,215
Common dolphin **(*Delphinus delphis*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Shelf, pelagic	Common	Year-round, but more abundant in summer	172,974
Sperm whale **(*Physeter macrocephalus*)** **North Atlantic Stock**	Endangered/ Strategic	Pelagic, steep topography	Uncommon	Mainly summer and fall	4,349
Striped dolphin (*Stenella coeruleoalba*) Western North Atlantic Stock	Not Listed/Not Strategic	Off continental shelf	Rare	NA	67,036
White-beaked dolphin (*Lagenorhynchus albirostris*) Western North Atlantic Stock	Not Listed/Not Strategic	Off continental shelf	Rare	NA	536,016
Pinnipeds					
Gray seal **(*Halichoerus grypus*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Nearshore, shelf	Common	Year-round	27,300
Harbor seal **(*Phoca vitulina*)** **Western North Atlantic Stock**	Not Listed/Not Strategic	Coastal	Common	Year-round, but rare in summer	61,336

Common Name (Species Name) and Stock	ESA/MMPA Status[a]	Habitat[b]	Occurrence in MA WEA[c]	Seasonality in MA WEA[c]	Abundance[d] (NMFS best available)
Harp seal (*Pagophilus groenlandicus*) Western North Atlantic Stock	Not Listed/Not Strategic	Nearshore	Rare	Winter and spring	7.6 M[h]
Hooded Seal (*Crysophora cristata*) Western North Atlantic Stock	Not Listed/Not Strategic	Off continental shelf	Rare	NA	Unknown

NA = Not applicable and/or insufficient data available to determine seasonal occurrence in the offshore project area.

[a] Listing status under the US Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA).

[b] Habitat descriptions are from NMFS Marine Mammal Stock Assessment Reports.

[c] Occurrence and seasonality in the Massachusetts Wind Energy Area (MA WEA) are derived from NMFS stock assessments (Hayes et al. 2023), a data review (Kenney and Vigness-Raposa 2010) and aerial surveys (Kraus et al. 2016; O'Brien et al. 2020; 2021, 2022; 2023) focused on the WEAs, Atlantic Marine Assessment Program for Protected Species (AMAPPS) annual (NEFSC and SEFSC 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022) and final (Palka et al. 2017; 2021) reports, as well as PSO data gathered during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). (Note that there were no marine mammal sightings during November 2023 of the construction campaign so sightings are for June–October and December that year.)..

[d] "Best Available" abundance estimate is from (Hayes et al. 2023).

[e] Common bottlenose dolphins occurring in the MA Wind Energy Area likely belong to the Western North Atlantic Offshore Stock because the northernmost limit of the the Western North Atlantic Northern Migratory Coastal Stock is south of the Lease Area.

[f] Estimate includes both dwarf and pygmy whales.

[g] Estimate is for all Mesoplodont beaked whales within the Western Atlantic (Hayes et al. 2023).

[h] Estimate is for the entire population, including waters outside the U.S.

4. Affected Species Status and Distribution

4.1. Mysticetes

4.1.1. Fin Whale (Balaenoptera physalus)

Fin whales are the second largest species of baleen whale in the Northern Hemisphere (NMFS 2023g), with a maximum length of about 22.8 m. These whales have a sleek, streamlined body with a V-shaped head that makes them fast swimmers. This species has a distinctive coloration pattern: the dorsal and lateral sides of the body are black or dark brownish-gray, and the ventral surface is white. The lower jaw is dark on the left side and white on the right side. Fin whales feed on krill (*Euphausiacea*), small schooling fish (e.g., herring [*Clupea harengus*], capelin [*Mallotus villosus*], sand lance [*Ammodytidae spp*.]), and squid (*Teuthida spp*.) by lunging into schools of prey with their mouths open (Kenney and Vigness-Raposa 2010).

Fin whales produce characteristic vocalizations that can be distinguished during PAM surveys (BOEM 2014; Erbe et al. 2017). The most commonly observed calls are the "20-Hz signals," a short down sweep falling from 30 to 15 Hz over a one-second period. Fin whales can also produce higher frequency sounds up to 310 Hz, and sound levels (SLs) as high as 195 decibels (dB) relative to one microPascal (re 1 µPa) @ 1 m root mean square sound pressure level (SPL_{rms}) have been reported, making it one of the most powerful biological sounds in the ocean (Erbe et al. 2017). Anatomical modeling based on fin whale ear morphology suggests their greatest hearing sensitivity is between 20 Hz and 20 kHz (Cranford and Krysl 2015; Southall et al. 2019).

4.1.1.1. Status

Fin whales are listed as endangered under the ESA (Hayes et al. 2022) and the MA ESA (MassWildlife 2023). This stock is listed as strategic under the MMPA due to its endangered status

(Hayes et al. 2022). Potential Biological Removal (PBR) for the western North Atlantic fin whale is 11 (Hayes et al. 2022). PBR is defined as the product of minimum population size, one-half the maximum net productivity rate and recovery factor for endangered, depleted, threatened, or stocks of unknown status relative to the optimal sustainable population (OSP) (Hayes et al. 2022). Annual human-caused mortality and serious injury for the period between 2015 and 2019 was estimated to be 1.85 per year (Hayes et al. 2022). This estimate includes incidental fishery interactions (i.e., bycatch/entanglement) and vessel collisions, but does not include other threats to fin whales such as contaminants found within their habitat and potential climate-related shifts in distribution of prey species (Hayes et al. 2022).

4.1.1.2. Distribution

Fin whales have a wide distribution and can be found in the Atlantic and Pacific Oceans in both the Northern and Southern Hemisphere (NMFS 2023g). The population is divided by ocean basins; however, these boundaries are arbitrary as they are based on historical whaling patterns rather than biological evidence (Hayes et al. 2022). Fin whales off the eastern US, Nova Scotia, and the southeastern coast of Newfoundland are believed to constitute a single stock under the present International Whaling Commission (IWC) management scheme (Donovan 1991), which has been called the Western North Atlantic stock.

Fin whales transit between summer feeding grounds in the high latitudes and the wintering, calving, or mating habitats in low latitudes or offshore. However, acoustic records indicate that fin whale populations may be less migratory than other mysticetes whose populations make distinct annual migrations (Watkins et al. 2000). Fin whales typically feed in New England waters on fishes (e.g., sand lance, capelin, herring), krill, copepods, and squid in deeper waters near the edge of the continental shelf (90–180 m) but will migrate towards coastal areas following prey distribution. However, fin whales' habitat use has shifted in the southern Gulf of Maine, most likely due to changes in the abundance of sand lance and herring, both of which are prey for the fin whale (Kenney and Vigness-Raposa 2010). While fin whales typically feed in the Gulf of Maine and the waters surrounding New England, mating and calving (and general wintering) areas remain largely unknown (Hayes et al. 2022). The WDA is flanked by two Biologically Important Areas (BIAs) for feeding for fin whales—the area to the northeast in the Southern Gulf of Maine is considered a BIA year-round, while the area to the southwest off the tip of Long Island is a BIA from March to October (LaBrecque et al. 2015).

Kraus et al. (2016) suggest that, compared to other baleen whale species, fin whales have a high multi-seasonal relative abundance in the MA WEA and RI/MA WEA and surrounding areas. Fin whales were observed during spring and summer of the 2011–2015 Northeast Large Pelagic Survey Collaborative (NLPSC) aerial surveys. This species was observed primarily in the offshore (southern) regions of the MA and RI/MA WEAs during spring and was found closer to shore (northern areas) during the summer months (Kraus et al. 2016). Calves were observed three times and feeding was observed nine times during the Kraus et al. (2016) study. Although fin whales were largely absent from visual surveys in the MA and RI/MA WEAs and in the fall and winter months (Kraus et al. 2016), acoustic data indicated that this species was present in the MA and RI/MA WEAs during all months of the year. Fin whales were acoustically detected in the MA WEA on 87% of study days (889/1,020 days). Acoustic detection data indicated a lack of seasonal trends in fin whale abundance with slightly less detections from April to July (Kraus et al. 2016). Because the detection range for fin whale vocalizations is more than 200 km (108 n.mi), detected signals may have originated from areas far outside of the MA and RI/MA WEAs;

however, arrival patterns of many fin whale vocalizations indicated that received signals likely originated from within the Kraus et al. (2016) study area.

Following Kraus et al. (2016), aerial surveys focused on marine mammal occurrence have continued in the MA and RI/MA WEA study area (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). There were 32 sightings of 53 individual fin whales between October 2018 and August 2019 (O'Brien et al. 2020), most of which occurred in late spring and early summer (May–June). Fin whale sightings were clustered in the southern and eastern parts of the MA and RI/MA WEAs during those surveys (O'Brien et al. 2020). In the following year of this study, between March and October 2020, fin whales were only observed during summer months within the MA and RI/MA WEAs (O'Brien et al. 2021). In the subsequent study, between September 2020 and October 2021, there were 18 sightings of 27 individual fin whales (O'Brien et al. 2022). Sightings in those surveys occurred during winter, spring, and summer, with most sightings in the summer (O'Brien et al. 2022). Finally, during the most recent surveys by this group (February–August 2022), there were 163 sightings of 212 fin whales (O'Brien et al. 2023). There were sightings in winter, spring, and summer, with most of the sightings in summer. Sightings were clustered in the western portion of the MA and RI/MA WEAs (O'Brien et al. 2023).

Fin whales were observed 7 times (12 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Fin whales were observed during the 2010–2017 Atlantic Marine Assessment Program for Protected Species (AMAPPS) Northeast shipboard surveys conducted during summer and fall, with only one sighting in fall, and they were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest fin whales are most abundant in the area during the summer, followed by spring and then fall, and least abundant, though still present, during winter (Palka et al. 2021).

4.1.1.3. Abundance

The best abundance estimate available for the Western North Atlantic stock is 6,802 based on data from NMFS shipboard and aerial surveys and the 2016 NEFSC and Department of Fisheries and Oceans Canada (DFO) surveys (Hayes et al. 2022). A population trend analysis does not currently exist for this species because of insufficient data; however, based on photographic identification, the gross annual reproduction rate is 8% with a mean calving interval of 2.7 years (Agler et al. 1993; Hayes et al. 2022).

4.1.2. Humpback Whale (Megaptera novaeangliae)

Female humpback whales are larger than males and can reach lengths of up to 18 m (NMFS 2023b). Humpback whale body coloration is primarily dark gray, but individuals have a variable amount of white on their pectoral fins, belly, and flukes. These distinct coloration patterns are used by scientists to identify individuals. These baleen whales feed on small prey often found in large concentrations, including krill and fish such as herring and sand lance (Kenney and Vigness-Raposa 2010). Humpback whales use unique behaviors, including bubble nets, bubble clouds, and flicking of their flukes and fins, to herd and capture prey (NMFS 1991).

During migration and breeding seasons, male humpback whales are often recorded producing vocalizations arranged into repetitive sequences termed “songs” that can last for hours or even days.

These songs have been well studied in the literature to document changes over time and geographic differences. Generally, the frequencies produced during these songs range from 20 Hz to over 24 kHz. Most of the energy is focused between 50 and 1,000 Hz and reported SLs range from 151 to 189 dB re 1 μPa @ 1 m SPL_{rms} (Erbe et al. 2017). Other calls produced by humpbacks, both male and female, include pulses, moans, and grunts used for foraging and communication. These calls are lower frequency (under 2 kHz) with SLs ranging from 162 to 190 dB re 1 μPa @ 1 m SPL_{rms} (Thompson et al. 1986; Erbe et al. 2017). Anatomical modeling based on humpback whale ear morphology indicates that their best hearing sensitivity is between 18 Hz and 15 kHz (Ketten et al. 2014; Southall et al. 2019).

4.1.2.1. Status

Humpback whales are considered endangered under the MA ESA (MassWildlife 2023). However, NMFS revised the listing status for humpback whales under the ESA in 2016 (81 FR 62260 2016). Globally, there are 14 distinct population segments (DPSs) recognized for humpback whales, four of which are listed as endangered. The Gulf of Maine stock (formerly known as the Western North Atlantic stock) which occurs in the WDA is considered non-strategic under the MMPA and does not coincide with any ESA-listed DPS (Hayes et al. 2020). This stock is considered non-strategic because the detected level of US fishery-caused mortality and serious injury derived from the available records do not exceed the calculated PBR of 22, with a set recovery factor at 0.5 (Hayes et al. 2020). Because the observed mortality is estimated to be only 20% of all mortality, total annual mortality may be 60-70 animals in this stock (Hayes et al. 2020). If anthropogenic causes are responsible for as little as 31% of potential total mortality, this stock could be over its PBR. While detected mortalities yield an estimated minimum fraction anthropogenic mortality of 0.85, additional research is being done before apportioning mortality to anthropogenic versus natural causes for undetected mortalities and making a potential change to the MMPA status of this stock.

An Unusual Mortality Event (UME) was declared for this species in January 2016, which as of November 2023, has caused 209 stranded humpback whales, with 41 of those occurring off Massachusetts (NMFS 2023k). Stranding investigations have concluded that 40% of the stranded humpback whales show signs of interaction with vessels or entanglement in commercial fishing gear (NMFS 2023k). A BIA for humpback whales for feeding has been designated northeast of the WDA in the Gulf of Maine, Stellwagen Bank, and the Great South Channel from March through December (LaBrecque et al. 2015). Major threats to humpback whales include vessel strikes, entanglement, and climate-related shifts in prey distribution (Hayes et al. 2020).

4.1.2.2. Distribution

The humpback whale can be found worldwide in all major oceans from the equator to sub-polar latitudes and have annual migrations of thousands of miles between breeding and feeding grounds (NMFS 2023b). In summer, humpbacks are found at higher latitudes feeding in the Gulf of Maine and Gulf of Alaska. During the winter months, humpbacks migrate to calving grounds in subtropical or tropical waters, such as the Dominican Republic in the Atlantic and Hawaiian Islands in the Pacific (Hayes et al. 2020). Humpback whales from the North Atlantic feed, mate, and calve in the West Indies (Hayes et al. 2020). In the summer, humpback whales in the western North Atlantic are typically observed in the Gulf of Maine and along the Scotian Shelf; there have also been numerous winter sightings in the southeastern US (Hayes et al. 2020). Feeding behavior has also been observed in New England off Long Island, New York, and NMFS survey data suggests a potential increase in humpback whale abundance off New Jersey and New York (Hayes et al. 2020).

Kraus et al. (2016) observed humpback whales in the MA and RI/MA WEAs, and surrounding areas during all seasons of the 2011–2015 NLPSC aerial surveys. Humpback whales were observed most often during the spring and summer months, with a peak from April to June. Calves were observed 10 times and feeding was observed 10 times during the Kraus et al. (2016) study. That study also observed one instance of courtship behavior. Although humpback whales were only rarely seen during fall and winter surveys, acoustic data indicate that this species may be present within the MA WEA year-round, with the highest rates of acoustic detections in winter and spring (Kraus et al. 2016). Humpback whales were acoustically detected in the MA WEA on 56% of acoustic survey days (566/1,020 days). Acoustic detections do not differentiate between individuals, so detections on multiple days could be the same or different individuals. The mean detection range for humpback whales using PAM was 30–36 km (16-19 n.mi.), with a mean radius of 36 km (19 n.mi) for the PAM system. Kraus et al. (2016) estimated that 63% of acoustic detections of humpback whales represented whales within their study area.

Following Kraus et al. (2016), aerial surveys focused on marine mammal occurrence have continued in the MA and RI/MA WEA study area (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). Trends similar to those observed by Kraus et al. (2016) were seen during the October 2018 and August 2019 study (O'Brien et al. 2020). There was a total of 30 humpback whale sightings of 32 individuals observed in the MA and RI/MA WEAs (O'Brien et al. 2020). Humpback whales were present during all seasons with peak sightings and the greatest relative abundance in spring and summer. The majority of sightings were on the eastern side of the MA and RI/MA WEAs, regardless of time of year (O'Brien et al. 2020). In the following year of this study, from March to October 2020, humpback whales were the most frequently sighted cetacean, although not the most abundant, accounting for 22% of all sightings (O'Brien et al. 2021). Over the survey period, there were 22 sightings of 44 individual humpback whales. During the 2020 survey, sightings were also concentrated more on the eastern side of the MA and RI/MA WEAs, and just outside the WEAs in the Nantucket Shoals area. In the subsequent study, from September 2020 to October 2021, there were 66 sightings of 97 individuals observed (O'Brien et al. 2022). Humpback whales were sighted across the entire study area; however, seasonal distribution patterns were observed. During fall seasons, humpback whales were observed most prevalently in Nantucket Shoals; during spring and summer months, humpback whales were spread more evenly across the MA and RI/MA WEAs (O'Brien et al. 2022). Finally, during the most recent surveys by this group (February–August 2022), there were 137 sightings of 197 fin whales (O'Brien et al. 2023). There were sightings in all months during spring and summer. Sightings occurred throughout the MA and RI/MA WEAs but were clustered more to the north in the summer and to the south in the spring (O'Brien et al. 2023) There were 33 sightings of bubble feeding humpback whales during May–August and mother–calf pairs were seen on six occasions.

Humpback whales were observed 29 times (56 individuals) in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Humpback whales were observed only in the summer during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall, and were observed during all seasons of the 2010–2017 AMAPPS Northeast aerial surveys, but most often in summer and fall (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest humpback whales are most abundant in the area during the summer, followed by spring and then fall, and least abundant, though still present, during winter (Palka et al. 2021).

4.1.2.3. Abundance

The best available abundance estimate of the Gulf of Maine stock is 1,396, derived from modeled sighting histories constructed using photo-identification data collected through October 2016 (Hayes et al. 2020). Available data indicate that this stock is characterized by a positive population trend, with an estimated increase in abundance of 2.8% per year (Hayes et al. 2020).

4.1.3. Minke Whale (Balaenoptera acutorostrata)

Minke whales are a baleen whale species reaching 10 m in length. The minke whale is common and widely distributed within the US Atlantic EEZ and is the third most abundant great whale (any of the larger marine mammals of the order Cetacea) in the EEZ (CeTAP 1982). A prominent morphological feature of the minke whale is the large, pointed median ridge on top of the rostrum. The body is dark gray to black with a pale belly, and frequently shows pale areas on the sides that may extend up onto the back. The flippers are smooth and taper to a point, and the middle third of each flipper has a conspicuous bright white band that can be distinguished during visual surveys (Kenney and Vigness-Raposa 2010). Its diet is comprised primarily of crustaceans, schooling fish, and copepods. Minke whales generally travel in small groups (one to three individuals), but larger groups have been observed on feeding grounds (NMFS 2023l).

In the North Atlantic, minke whales commonly produce pulse trains lasting 10 –70 seconds with a frequency range between 10 and 800 Hz. SLs for this call type have been reported between 159 and 176 dB re 1 µPa @ 1 m $\mathrm{SPL_{rms}}$ (Erbe et al. 2017). Some minke whales also produce a unique “boing” sound which is a train of rapid pulses often described as an initial pulse followed by an undulating tonal (Rankin and Barlow 2005; Erbe et al. 2017). The “boing” ranges from one to five kHz with an SLs of approximately 150 dB re 1 µPa @ 1 m $\mathrm{SPL_{rms}}$ (Rankin and Barlow 2005; Erbe et al. 2017). Auditory sensitivity for this species based on anatomical modeling of minke whale ear morphology is best between 10 Hz and 34 kHz (Ketten et al. 2014; Southall et al. 2019).

4.1.3.1. Status

Minke whales are not listed under the ESA or classified as strategic under the MMPA (Hayes et al. 2022). The estimated annual human-caused mortality and serious injury from 2015 to 2019 was 9.55 per year attributed to fishery interactions, vessel strikes, and non-fishery entanglement in both the US and Canada (Hayes et al. 2022). A UME was declared for this species in January 2017, which is ongoing (NMFS 2023d). As of September 2023, a total of 160 strandings have been reported, with 56 of those occurring off Massachusetts (NMFS 2023d). The PBR for this stock is estimated to be 170 (Hayes et al. 2022). A BIA for minke whales for feeding has been designated east of the WDA from March through November (LaBrecque et al. 2015). Minke whales may also be vulnerable to climate-related changes in prey distribution, although the extent of this effect on minke whales remains uncertain (Hayes et al. 2022).

4.1.3.2. Distribution

Minke whales prefer the colder waters in northern and southern latitudes, but they can be found in every ocean in the world. Available data suggest that minke whales are distributed in shallower waters along the continental shelf between the spring and fall and are located in deeper oceanic waters between the winter and spring (Hayes et al. 2022). They are most abundant in New England waters during spring through fall (Hayes et al. 2022). Acoustic detections show that minke whales migrate sound in mid-October to early November and return from wintering grounds starting in March through early April (Risch et al. 2014).

Kraus et al. (2016) observed minke whales in the MA and RI/MA WEAs and surrounding areas primarily from May to June during the 2011–2015 NLPSC aerial survey. This species demonstrated a distinct seasonal habitat usage pattern that was consistent throughout the study. Minke whales were not observed between October and February, but acoustic data indicate the presence of this species in the winter months. Calves were observed twice, and feeding was also observed twice during the Kraus et al. (2016) study. Minke whales were acoustically detected in the MA WEA on 28% of project days (291/1,020 days). Minke whale acoustic presence data also exhibited a distinct seasonal pattern; acoustic presence was lowest in the months of December and January, steadily increased beginning in February, peaked in April, and exhibited a gradual decrease throughout the summer months (Kraus et al. 2016). Acoustic detection range for this species was small enough that over 99% of detections were limited to within the Kraus et al. (2016) study area.

Following Kraus et al. (2016), aerial surveys focused on marine mammal occurrence have continued in the MA and RI/MA WEA study area (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). There were 98 sightings of 115 individual minke whales between October 2018 and August 2019 (O'Brien et al. 2020). Minke whales were the most frequently sighted cetacean at 28% of on-effort sightings. The majority of these sightings occurred during the spring and summer (mostly during April and June). Only two sightings occurred during the winter, and none occurred during the fall. In the following year of this study, between March and October 2020, minke whales were sighted during all months within the MA and RI/MA WEAs except March and October (O'Brien et al. 2021). In the subsequent study, between September 2020 and October 2021, there were 24 sightings of 24 individuals observed (O'Brien et al. 2022). These sightings occurred during all seasons, and the majority were in the Nantucket Shoals. Finally, during the most recent surveys by this group (February–August 2022), there were 96 sightings of 100 individual minke whales, sighted in the spring and summer (O'Brien et al. 2023).

Minke whales were observed 36 times (36 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Minke whales were observed during the 2010–2017 Northeast shipboard surveys conducted during summer and fall, and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest minke whales are most abundant in the area during the spring, followed by summer and then fall, and then winter (Palka et al. 2021).

4.1.3.3. Abundance

The most recent population estimate for the Canadian East Coast stock which occurs in the WDA is 21,968 minke whales, derived from surveys conducted by NMFS and DFO Canada between Labrador and central Virginia (Hayes et al. 2022). There are no current population trends or net productivity rates for this species due to insufficient data.

4.1.4. North Atlantic Right Whale (Eubalaena glacialis)

NARWs are among the rarest of all marine mammal species in the Atlantic Ocean. adults can be as large as 16 m in length (NMFS 2023h). They have stocky, black bodies with no dorsal fin, and bumpy, coarse patches of skin on their heads called callosities, and have a distinctive v-shaped blow. They are slow-moving grazers that feed on dense concentrations of prey (mostly copepods and other zooplankton) at or below the water's surface, as well as at depth (NMFS 2023h). Research suggests that NARWs must locate and exploit extremely dense patches of zooplankton to feed efficiently (Mayo and Marx 1990). These dense zooplankton patches are a primary characteristic of the spring, summer, and fall NARW habitats (Kenney et al. 1995). NARWs are usually observed in groups of less than 12 individuals, and most often as single individuals or pairs. Larger groups may be observed in feeding or breeding areas (Jefferson et al. 2008).

NARW vocalizations most frequently observed during PAM studies include upsweeps rising from 30 to 450 Hz, often referred to as "upcalls," and broadband (30 to 8,400 Hz) pulses, or "gunshots," with SLs between 172 and 187 dB re 1 µPa @ 1 m SPL_{rms} (Erbe et al. 2017). However, recent studies have shown that mother-calf pairs reduce the amplitude of their calls in the calving grounds, possibly to avoid detection by predators (Parks et al. 2019). Modeling conducted using right whale ear morphology suggest that the best hearing sensitivity for this species is between 16 Hz and 25 kHz (Ketten et al. 2014; Southall et al. 2019).

4.1.4.1. Status

The NARW is listed as endangered under the ESA (Hayes et al. 2023) and MA ESA (MassWildlife 2023). NARWs are considered to be the most critically endangered large whales in the world (Hayes et al. 2023). The average annual human-related mortality/injury rate exceeds that of the calculated PBR of 0.7, classifying this population as strategic and depleted under the MMPA (Hayes et al. 2023). Estimated human-caused mortality and serious injury between 2016 and 2020 was 8.1 whales per year (Hayes et al. 2023). Using a hierarchical Bayesian, state-space model (Pace et al. 2021) the estimated rate of total mortality is 31.2 animals per year, or 156 animals total, for the period of 2015–2019. That annual rate of total mortality is 4.1 times higher than the 7.7 detected mortality and serious injury value reported for the same period in the previous stock assessment report (Hayes et al. 2023). To apportion the estimated total NARW mortality by cause, the proportion of observed mortalities and serious injuries from entanglement compared to those from vessel collision for the period of 2016–2020 was used (Hayes et al. 2023). During this period, 71% of the observed mortalities and serious injuries were the result of entanglement and 29% were from vessel collisions (Hayes et al. 2023).

To protect this species from ship strikes, NMFS designated Seasonal Management Areas (SMAs) in US waters in 2008 (NMFS 2008). All vessels greater than 19.8 m (65 ft) in overall length must operate at speeds of 18.4 km/hour (10 n.mi./h) or less within these areas during specific time periods. The Block Island Sound SMA overlaps with the southern portion of the MA WEA and is active between November 1 and April 30 each year. The Great South Channel SMA lies to the northeast of the MA WEA and is active April 1 to July 31. In addition, the rule provides for the establishment of Dynamic Management Areas (DMAs) when and where NARWs are sighted outside SMAs. DMAs are generally in effect for two weeks and the 18.4 km/hour (10 knots) or less speed restriction is voluntary.

NMFS has designated two critical habitat areas for the NARW under the ESA: the Gulf of Maine/Georges Bank region and the southeast calving grounds from North Carolina to Florida (81 FR 4838 2016). Two additional critical habitat areas in Canadian waters, Grand Manan Basin and Roseway

Basin, were identified in Canada's final recovery strategy for the NARW (Brown et al. 2009). The WDA is encompassed by a NARW BIA for migration from March to April and from November to December (LaBrecque et al. 2015). The NARW BIA for migration includes the MA and RI/MA WEAs and beyond to the continental slope, extending northward to offshore of Provincetown, MA and southward to halfway down the Florida coast (LaBrecque et al. 2015).

4.1.4.2. Distribution

The NARW is a migratory species that travels from high-latitude feeding waters to low-latitude calving and breeding grounds (Whitt et al. 2013). The Western Atlantic stock of NARWs ranges primarily from calving grounds in coastal waters of the southeastern US to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence (Hayes et al. 2023). These whales undertake a seasonal migration from their northeast feeding grounds (generally spring, summer, and fall habitats) south along the US east coast to their calving grounds in the waters of the southeastern US (Kenney and Vigness-Raposa 2010).

NARWs are considered to be comprised of two separate stocks: Eastern and Western Atlantic stocks. The Eastern North Atlantic stock was largely extirpated by historical whaling (Aguilar 1986). NARWs in US waters belong to the Western Atlantic Stock. Previously, seven areas were identified where NARWs were known to congregate seasonally: the coastal waters of the southeastern US, the Great South Channel, Jordan Basin, Georges Basin along the northeastern edge of Georges Bank, Cape Cod and Massachusetts Bays, the Bay of Fundy, and the Roseway Basin on the Scotian Shelf (Hayes et al. 2018). However, since 2010, NARWs have been declining in and around once key habitats in the Gulf of Maine and the Bay of Fundy (Davies et al. 2015; Davis et al. 2017), while sightings have increased in other areas including Cape Cod Bay, Massachusetts Bay, the Mid-Atlantic Bight, and the Gulf of St. Lawrence (Whitt et al. 2013; Davis et al. 2017; Mayo et al. 2018; Davies and Brillant 2019; Ganley et al. 2019; Charif et al. 2020). An eight-year analysis of NARW sightings within southern New England (SNE) showed that the NARW distribution has been shifting (Quintana-Rizzo et al. 2021). Sightings of NARWs were recorded in the SNE study area (shores of Martha's Vineyard and Nantucket to and covering all the offshore wind lease sites of Massachusetts and Rhode Island) in almost all months of the year, with the highest sighting rates between December and May, when close to a quarter of the population may be present at any given time (Quintana-Rizzo et al. 2021). Recently, NARWs have been seen both within the MA and RI/MA WEAs and over the Nantucket Shoals in every season (O'Brien et al. 2023).

The winter distribution of much of the NARW population is largely unknown. Some evidence provided through acoustic monitoring suggests that not all individuals of the population participate in annual migrations, with a continuous presence of NARWs occupying their entire habitat range throughout the year, particularly north of Cape Hatteras (Davis et al. 2017). These data also recognize changes in population distribution throughout the NARW habitat range that could be due to environmental or anthropogenic effects, a response to short-term changes in the environment, or a longer-term shift in the NARW distribution cycle (Davis et al. 2017). A climate-driven shift in the Gulf of Maine/western Scotian Shelf region occurred in 2010 and impacted the foraging environment, habitat use, and demography of the NARW population (Meyer-Gutbrod et al. 2021). In 2010, the number of NARWs returning to the traditional summertime foraging grounds in the eastern Gulf of Maine/Bay of Fundy region began to decline rapidly (Davies and Brillant 2019; Davies et al. 2019; Record et al. 2019). Despite considerable survey effort, the location of most of the population during the 2010-2014 foraging seasons is largely unknown; however, sporadic sightings and acoustic detections in Canadian waters suggest a dispersed distribution (Davies et al. 2019) and a significant increase in the presence of whales in the southern Gulf of St. Lawrence beginning in 2015 (Simard et al. 2019).

Kraus et al. (2016) observed NARWs in the MA and RI/MA WEAs and surrounding waters in winter and spring during the 2011–2015 NLPSC aerial survey and observed 11 instances of courtship behavior. The greatest SPUE in the MA and RI/MA WEAs was in March. Seventy-seven unique individual NARWs were observed in the MA and RI/MA WEAs over the duration of the NLPSC surveys (Kraus et al. 2016). No calves were observed. Kraus et al. (2016) acoustically detected NARWs with PAM within the MA WEA on 43% of project days (443/1,020 days) and during all months of the year. Acoustic detections do not differentiate between individuals, so detections on multiple days could be the same or different individuals. NARWs exhibited notable seasonal variability in acoustic presence, with maximum occurrence in the winter and spring (January through March), and minimum occurrence in summer (July, August, and September). The mean detection range for NARWs using PAM was 15–24 km (8-13 n.mi.), with a mean radius of 21 km (11 n.mi.) for the PAM system within the study area.

Following Kraus et al. (2016), aerial surveys focused on marine mammal occurrence have continued in the MA and RI/MA WEA study area (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). There were 112 sightings of 164 individual NARWs during directed surveys between October 2018 and August 2019 (O'Brien et al. 2020). In contrast with the aerial surveys conducted by Kraus et al. (2016), NARWs were observed in the MA and RI/MA WEAs during every season, in nine of eleven months. December through February had the highest number of sightings, with a peak in January. NARWs were recorded predominantly on the eastern side of the survey area. The distribution was observed to change seasonally with NARWs moving north from the southern portion of Nantucket Shoals in winter to an area 18.52 km (10 n.mi.) south of Nantucket in April. The aggregation was then observed to move south again back to Nantucket Shoals in late July persisting in the area until the end of the survey period in August (O'Brien et al. 2020). In the following survey year, Between March and October 2020, there were 10 sightings of 15 individual NARWs (O'Brien et al. 2021). Sighting rates were higher in the fall than summer, and the feeding aggregation observed in previous years during the summer was absent (O'Brien et al. 2021). NARWs were only sighted on the eastern side of the study area, over Nantucket Shoals. In the subsequent study, between September 2020 and October 2021, right whales were the mostly commonly sighted whale, with 90 sightings of 169 NARWs (O'Brien et al. 2022). NARWs were sighted in all seasons. During summer and fall, all but one sighting of NARWs were over the Nantucket Shoals. In winter, the majority of NARW sightings were still over the Nantucket Shoals, but they were also sighted within the RI and MA WEAs and near Martha’s Vineyard. During spring months, there were no NARW sightings over the Nantucket Shoals; all sightings were aggregated in or near the MA and RI/MA WEAs (O'Brien et al. 2022). Finally, during the most recent surveys by this group (February–August 2022), there were 22 NARW sightings of 31 individuals. During this survey, NARWs were sighted both in the RI and MA WEAs and over the Nantucket Shoals in every season, with most sightings over the Nantucket Shoals (O'Brien et al. 2023). NARWs were observed 8 times (13 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b).

Based on the available information, sightings of this species in the WDA are possible at any time of year.

4.1.4.3. Abundance

The Western North Atlantic population size was estimated to be 338 individuals in the most recent draft 2022 SAR, which used data from the photo-identification database maintained by the NEAq that were available in October 2019 (Hayes et al. 2023). However, the Right Whale Consortium 2020 Report Card estimates the NARW population to be 336 individuals (Pettis et al. 2021). A population trend analysis conducted on the abundance estimates from 1990 to 2011 suggest an increase at about 2.8% per year from an initial abundance estimate of 270 individuals in 1998 to 481 in 2011, but there was a 100% chance the abundance declined from 2011 to 2020 when the final estimate was 338 individuals (Hayes et al. 2023). Based on the abundance estimates between 2011 and 2019, there was an overall abundance decline of 29.7% (derived from 2011 and 2020 median point estimates) (Hayes et al. 2023). Modeling conducted by Pace et al. (2021) showed a decline in annual abundance after 2011, which has likely continued as evidenced by the decrease in the abundance estimate from 368 in 2022 (Hayes et al. 2022) to 338 in 2023 (Hayes et al. 2023). Highly variable data exists regarding the productivity of this stock. Over time, there have been periodic swings of per capita birth rates (Hayes et al. 2023). Net productivity rates do not exist as the Western North Atlantic stock lacks any definitive population trend (Hayes et al. 2020).

4.1.5. Sei Whale (Balaenoptera borealis)

Sei whales are a baleen whale that can reach lengths of about 12–18 m (NMFS 2023a). This species has a long, sleek body that is dark bluish gray to black in color and pale underneath (NMFS 2023a). Their diet is comprised primarily of plankton, schooling fish, and cephalopods. Sei whales generally travel in small groups of two to five individuals (NMFS 2023a).

Although uncertainties still exist with distinguishing sei whale vocalizations during PAM surveys, they are known to produce short duration (0.7 to 2.2 seconds) upsweeps and downsweeps between 20 and 600 Hz. SLs for these calls can range from 147 to 183 dB re 1 µPa @ 1 m SPL_{rms} (Erbe et al. 2017). No auditory sensitivity data are available for this species (Southall et al. 2019).

4.1.5.1. Status

Sei whales are listed as endangered under the ESA (Hayes et al. 2022) and MA ESA (MassWildLife 2023). This stock is listed as depleted under the MMPA and is considered strategic due to its endangered status (Hayes et al. 2022). Annual human-caused mortality and serious injury from 2015 to 2019 was estimated to be 0.8 per year (Hayes et al. 2022). The PBR for this stock is 6.2 (Hayes et al. 2022). Like fin whales, major threats to sei whales include fishery interactions, vessel collisions, contaminants, and climate-related shifts in prey species (Hayes et al. 2022). There are no critical habitat areas designated for the sei whale under the ESA. A BIA for feeding for sei whales occurs east of the WDA from May through November (LaBrecque et al. 2015).

4.1.5.2. Distribution

Sei whales occur in all the world’s oceans and migrate between feeding grounds in temperate and sub-polar regions to wintering grounds in lower latitudes (Kenney and Vigness-Raposa 2010; NMFS 2023a). In the western North Atlantic, most of the population is concentrated in northerly waters along the Scotian Shelf. Sei whales are observed in the spring and summer, using the northern portions of the US Atlantic EEZ as feeding grounds, including the Gulf of Maine and Georges Bank (Hayes et al. 2022). The highest concentration is observed during the spring along the eastern margin of Georges Bank and in the Northeast Channel area along the southwestern edge of Georges Bank. PAM conducted along the Atlantic Continental Shelf and Slope in 2004-2014 detected sei whales calls from south of Cape Hatteras to the

Davis Strait with evidence of distinct seasonal and geographic patterns. Davis et al. (2020) detected peak call occurrence in northern latitudes during summer indicating feeding grounds ranging from SNE through the Scotian Shelf. Sei whales were recorded in the southeast on Blake’s Plateau in the winter months, but only on the offshore recorders indicating a more pelagic distribution in this region. Persistent year-round detections in SNE and the New York Bight highlight this as an important region for the species (Hayes et al. 2022). In general, sei whales are observed offshore with periodic incursions into more shallow waters for foraging (Hayes et al. 2022).

Kraus et al. (2016) observed sei whales in the MA and RI/MA WEAs and surrounding areas only between the months of March and June during the 2011–2015 NLPSC aerial survey. The number of sei whale observations was less than half that of other baleen whale species in the two seasons in which sei whales were observed (spring and summer). This species demonstrated a distinct seasonal habitat use pattern that was consistent throughout the study. Calves were observed three times and feeding was observed four times during the Kraus et al. (2016) study.

Following Kraus et al. (2016), aerial surveys focused on marine mammal occurrence have continued in the MA and RI/MA WEA study area (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). There were 28 sightings of 55 individual sei whales observed between October 2018 and August, all of which occurred in May and June (O'Brien et al. 2020). Observations of sei whales were made in the southern portion of the survey area outside the MA and RI/MA WEAs (O'Brien et al. 2020). No sei whales were observed within the MA and RI/MA WEAs in the following year of this study (O'Brien et al. 2021). In the subsequent study, between September 2020 and October 2021, there was one sighting of one individual sei whale (O'Brien et al. 2022). Finally, during the most recent surveys by this group (February–August 2022), there were three sightings of three individual sei whales (O'Brien et al. 2023). Based on the observed sightings from these as well as the Kraus et al. (2016) aerial surveys, sei whales are expected to be present in much lower numbers than the other baleen whales.

Sei whales were observed once (1 individual) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Sei whales were observed only in summer during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and they were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys, but most frequently in spring (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest sei whales are most abundant in the area during the spring, followed by summer, and then fall, then winter (Palka et al. 2021).

4.1.5.3. Abundance

Prior to 1999, sei whales in the Western North Atlantic were considered a single stock. Following the suggestion of the Scientific Committee of the IWC, two separate stocks were identified for this species: a Nova Scotia stock and a Labrador Sea stock. Only the Nova Scotia stock can be found in US waters, and the current abundance estimate for this population is 6,292 derived from recent surveys conducted between Halifax, Nova Scotia and Florida (Hayes et al. 2022). Population trends are not available for this stock because of insufficient data (Hayes et al. 2022).

4.2. Odontocetes

4.2.1. Sperm Whale (Physeter macrocephalus)

The sperm whale is the largest of all toothed whales; males can reach 16 m in length and weigh over 45 tons, and females can attain lengths of up to 11 m and weigh over 15 tons (Whitehead 2018). Sperm whales have extremely large heads, which account for 25–35% of the total length of the animal. This species tends to be uniformly dark gray in color, though lighter spots may be present on the ventral surface. Sperm whales typically dive to depths of 600 m for about 45 minutes in search of their prey, which mainly consist of mesopelagic fish and squid; some dives can be deeper (over 1,000 m) and last longer (Whitehead 2018). Sperm whales form stable social groups and exhibit a geographic social structure; females and juveniles form mixed groups and primarily reside in tropical and subtropical waters, whereas males are more solitary and wide-ranging and occur at higher latitudes (Whitehead 2003).

Unlike mysticete whales that produce various types of calls used solely for communication, sperm whales produce clicks that are used for echolocation and foraging as well as communication (Erbe et al. 2017). Sperm whale clicks have been grouped into five classes based on the click rate, or number of clicks per second; these include “squeals,” “creaks,” “usual clicks,” “slow clicks,” and “codas.” In general, these clicks are broadband sounds ranging from 100 Hz to 30 kHz with peak energy centered around 15 kHz. Depending on the class, SLs for sperm whale calls range between approximately 166 and 236 dB re 1 µPa @ 1 m SPL_{rms} (Erbe et al. 2017). Hearing sensitivity data for this species are currently unavailable (Southall et al. 2019).

4.2.1.1. Status

Sperm whales are listed as endangered under the ESA (Hayes et al. 2020). The western North Atlantic stock is considered strategic under the MMPA due to its listing as endangered under the ESA (Hayes et al. 2020). Between 2013 and 2017, 12 sperm whale strandings were documented along the US east coast, but none of the strandings showed evidence of human interactions (Hayes et al. 2020). A moratorium on sperm whale hunting was adopted in 1986 and currently no hunting is allowed for any purposes in the North Atlantic. Occasionally, sperm whales will become entangled in fishing gear or be struck by ships off the east coast of the US. However, this rate of mortality is not believed to have biologically significant impacts. The current PBR for this stock is 6.9, and because the total estimated human-caused mortality and serious injury is <10% of this calculated PBR, it is considered insignificant (Hayes et al. 2020). Other threats to sperm whales include contaminants, climate-related changes in prey distribution, and anthropogenic noise, although the severity of these threats on sperm whales is currently unknown (Hayes et al. 2020). There is no designated critical habitat for this population in the WDA.

4.2.1.2. Distribution

Sperm whales can be found throughout the world’s oceans. They can be found near the edge of the ice pack in both hemispheres and are also common along the equator. The North Atlantic stock is distributed mainly along the continental shelf-edge, over the continental slope, and mid-ocean regions (Hayes et al. 2020). In the winter, sperm whales are observed east and northeast of Cape Hatteras. In the spring, sperm whales are more widely distributed throughout the Mid-Atlantic Bight and southern portions of George’s Bank (Hayes et al. 2020). In the summer, sperm whale distribution is similar to the spring, but they are more widespread in Georges Bank and the northeast Channel region and are also observed inshore of the 100-m isobath south of New England (Hayes et al. 2020). Sperm whale occurrence on the continental shelf in areas south of New England is at its highest in the fall (Hayes et al. 2020).

Kraus et al. (2016) observed sperm whales four times in the MA and RI/MA WEAs and surrounding areas in the summer and fall during the 2011–2015 NLPSC aerial survey. Sperm whales, traveling individually or in groups of three or four, were observed three times in August and September of 2012, and once in June of 2015 (Kraus et al. 2016). Effort-weighted average sighting rates could not be calculated. The frequency of sperm whale clicks exceeded the maximum frequency of PAM equipment used in the Kraus et al. (2016) study, so no acoustic data are available for this species from that study. During more recent aerial surveys conducted within the MA and RI/MA WEAs, two groups of sperm whales were observed in June and July of 2019 (O'Brien et al. 2020). On June 12, a group of four whales was sighted, and a group of two whales was sighted on July 15. Both groups were observed in relatively shallow water close to shore, with the June 12 sighting 18.5 km (10 n.mi) south of Nantucket Island and the July 15 sighting 24 km (13 n.mi.) southwest of the island. Both groups were observed diving and milling at the surface (O'Brien et al. 2020). In subsequent studies by this group – March–October 2020 (O'Brien et al. 2021), November 2020–October 2021 (O'Brien et al. 2022), and February–August 2022 (O'Brien et al. 2023) – no sperm whales were observed.

Sperm whales were not observed in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Sperm whales were observed during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall, and were observed in all seasons except winter during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest sperm whales are most abundant in the area during the summer, though much less abundant than the mysticete whales, and at very low abundances the rest of the year (Palka et al. 2021).

4.2.1.3. Abundance

The IWC recognizes only one stock of sperm whales for the North Atlantic, and Reeves and Whitehead (1997) and Dufault et al. (1999) suggest that sperm whale populations lack clear geographic structure. The best and most recent abundance estimate based on 2016 surveys conducted between the lower Bay of Fundy and Florida is 4,349 (Hayes et al. 2020). No population trend analysis is available for this stock.

4.2.2. Pilot Whale, Long-finned (Globicephalus melas)

Two species of pilot whale occur within the western North Atlantic: the long-finned pilot whale and the short-finned pilot whale (*G. macrorhynchus*). These species are difficult to differentiate at sea and cannot be reliably distinguished during most surveys (Rone and Pace 2012; Hayes et al. 2022). Both short-finned and long-finned pilot whales are similar in coloration and body shape. Pilot whales have bulbous heads, are dark black in color, and can reach approximately 7.3 m in length (NMFS 2023e). However, long-finned pilot whales can be distinguished by their long flippers, which are 18 to 27% of the body length with a pointed tip and angled leading edge (Jefferson et al. 1993). These whales form large, relatively stable aggregations that appear to be maternally determined (ACS 2018). Long-finned pilot whales can dive up to 600 m where they feed primarily on fish, cephalopods (squid and octopus), and crustaceans (NMFS 2023e).

Like dolphin species, long-finned pilot whales can produce whistles and burst-pulses used for foraging and communication. Whistles typically range in frequency from one to 11 kHz while burst-pulses cover a broader frequency range from 100 Hz to 22 kHz (Erbe et al. 2017). AEP measurements conducted by Pacini et al. (2010) indicate that the hearing sensitivity for this species ranges from <4 kHz to 89 kHz.

4.2.2.1. Status

Long-finned pilot whales are not listed as threatened or endangered under the ESA or the MA ESA (Hayes et al. 2022). Long-finned pilot whales have a propensity to mass strand, although the role of human activity in these strandings remains unknown (Hayes et al. 2022). The PBR for this stock is 306, and the annual mortality and serious injury incidental to U.S. fisheries was estimated to be nine whales between 2015 and 2019, and 7 long-finned pilot whales were reported stranded during that time with 2 of those in Massachusetts (Hayes et al. 2022). Threats to this population include entanglement in fishing gear, contaminants, climate-related shifts in prey distribution, and anthropogenic noise (Hayes et al. 2022).

4.2.2.2. Distribution

Because it is difficult to differentiate between the two pilot whale species in the field, sightings are usually reported to genus level only (CeTAP 1982; Hayes et al. 2022). However, short-finned pilot whales are a southern or tropical species and pilot whale sightings above approximately 42° North (N) are most likely long-finned pilot whales. Short-finned pilot whale occurrence in the WDA is considered rare (CeTAP 1982; Hayes et al. 2022). Long-finned pilot whales are distributed along the continental shelf waters off the northeastern US in the winter and early spring. By late spring, pilot whales migrate into more northern waters including Georges Bank and the Gulf of Maine and will remain there until fall (CeTAP 1982; Hayes et al. 2022). The two species' ranges overlap spatially along the shelf break between the southern flank of Georges Bank and New Jersey (Rone and Pace 2012; Hayes et al. 2022).

Kraus et al. (2016) observed pilot whales infrequently in the MA and RI/MA WEAs and surrounding areas during the 2011–2015 NLPSC aerial survey. Effort-weighted average sighting rates for pilot whales could not be calculated. No pilot whales were observed during the fall or winter, and these species were only observed 11 times in the spring and three times in the summer. Two of these sightings included calves. It is possible that the NLPSC survey may have underestimated the abundance of pilot whales, as this survey was designed to target large cetaceans and most small cetaceans were not identified to species (Kraus et al. 2016).

During continued aerial surveys in the MA and RI/MA WEA study area between October 2018 and August 2019, pilot whales were observed only between April and July and only on the eastern side of the study area south of Nantucket Shoals (O'Brien et al. 2020). Between March and October 2020 (O'Brien et al. 2021) and during the September 2020 through October 2021 study period, no pilot whales were seen (O'Brien et al. 2022). During the February–August 2022 surveys, there were 4 sightings of 72 pilot whales (O'Brien et al. 2023). This species was only seen during the spring.

Long-finned pilot whales were not observed in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Long-finned pilot whales were observed only in the summer during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest long-finned pilot whales are most abundant in the area during the summer, followed by fall and then spring, and least abundant, though still present, during winter (Palka et al. 2021).

4.2.2.3. Abundance

The best available estimate of long-finned pilot whales in the western North Atlantic is 39,215 based on recent surveys covering waters between Labrador and central Virginia (Hayes et al. 2022). A trend analysis has not been conducted for this stock due to the relatively imprecise abundance estimates (Hayes et al. 2022).

4.2.3. Atlantic White-sided Dolphin (Lagenorhynchus acutus)

The Atlantic white-sided dolphin is robust and attains a body length of approximately 2.8 m (Jefferson et al. 2008). It is more colorful than most dolphins and is characterized by a bright white patch on the side that extends from below the dorsal fin toward the tail flukes as a yellowish blaze above a thin dark stripe (Cipriano 2018). Atlantic white-sided dolphins feed mostly on small schooling fishes (e.g., herring, mackerel, hake, sand lance) and squid, and are often observed feeding in mixed-species groups with baleen whales and other dolphin species (Jefferson et al. 2008; Cipriano 2018). Behaviorally, this species is highly social, but not as demonstrative as some other common dolphins. Off New England, typical group size is around 40 individuals, but can range from a few to ~500 animals (Cipriano 2018).

Like most dolphin species, Atlantic white-sided dolphins produce clicks, buzzes, calls, and whistles. Their clicks are broadband sounds ranging from 30 to 40 kHz that can contain frequencies over 100 kHz and are often produced during foraging and for orientation within the water column. Buzzes and calls are not as well studied, and they may be used for socialization as well as foraging. Whistles are primarily for social communication and group cohesion and are characterized by a down sweep followed by an upsweep with an approximate starting frequency of 20 kHz and ending frequency of 17 kHz (Hamran 2014). No hearing sensitivity data are currently available for this species (Southall et al. 2019).

4.2.3.1. Status

Atlantic white-sided dolphins are not listed under the ESA or considered a strategic stock under the MMPA (Hayes et al. 2022). The PBR for this stock is 544 and the annual rate of human-caused mortality and serious injury from 2015 to 2019 was estimated to be 27 dolphins (Hayes et al. 2022). This estimate is based on observed fishery interactions, but Atlantic white-sided dolphins are also threatened by contaminants in their habitat, and climate-related shifts in prey distribution (Hayes et al. 2022).

4.2.3.2. Distribution

Atlantic white-sided dolphins are the most abundant dolphin in the Gulf of Maine and the Gulf of St. Lawrence; they are rarely seen off the coast of Nova Scotia (Kenney and Vigness-Raposa 2010). The species occurs year-round between central West Greenland to North Carolina primarily in continental shelf waters to the 100-m (328-ft) depth contour (Hayes et al. 2022). There are seasonal shifts in the distribution of the Atlantic white-sided dolphins off the northeastern US coast, with low abundance in winter between Georges Basin and Jeffrey’s Ledge and very high abundance in the Gulf of Maine during spring. During summer, Atlantic white-sided dolphins are most abundant between Cape Cod and the lower Bay of Fundy. During fall, the distribution of the species is similar to that in summer, with less overall abundance (DoN 2005).

Kraus et al. (2016) suggest that Atlantic white-sided dolphins occur infrequently in the MA and RI/MA WEAs and surrounding areas. Effort-weighted average sighting rates for Atlantic white-sided dolphins could not be calculated because this species was only observed on eight occasions throughout the duration of the study (October 2011 through June 2015). No Atlantic white-sided dolphins were observed during winter, and this species was only sighted twice in the fall and three times in the spring and summer. It is possible that the NLPSC survey may have underestimated the abundance of Atlantic white-sided dolphins because this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species.

During continued aerial surveys in the MA and RI/MA WEA study area, between October 2018 and August 2019, Atlantic white-sided dolphins were only observed during the months of April through July, and only on the western side of the survey area (O'Brien et al. 2020). Between March and October 2020, there was only a single sighting of this species (15 individuals) in the MA and RI/MA WEAs, which occurred in summer (O'Brien et al. 2021). During the September 2020 through October 2021 study period, there was one sighting of nine individuals (O'Brien et al. 2022) and during the February–August 2022 surveys (O'Brien et al. 2023), there was one sighting of ten Atlantic white-sided dolphins.

Atlantic white-sided dolphins were observed 5 times (8 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Atlantic white-sided dolphins were observed only in the summer during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest Atlantic white-sided dolphins are most abundant in the area during the spring, and present in lower, but similar, numbers during the other three seasons (Palka et al. 2021).

4.2.3.3. Abundance

The best abundance estimate currently available for the Western North Atlantic stock is 93,233 based on surveys conducted between Labrador and central Virginia (Hayes et al. 2022). A trend analysis is not currently available for this stock due to insufficient data (Hayes et al. 2022).

4.2.4. Common Bottlenose Dolphin (Tursiops truncatus)

Common bottlenose dolphins are one of the most well-known and widely distributed species of marine mammals. These dolphins reach 2–4 m in length (NMFS 2023j). The snout is stocky and set off from the head by a crease. They are typically light to dark grey in color with a white underside (Jefferson et al. 1993). Bottlenose dolphins are considered generalist feeders and consume a wide variety of organisms, including fish, squid, and shrimp and other crustaceans (Jefferson et al. 2008).

Whistles produced by bottlenose dolphins can vary over geographic regions, and newborns are thought to develop “signature whistles” within the first few months of their lives that are used for intraspecific communication. Whistles generally range in frequency from 300 Hz to 39 kHz with SLs between 114 and 163 dB re 1 µPa @ 1 m SPL_{rms} (Erbe et al. 2017). Bottlenose dolphins also make burst-pulse sounds and echolocation clicks, which can range from a few kHz to over 150 kHz. As these sounds are used for locating and capturing prey, they are directional calls; the recorded frequency and sound level can vary depending on whether the sound was received head-on or at an angle relative to the vocalizing dolphin. SLs for burst-pulses and clicks range between 193 and 228 dB re 1 µPa @ 1 m $\mathrm{SPL_{rms}}$ (Erbe et al. 2017). There are sufficient available data for bottlenose dolphin hearing sensitivity using both behavioral and auditory evoked potential (AEP) methods as well as anatomical modeling studies, which show hearing for the species is most sensitive between approximately 400 Hz and 169 kHz (Southall et al. 2019).

4.2.4.1. Status

Common bottlenose dolphins are not listed under the ESA and the stock of bottlenose dolphins that occurs in the WDA is not considered strategic under the MMPA (Hayes et al. 2020). The PBR for this stock is 519, and the average annual human-cause mortality and serious injury from 2013 to 2017 was estimated to be 28, attributed to fishery interactions (Hayes et al. 2020). In addition to fisheries, threats to common bottlenose dolphins include non-fishery related human interaction; anthropogenic noise; offshore development; contaminants in their habitat; and climate-related changes in prey distribution (Hayes et al. 2020). There is no designated critical habitat for bottlenose dolphins in the WDA.

4.2.4.2. Distribution

In the western North Atlantic, there are two morphologically and genetically distinct common bottlenose morphotypes – offshore and coastal (Hoelzel et al. 1998; Rosel et al. 2009). These are divided into the Western North Atlantic Northern Migratory Coastal stock and the Western North Atlantic Offshore Stock for management purposes (Hayes et al. 2020). The offshore stock is primarily distributed along the outer shelf and slope from Georges Bank to Florida during spring and summer and has been observed in the Gulf of Maine during late summer and fall (Hayes et al. 2020), whereas the northern migratory coastal stock is distributed along the coast between southern Long Island, New York, and Florida (Hayes et al. 2021). Because the northern limit of the coastal stock is approximately Sandy Hook, NJ (Hayes et al. 2021), only the offshore stock is likely to occur in the WDA.

Kraus et al. (2016) observed common bottlenose dolphins during all seasons within the MA and RI/MA WEAs in the 2011–2015 NLPSC aerial survey. This was the second most commonly observed small cetacean species and exhibited little seasonal variability in abundance. One sighting of common bottlenose dolphins in the Kraus et al. (2016) study included calves, and one sighting involved mating behavior. It is possible that the NLPSC survey may have underestimated the abundance of common bottlenose dolphins because this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al. 2016).

During continued aerial surveys in the MA and RI/MA WEA study area, between October 2018 and August 2019, common bottlenose dolphins were the second most abundant small cetacean, accounting for 15% of sightings (O'Brien et al. 2020). They were seen throughout the study area, but only during April through July. During the March–October 2020 surveys, common bottlenose dolphins accounted for 22% of small cetacean sightings. They were seen only in the summer and only in the southern portion of the study area (O'Brien et al. 2021). During the September 2020–October 2021 study period, they accounted for 10% of cetacean sightings, and similar to the previous study they were only seen in the southern part of the study area (O'Brien et al. 2022). They were seen in every season except fall. During the February–August 2022 surveys, they accounted for 18% of small cetacean sightings and were seen in all seasons surveyed. They were seen primarily in the center of the WEAs and less commonly over the Nantucket Shoals (O'Brien et al. 2023).

Common bottlenose dolphins were observed twice (9 individuals) in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Common bottlenose dolphins were observed in both seasons of the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest common bottlenose dolphins are most abundant in the area during the summer followed by the spring, and present in lower, but similar, numbers during fall and winter (Palka et al. 2021).

4.2.4.3. Abundance

The best abundance estimate for the Western North Atlantic offshore stock is 62,851 based on recent surveys between the lower Bay of Fundy and Florida (Hayes et al. 2020). A population trend analysis for this stock was conducted using abundance estimates from 2004, 2011, and 2016, which show no statistically significant trend (Hayes et al. 2020).

4.2.5. Common Dolphin (Delphinus delphis)

Two common dolphin species were previously recognized: the long-beaked common dolphin (*D. capensis*) and short-beaked common dolphin (*D. delphis*); however, Cunha et al. (2015) summarized the relevant data and analyses along with additional molecular data and analysis and recommended that the long-beaked common dolphin not be further recognized in the Atlantic Ocean. Thus, only a single species of common dolphin exists in the North Atlantic Ocean. Adult common dolphins are 1.5–2.3 m in length with a tall dorsal fin and long beak. They have a distinct crisscross coloration with a four-part pattern of a dark gray to black cap, buff to pale yellow anterior portion, light-to-medium gray flank patch, and white abdomen (Perrin 2018). This species feeds on schooling fish and squid found near the surface at night (NMFS 2023c). Common dolphins are a highly social and energetic species that usually travels in large pods consisting of 50 to >1,000 individuals (Cañadas and Hammond 2008). The common dolphin can frequently be seen performing acrobatics and interacting with large vessels and other marine mammals.

Common dolphin clicks are broadband sounds between 17 and 45 kHz with peak energy between 23 and 67 kHz. Burst-pulse sounds are typically between 2 and 14 kHz while the key frequencies of common dolphin whistles are between 3 and 24 kHz (Erbe et al. 2017). No hearing sensitivity data are available for this species (Southall et al. 2019).

4.2.5.1. Status

The common dolphin is not listed under the ESA and the western North Atlantic stock is not considered strategic under the MMPA (Hayes et al. 2022). Historically, this species was hunted in large numbers for food and oil. Currently, they continue to suffer incidental mortality from commercial fisheries (Hayes et al. 2022). The common dolphin faces anthropogenic threats because of its utilization of nearshore habitat and highly social nature, but it is not considered a strategic stock under the MMPA because the average annual human-caused mortality and serious injury does not exceed the calculated PBR of 1,452 for this stock (Hayes et al. 2022). The annual estimated human-caused mortality and serious injury for 2015 to 2019 was 390.4, which included fishery-interactions and research takes (Hayes et al. 2022). Other threats to this species include contaminants in their habitat and climate-related changes in prey distribution (Hayes et al. 2022). There is no designated critical habitat for this stock in the WDA.

4.2.5.2. Distribution

The common dolphin is the most abundant dolphin in warm-temperate waters of the Atlantic and Pacific oceans (Perrin 2018). Common dolphins in the US Atlantic EEZ belong to the Western North Atlantic stock, generally occurring from Cape Hatteras, North Carolina to the Scotian Shelf (Hayes et al. 2022). Common dolphins are a highly seasonal, migratory species. In the US Atlantic EEZ this species is distributed along the continental shelf between the 200 and 2,000 m isobaths and is associated with Gulf Stream features (CeTAP 1982; Hamazaki 2002; Hayes et al. 2022). Common dolphins occur from Cape Hatteras northeast to Georges Bank (35° to 42°N) during mid-January to May and move as far north as the Scotian Shelf from mid-summer to fall (Hayes et al. 2022). Migration onto the Scotian Shelf and continental shelf off Newfoundland occurs when water temperatures exceed 11°C (Sergeant et al. 1970; Gowans and Whitehead 1995).

Kraus et al. (2016) suggested that common dolphins occur year-round in the MA and RI/MA WEAs and surrounding areas based on data from the 2011–2015 NLPSC aerial survey. They were the most frequently observed small cetacean species within the Kraus et al. (2016) study area. Common dolphins were observed in the MA and RI/MA WEAs in all seasons but were most frequently observed during the summer months; observations of this species peaked between June and August. Two sightings of common dolphins in the Kraus et al. (2016) study included calves, two sightings involved feeding behavior, and three sightings involved mating behavior. Sighting data indicate that common dolphin distribution tended to be farther offshore during the winter months than during spring, summer, and fall. It is possible that the NLPSC survey may have underestimated the abundance of common dolphins, because this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al. 2016).

During continued aerial surveys in the MA and RI/MA WEA study area, between October 2018 and August 2019, common dolphins were the most commonly sighted small cetacean, observed in all seasons and throughout the study area (O'Brien et al. 2020). They were most abundant during summer, followed by fall, winter, and then spring. During the March–October 2020 surveys, common dolphins accounted for 41% of small cetacean sightings and again were seen in all seasons and throughout the study area (O'Brien et al. 2021). During the September 2020–October 2021 study period, they accounted for 39% of small cetacean sightings, and similar to the previous studies they were seen in all seasons and throughout the study area (O'Brien et al. 2022). During the February–August 2022 surveys, they accounted for 50% of small cetacean sightings and were seen in all seasons surveyed. They were seen primarily in the center of the WEAs and less commonly over the Nantucket Shoals (O'Brien et al. 2023).

Common dolphins were observed 281 times (2,757 individuals) in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Common dolphins were observed in both seasons of the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest common dolphins are most abundant in the area during the summer followed by the fall, spring, and then winter (Palka et al. 2021).

4.2.5.3. Abundance

The best available abundance estimate for the Western North Atlantic stock of common dolphins is 172,947 based on recent surveys conducted between Newfoundland/Labrador and Florida (Hayes et al. 2022). A trend analysis was not conducted for this stock because of the imprecise abundance estimate and long survey intervals (Hayes et al. 2022).

4.2.6. Risso's Dolphin (Grampus griseus)

The Risso's dolphin attains a body length of approximately 2.6–4 m (NMFS 2023i). Unlike most other dolphins, Risso's dolphins have blunt heads without distinct beaks. Coloration for this species ranges from dark to light grey. Adult Risso's dolphins are typically covered in white scratches and spots that can be used to identify the species in field surveys (Jefferson et al. 1993). The Risso's dolphin forms groups ranging from 10 to 30 individuals and primarily feed on squid, but also fish such as anchovies (*Engraulidae*), krill, and other cephalopods (NMFS 2023i).

Whistles for this species have frequencies ranging from around 4 kHz to over 22 kHz with estimated SLs between 163 and 210 dB re 1 µPa @ 1 m $\mathrm{SPL}_{\mathrm{rms}}$ (Erbe et al. 2017). Studies using both behavioral and AEP methods have been conducted for this species, which show greatest auditory sensitivity between <4 kHz to >100 kHz (Nachtigall et al. 1995; Nachtigall et al. 2005).

4.2.6.1. Status

Risso's dolphins are not listed as threatened or endangered under the ESA (Hayes et al. 2022). The PBR for this stock is 301, and the annual human-caused mortality and injury for 2015 to 2019 was estimated to be 34 (Hayes et al. 2022). This stock is not classified as strategic under the MMPA because mortality does not exceed the calculated PBR. Threats to this stock include fishery interactions, non-fishery related human interaction, contaminants in their habitat, and climate-related shifts in prey distribution (Hayes et al. 2022). There is no designated critical habitat for this stock in the WDA.

4.2.6.2. Distribution

Risso's dolphins in the US Atlantic EEZ are part of the Western North Atlantic Stock. This stock inhabits waters from Florida to eastern Newfoundland (Leatherwood et al. 1976; Baird and Stacey 1991). Off the northeastern US Coast, Risso's dolphins are primarily concentrated along the continental shelf edge, but they can also be found swimming in shallower waters to the mid-shelf (Hayes et al. 2022). During spring, summer, and fall, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank (CeTAP 1982; Payne et al. 1984). During the winter, the distribution extends outward into oceanic waters (Payne et al. 1984)(Payne et al. 1984). The stock may contain multiple demographically independent populations that should themselves be stocks because the current stock spans multiple eco-regions (Ljungblad et al. 1988; Spalding et al. 2007).

Kraus et al. (2016) results from the 2011–2015 NLPSC aerial survey suggest that Risso's dolphins occur infrequently in the MA and RI/MA WEAs and surrounding areas. Effort-weighted average sighting rates for Risso's dolphins could not be calculated. No Risso's dolphins were observed during summer, fall, or winter, and this species was only observed twice in the spring. It is possible that the NLPSC survey may have underestimated the abundance of Risso's dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species.

Risso's dolphins were not observed during continued aerial surveys in the Kraus et al. (2016) MA and RI/MA WEA study area between 2018 and 2022 (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023).

Risso's dolphins were not observed in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Risso's dolphins were observed in both seasons of the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest Risso's dolphins are most abundant in the area during the summer followed by the fall, and less abundant during spring and winter (Palka et al. 2021).

4.2.6.3. Abundance

The best abundance estimate for the Western North Atlantic stock of Riss's dolphins is 35,215 based on surveys from central Florida to the Gulf of St. Lawrence, Bay of Fundy, and Scotian Shelf combined (Hayes et al. 2022). A trend analysis was not conducted on this species, because there are insufficient data to generate this information.

4.2.7. Harbor Porpoise (Phocoena phocoena)

This species is among the smallest of the toothed whales and is the only porpoise species found in northeastern US waters. A distinguishing physical characteristic is the dark stripe that extends from the flipper to the eye. The rest of its body has common porpoise features; a dark gray back, light gray sides, and small, rounded flippers (Jefferson et al. 1993). It reaches a maximum length of 1.8 m and feeds on a wide variety of small fish and cephalopods (Reeves and Read 2003; Kenney and Vigness-Raposa 2010). Most harbor porpoise are observed in small groups, usually between five and six individuals, although they aggregate into larger groups for feeding or migration (Jefferson et al. 2008).

Harbor porpoises produce high frequency clicks with a peak frequency between 129 and 145 kHz and an estimated SLs that ranges from 166 to 194 dB re 1 µPa @ 1 m $\mathrm{SPL}_{\mathrm{rms}}$ (Villadsgaard et al. 2007). Available data estimating auditory sensitivity for this species suggest that they are most receptive to noise between 300 Hz and 160 kHz (Southall et al. 2019).

4.2.7.1. Status

This species is not listed under the ESA and is considered non-strategic under the MMPA (Hayes et al. 2022). The PBR for this stock is 851, and the estimated human-caused annual mortality and serious injury from 2015 to 2019 was 164 harbor porpoises per year (Hayes et al. 2022). This species faces major anthropogenic impacts because of its nearshore habitat. Historically, Greenland populations were hunted in large numbers for food and oil. Currently, they continue to suffer incidental mortality from western North Atlantic fishing activities such as gillnets and bottom trawls (Hayes et al. 2022). Harbor porpoises also face threats from contaminants in their habitat, vessel traffic, habitat alteration due to offshore development, and climate-related shifts in prey distribution (Hayes et al. 2022). There is no designated critical habitat for this species near the WDA.

4.2.7.2. Distribution

The harbor porpoise is mainly a temperate, inshore species that prefers to inhabit shallow, coastal waters of the North Atlantic, North Pacific, and Black Sea. Harbor porpoises mostly occur in shallow shelf and coastal waters. In the summer, they tend to congregate in the northern Gulf of Maine, southern Bay of Fundy, and around the southern tip of Nova Scotia (Hayes et al. 2022). In the fall and spring, harbor porpoises are widely distributed from New Jersey to Maine (Hayes et al. 2022). In the winter, intermediate densities can be found from New Jersey to North Carolina, with lower densities from New York to New Brunswick, Canada (Kenney and Vigness-Raposa 2010). In cooler months, harbor porpoises have been observed from the coastline to deeper waters (>1,800 m), although the majority of sightings are over the continental shelf (Hayes et al. 2022).

Kraus et al. (2016) indicate that harbor porpoises occur within the MA and RI/MA WEAs in fall, winter, and spring. Harbor porpoises were observed in groups ranging in size from three to 15 individuals and were primarily observed in the Kraus et al. (2016) study area from November through May, with very few sightings during June through September. It is possible that the NLPSC survey may have underestimated the abundance of harbor porpoise because this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al. 2016).

During continued aerial surveys in the MA and RI/MA WEA study area, between October 2018 and August 2019, harbor porpoises accounted for 15% of small cetacean sightings, and were seen in all seasons except fall (O'Brien et al. 2020). They were distributed farther north in the MA and RI/MA WEAs than the other small cetacean species. During the March–October 2020 surveys, there were only two sightings of single harbor porpoises and these occurred during the summer months (O'Brien et al. 2021). During the September 2020–October 2021 study period, similar to the 2018–2019 study, harbor porpoise were seen in every season except fall (O'Brien et al. 2022). During the February–August 2022 surveys, this species accounted for <1% of small cetacean sightings and they were only seen during the spring (O'Brien et al. 2023).

Harbor porpoise were observed 3 times (4 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Harbor porpoises were observed only in summer during the 2010–2017 AMAPPS Northeast shipboard surveys conducted during summer and fall and were observed in all four seasons during the 2010–2017 AMAPPS Northeast aerial surveys (Palka et al. 2021). Those surveys were used to calculate seasonal abundance estimates for the RI/MA WEA study area (which includes a 10-km buffer around the WEA) that suggest harbor porpoises are most abundant in the area during the winter and spring, and less abundant though still quite common during the summer and fall (Palka et al. 2021).

4.2.7.3. Abundance

The best available abundance estimate for the Gulf of Maine/Bay of Fundy stock occurring in the WDA is 95,543 based on combined survey data from NMFS and DFO Canada between the Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf and central Virginia (Hayes et al. 2022). A population trend analysis is not available because data are insufficient for this species (Hayes et al. 2022).

4.3. Pinnipeds

4.3.1. Gray Seal (Halichoerus grypus)

Gray seals are the second most common pinniped in the US Atlantic EEZ (Jefferson et al. 2008). This species inhabits temperate and sub-arctic waters and lives on remote, exposed islands, shoals, and unstable sandbars (Jefferson et al. 2008). Gray seals are large, reaching 2–3 m in length, and have a silver-gray coat with scattered dark spots (NMFS 2023f). These seals are generally gregarious and live in loose colonies while breeding (Jefferson et al. 2008). Though they spend most of their time in coastal waters, gray seals can dive to depths of 300 m, and frequently forage on the outer shelf (Hammill et al. 2001; Jefferson et al. 2008). These opportunistic feeders primarily consume fish, crustaceans, squid, and octopus (NMFS 2023f). They often co-occur with harbor seals because their habitat and feeding preferences overlap (NMFS 2023f).

Two types of underwater vocalizations have been recorded for male and female gray seals; clicks and hums. Clicks are produced in a rapid series resulting in a buzzing noise with a frequency range between 500 Hz and 12 kHz. Hums, which is described as being similar to that of a dog crying in its sleep, are lower frequency calls, with most of the energy <1 kHz (Schusterman et al. 1970). AEP studies indicate that hearing sensitivity for this species is greatest between 140 Hz and 100 kHz (Southall et al. 2019).

4.3.1.1. Status

The Western North Atlantic Stock of gray seals is not listed under the ESA or the MA ESA and is not considered strategic under the MMPA because anthropogenic mortality does not exceed PBR (Hayes et al. 2022). The PBR for this stock is 1,458, and the annual human-caused mortality and serious injury between 2015 and 2019 was estimated to be 4,452 in both the US and Canada (Hayes et al. 2022). Like harbor seals, the gray seal was hunted in New England waters until the late 1960s and this may have depleted this stock. Mortality is currently attributed to fishery interactions, non-fishery related human interactions, research activities, the Canadian commercial harvest, and removals of nuisance animals in Canada (Hayes et al. 2022). Other threats to this population include disease, predation, and natural phenomena like storms (Hayes et al. 2022). There is no designated critical habitat for this species in the WDA.

4.3.1.2. Distribution

Gray seals are found on both sides of the North Atlantic and these populations are genetically distinct (Hayes et al. 2022). The Northwest Atlantic population is equivalent to the Western North Atlantic Stock that occurs in US waters. This stock ranges from New Jersey to Labrador and is centered at Sable Island, Nova Scotia (Davies 1957; Mansfield 1966; Katona et al. 1993; Hammill et al. 2001). There are three breeding concentrations in eastern Canada: Sable Island, the Gulf of St. Lawrence, and along the east coast of Nova Scotia (Lavigueur and Hammill 1993). In US waters, gray seals breed on several isolated islands along the Maine coast and in Nantucket Sound, Massachusetts (Hayes et al. 2022). Following the breeding season, gray seals may spend several weeks ashore in the late spring and early summer while undergoing a yearly molt.

Kraus et al. (2016) observed gray seals in the MA and RI/MA WEAs and surrounding areas during the 2011–2015 NLPSC aerial survey, but this survey was designed to target large cetaceans so locations and numbers of seal observations were not included in the study report. During continued aerial surveys in the Kraus et al. (2016) study area, gray seals were seen during the October 2018–August 2019 study period (O'Brien et al. 2020), September 2020–October 2021 study period (O'Brien et al. 2022), and during the February–August 2022 surveys (O'Brien et al. 2023). All seals observed during the March–October 2020 surveys were unidentified to species (O'Brien et al. 2021).

Gray seals were observed 18 times (18 individuals) in the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b). Gray seals were regularly observed in the MA WEA and nearby waters during all seasons of the 2010–2017 AMAPPS surveys (NEFSC and SEFSC 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). Gray seals tagged near Cape Cod during Phase I of AMAPPS showed strong site fidelity to Cape Cod throughout the summer and fall then movement south and east toward Nantucket beginning in mid-December (Palka et al. 2017). One pup tagged in January spent most of the month that the tag was active in the MA WEA.

4.3.1.3. Abundance

The best available abundance estimate for the Western North Atlantic Stock of gray seals in US waters is 27,300, and the total gray seal population in Canada is estimated at 424,300 (Hayes et al. 2022). The stock size of gray seals is likely increasing in the US Atlantic EEZ as the number of pups born at most US breeding colonies is increasing and as Canadian seals migrate to the region (Hayes et al. 2022).

4.3.2. Harbor Seal (Phoca vitulina)

The harbor seal is one of the smaller pinnipeds, and adults are often light to dark grey or brown with a paler belly and dark spots covering the head and body (Jefferson et al. 1993; Kenney and Vigness-Raposa 2010). This species is approximately 2 m in length (NMFS 2023m). Harbor seals complete both shallow and deep dives during hunting, depending on the availability of prey (Tollit et al. 1997). Harbor seals consume a variety of prey, including fish, shellfish, and crustaceans (Bigg 1981; Reeves et al. 1992; Burns 2002; Jefferson et al. 2008). They commonly occur in coastal waters and on coastal islands, ledges, and sandbars (Jefferson et al. 2008).

Male harbor seals have been documented producing an underwater roar call which is used for competition with other males and attracting mates. These are relatively short calls with a duration of about two seconds and a peak frequency between one and two kHz (Van Parijs et al. 2003)(Van Parijs et al. 2003). Behavioral audiometric studies for this species estimate peak hearing sensitivity between 100 Hz and 79 kHz (Southall et al. 2019).

4.3.2.1. Status

Harbor seals are not listed under the ESA or MA ESA and are not considered strategic because anthropogenic mortality does not exceed PBR (Hayes et al. 2022). The PBR for this population is 1,729 and the annual human-caused mortality and serious injury from 2015 to 2019 was estimated to be 399 seals per year (Hayes et al. 2022). This mortality and serious injury was attributed to fishery interactions, non-fishery related human interactions, and research activities (Hayes et al. 2022). Like the gray seal, harbor seals were hunted in New England waters until the late 1960s and this may have depleted this stock. Other threats to harbor seals include disease and predation (Hayes et al. 2022). There is no designated critical habitat for this species in the WDA.

4.3.2.2. Distribution

The harbor seal is found throughout coastal waters of the Atlantic Ocean and adjoining seas above 30°N and is the most abundant pinniped in the US Atlantic EEZ (Hayes et al. 2022). Harbor seals, also known as common seals, are one of the most widely distributed seal species in the Northern Hemisphere. They can be found inhabiting coastal and inshore waters from temperate to polar latitudes. Harbor seals occur seasonally along the coast during winter months from southern New England to New Jersey, typically from September through late May (Kenney and Vigness-Raposa 2010; Hayes et al. 2022). In recent years, this species has been seen regularly as far south as North Carolina, and regular seasonal haul-out sites of up to 40-60 animals have been documented on the eastern shore of Virginia and the Chesapeake Bay (Jones and Rees 2020). During the summer, most harbor seals can be found north of New York, within the coastal waters of central and northern Maine, as well as the Bay of Fundy (DoN 2005; Hayes et al. 2022). Genetic variability from different geographic populations has led to five subspecies being recognized. Peak breeding and pupping times range from February to early September, and breeding occurs in open water (Temte 1994).

Kraus et al. (2016) observed harbor seals in the MA and RI/MA WEAs and surrounding areas during the 2011–2015 NLPSC aerial survey, but this survey was designed to target large cetaceans so locations and numbers of seal observations were not included in the study report. Harbor seals have five major haul-out sites in and near the MA and RI/MA WEAs: Monomoy Island, the northwestern side of Nantucket Island, Nomans Land, the north side of Gosnold Island, and the southeastern side of Naushon Island (Payne and Selzer 1989). Payne and Selzer (1989) conducted aerial surveys and found that for haul-out sites in Massachusetts and New Hampshire, Monomoy Island had approximately twice as many seals as any of the 13 other sites in the study (maximum count of 1,672 in March of 1986). During continued aerial surveys in the Kraus et al. (2016) study area, unidentified seals were sighted in all study years but there were no seal sightings positively identified as harbor seals (O'Brien et al. 2020; O'Brien et al. 2021, 2022; O'Brien et al. 2023). However, it is likely that at least some of the sightings in the MA WEA were of harbor seals. Harbor seals were observed in the MA WEA and nearby waters during spring, summer, and fall of the 2010–2017 AMAPPS surveys (NEFSC and SEFSC 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). Harbor seals were observed 6 times (6 individuals) in the June–December period during Vineyard Wind’s 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b).

4.3.2.3. Abundance

The best available abundance estimate for harbor seals in the Western North Atlantic is 61,336 (Hayes et al. 2022). Estimates of abundance are based on surveys conducted during the pupping season, when most of the population is assumed to be congregated along the Maine coast. Abundance estimates do not reflect the portion of the stock that might pup in Canadian waters (Hayes et al. 2022). There is no clear trend in the current abundance estimates. Trends were estimated for 1993 to 2018 using a Bayesian hierarchical model to account for missing data both within and between survey years. The estimated mean change in non-pup harbor seal abundance per year was positive from 2001 to 2004, but close to zero or negative between 2005 and 2018 (Hayes et al. 2022). After 2005, mean change in pup abundance was steady or declining until 2018 but these changes were not significant (Hayes et al. 2022).

5. Type of Incidental Take Authorization Requested

Vineyard Wind is requesting the issuance of an Incidental Harassment Authorization (IHA) pursuant to section 101(a)(5)(D) of the MMPA for incidental take by Level A and Level B harassment of small numbers of marine mammals during the impact pile driving activities described in Sections 1 and 2 in and around the OCS-A 0501 Lease Area to be effective for one year from the date of issuance. Per the seasonal restrictions shown in Table 17, there will be no pile driving between December 1, 2024 and May 31, 2025. Pile driving will not occur in December unless it is necessary to complete the installation of the 15 remaining MPs and as notified to and approved by the Bureau of Ocean Energy Management and NMFS. Any pile driving during December will be conducted in compliance with the enhanced monitoring summarized in Section 11.

Although exposure estimates predicted from modeling results indicate that Level A takes are zero or negligible when sound attenuation mitigation is employed, Level A takes are being requested as a precaution in the unlikely scenario that a marine mammal enters the zone of ensonification after pile driving has begun, and it is not feasible from an operational and safety perspective to cease the pile driving activity. In that case, the operator will power down the hammer energy, if feasible and safe.

The mitigation measures described in Section 11 below are designed to minimize the likelihood that Level A takes of any marine mammal species will occur. In particular, noise attenuation technology will be used that reduces sound levels by a target of up to approximately 6 dB. Additional mitigation measures focused on ensuring no Level A harassment of a NARW will occur include restricting pile driving to the months when NARWs are unlikely to be present in the WDA and significant NARW monitoring efforts.

6. Take Estimates for Marine Mammals

Takes of marine mammals, if any, are expected to be “takes by harassment”, involving temporary changes in behavior (i.e., Level B harassment). Specifically, acoustic exposure could result in temporary displacement of marine mammals from within ensonified zones or other temporary changes in behavioral state. The Level A take estimates below assume no mitigation measures other than 6 dB of sound attenuation. The additional mitigation measures to be applied in practice (detailed in Section 11) will reduce the already very low probability of Level A take, but for certain species and activities, some potential Level A takes could occur. The planned construction activities are not expected to “take” more than small numbers of marine mammals and will have a negligible impact on the affected species or stocks. In the sections below, we describe the methods used to calculate potential take and present the resulting request for take authorization.

6.1. Acoustic Impact Analysis Methods Overview

An underwater acoustic and animal movement and exposure modeling analysis was conducted for this project in 2018 (Pyć et al. 2018). That study established acoustic and exposure ranges to Level A and Level B thresholds that were used to inform take estimation and monitoring and mitigation for the current IHA. During the 2023 construction campaign, an SFV study (Küsel et al. 2023) was undertaken during pile installation activities to validate the 2018 model results.

During the 2023 SFV study, in situ measurements were made during impact pile driving installation of 12 monopile foundations. The five most representative monopiles and noise attenuation system (NAS) setup from the SFV study were chosen as being most relevant to this application. These five monopiles are most relevant because they were installed with the hydrosound damper, double big bubble curtain (DBBC), and enhanced BBC maintenance procedure that will be used for installation of the remaining 15 MP foundations. This enhanced BBC maintenance protocol, implemented from the installation of foundation AQ-38 onwards, is an adjustment from typical bubble curtain operations in the North Sea where hoses are usually inspected and cleared (hose holes are drilled to remove sedimentation) after every third deployment but was done here after every deployment to maximize performance considering siltier sediments in the Lease Area.

Figure 6 shows the locations of the 5 most representative monopiles in relation to the remaining 15 to be installed. Because factors such as water depth and sediment type can affect sound propagation, Table 6 shows the water depths and general sediment types for the locations of the five most representative piles from the SFV study and the 15 remaining MP foundations. Table 7 shows the detailed sedimentology. As seen in Table 6, the ground conditions anticipated at the remaining 15 monopile locations are interpreted to be very similar to the five representative MPs presented in the table. In other words, similar sediment properties and stratigraphic framework have been interpreted, which suggests that sound propagation will be similar in the vicinity of the 15 remaining MP foundations and the five most representative piles from the SFV study. This information is available in Volume II of the Vineyard Wind COP (Vineyard Wind 2020) and in detail in appendices containing the Subsurface Geology ground Model report and the Geotechnical Interpretive Report.

As noted in Section 4.4 of the 2018 acoustic modeling report (Pyć et al. 2018), water depth and bottom type are similar throughout the Lease Area and therefore there was minimal difference in sound propagation between the two modeled sites. One of the modeled sites was in the northeast portion of the Lease Area, which was developed in 2023, and the other is near the LIA, where the 15 remaining foundations will be installed (see Figure 5 of Pyć et al. 2018). Thus, sound propagation in the LIA is not expected to differ from where the SFV data were collected in 2023.

Table 6. Water depth and sediment characteristics at the locations of the five most representative piles from the SFV study and the locations of the 15 remaining monopiles.

FOU ID	Water Depth (m)	Sediment Types	Depth to Base (m) Below Seafloor U0	U1	U2	U3	U4
Five most representative piles							
AQ38	41.4	Sand/Clay	1.8	6.2	11.5	16.5	32.9
AT39	41.98	Sand/Clay	2	8.8	11.8	19.9	35.5
AV38	43.1	Sand/Clay	1.5	8.6	13	14.7	36.1
AN37	40.45	Sand/Clay	3	5.4	10	11.3	27.2
AU38	42.95	Sand/Clay	2.2	8.6	12.6	18.4	34.8
Remaining 15 piles							
AP36	42	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AR35	43.5	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AS35	44.5	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AT35	47	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AT34	45.4	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AR36	43.3	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AS36	44.6	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AT36	45.5	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AU36	46.7	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AP37	39.7	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AQ37	41	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AS38	41.2	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AT38	42	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AU37	44	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36
AV37	43.8	Sand/Clay	1-3	5-6.5	10-12.5	12-18.2	19-36

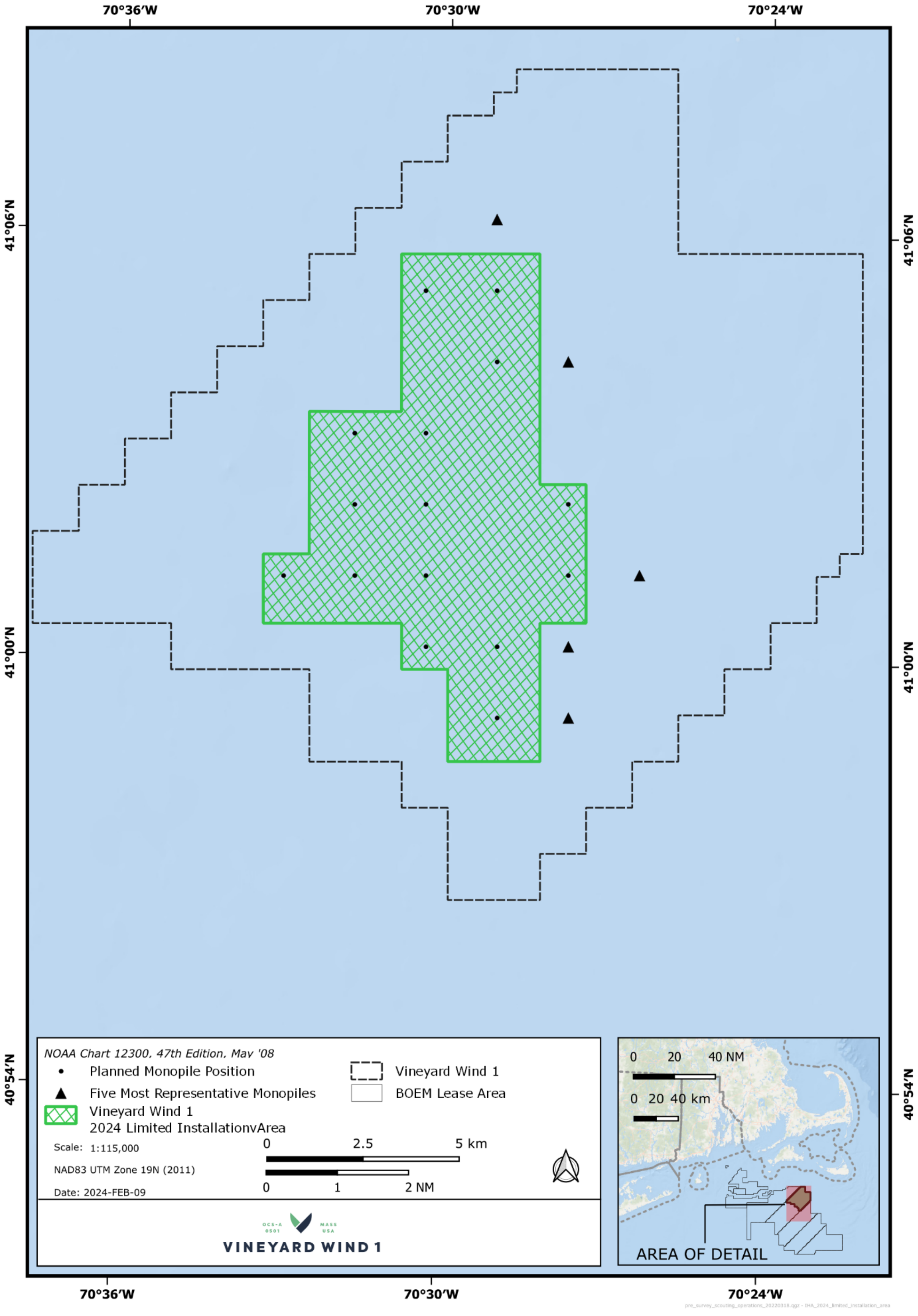
Table 7. Detailed sedimentology.

Formation	Lithology
U0	Loose to very loose olive grey silty fine SAND with shell fragments
U1	Medium dense olive grey silty SAND with micro-crystals
U2	Medium dense to very dense grey poorly graded SAND with silt
U3	Medium dense to very dense grey poorly graded SAND with silt
U4	Variable: gravelly SAND to silty SAND with some CLAY

The measured ranges (in meters) to the Level A and Level B harassment thresholds for these five piles are shown in Table 8. The results provided in Table 8 show ranges to Level A thresholds consistent with those modeled previously (Pyć et al. 2018) and shown below in Table 8, which were used to inform take estimation and monitoring and mitigation in the current IHA. The one exception is the 200 m range measured for high-frequency cetaceans for pile AN-37. This exceedance is probably not meaningful because it is likely due to noise in the extrapolation process exaggerated by the attenuation coefficient term because without attenuation the range for pile AN-37 was 80 m. Additionally, there is substantial higher-frequency noise produced by dynamic positioning thrusters rather than pile driving that disproportionately affects calculation of the high-frequency cetacean range. Additionally, 200 m is close to the DBBC so it is therefore unlikely that an animal would occur this close and remain there long enough to incur PTS. Thus, the original animal movement modeling results were used to estimate Level A harassment. The SFV study confirmed the average distance to the Level B threshold to be similar to the 4.1 km modeled range based on a detailed analysis of the five most representative monopiles and NAS setup (average of 4.4 km). However, as a cautionary approach, Level B takes in this request are calculated based on the maximum range to the 160 dB threshold, with sound attenuation, for the five most representative monopiles and NAS setup (i.e., 5,720 m, see Table 8). In situ sound measurements for the pile with the longest range to the Level B threshold (i.e., pile AU-38) showed maximum 95% exceedance received levels at 750 m of: PK 181.2 dB re 1 µPa, rms SPL 172.7 dB re 1 µPa, and SELss 166.0 dB re 1 µPa^2·s.

Table 8. Ranges (in meters) to the Level A and Level B harassment thresholds, with sound attenuation, for the five most representative monopiles and noise attenuation system operation from the 2023 sound field verification campaign.

	Range in meters to harassment thresholds with attenuation				
	Level A SELcum				**Level B SPL**
Pile ID	**LF cetaceans**	**MF cetaceans**	**HF cetaceans**	**Phocids**	**All species**
AQ-38	880	10	10	10	3,290
AT-39	1,870	10	10	110	4,010
AV-38	2,370	10	60	80	5,000
AN-37	1,820	10	200	10	4,000
AU-38	1,860	10	70	40	5,720



70°36′W
70°30′W
70°24′W
41°06′N
41°00′N
40°54′N
NOAA Chart 12300, 47th Edition, May '08
● Planned Monopile Position
▲ Five Most Representative Monopiles
Vineyard Wind 1 2024 Limited InstallationvArea
Vineyard Wind 1 BOEM Lease Area
Scale: 1:115,000
NAD83 UTM Zone 19N (2011)
Date: 2024-FEB-09
0 2.5 5 km
0 1 2 NM
0 20 40 NM
0 20 40 km
AREA OF DETAIL
VINEYARD WIND 1
pre_survey_scouting_operations_20220318.qgz - IHA_2024_limited_installation_area

Figure 6. Map showing locations of the 5 most representative monopiles, used in establishing the range to the Level B threshold, in relation to the LIA and 15 remaining monopiles.

6.2. Marine Mammal Occurrence Used in Take Estimation

6.2.1. Marine Mammal Densities

Marine mammal density estimates (animals/km^2) used in this assessment were obtained using the Duke University Marine Geospatial Ecological Laboratory (Duke/MGEL) Habitat-based Marine Mammal Density Models for the U.S. Atlantic, which underwent major revisions in 2022 (Roberts et al. 2016; 2023). Mean monthly densities for all animals were calculated using a 10-km buffered polygon around the remaining 15 MP foundations to be installed and overlaying it on the Duke/MGEL density maps (Figure 7). This buffer defines the area around the LIA used to calculate average density for behavioral disturbance. The mean density for each month was determined by calculating the unweighted mean (i.e., for cells only partially within the buffer zone polygon, the entire grid cell is used not only the portion that overlaps with the buffer zone polygon) of all 5 x 5 km grid cells partially or fully within the buffer zone polygon. Densities were computed for all months, for comparison, and are shown in Table 9. Where monthly densities were unavailable (i.e., long-finned pilot whales) annual mean densities were used instead. The months of June to December were presumed to coincide with potential pile driving activities for the purpose of this application. Table 9 shows the monthly marine mammal density estimates as well as the maximum monthly density estimate for each species or species group evaluated in the acoustic analysis. For density-based take calculations, the maximum density month for each species from the June to December period was used. This is a conservative estimate of the maximum possible take for each species because it assumes the remaining 15 monopile foundations will be installed during the maximum density month. If installation occurs in any other month, the take estimate would be lower.

The Roberts et al. (2016; 2023) density models provide densities for seals as a guild that includes both gray and harbor seals, as well as other rare phocid pinnipeds. In order to estimate density-based takes for the gray and harbor seal species individually, the seals guild density was divided into species densities based on the proportions of these two species observed by PSOs within the Lease Area during 2016 and 2018–2021 site characterization surveys and the 2023 construction campaign. Of the 181 seals sighted within the WDA and identified to species, 162 were gray seals and 19 were harbor seals, which results in proportions of 0.895 for gray seals and 0.105 for harbor seals.

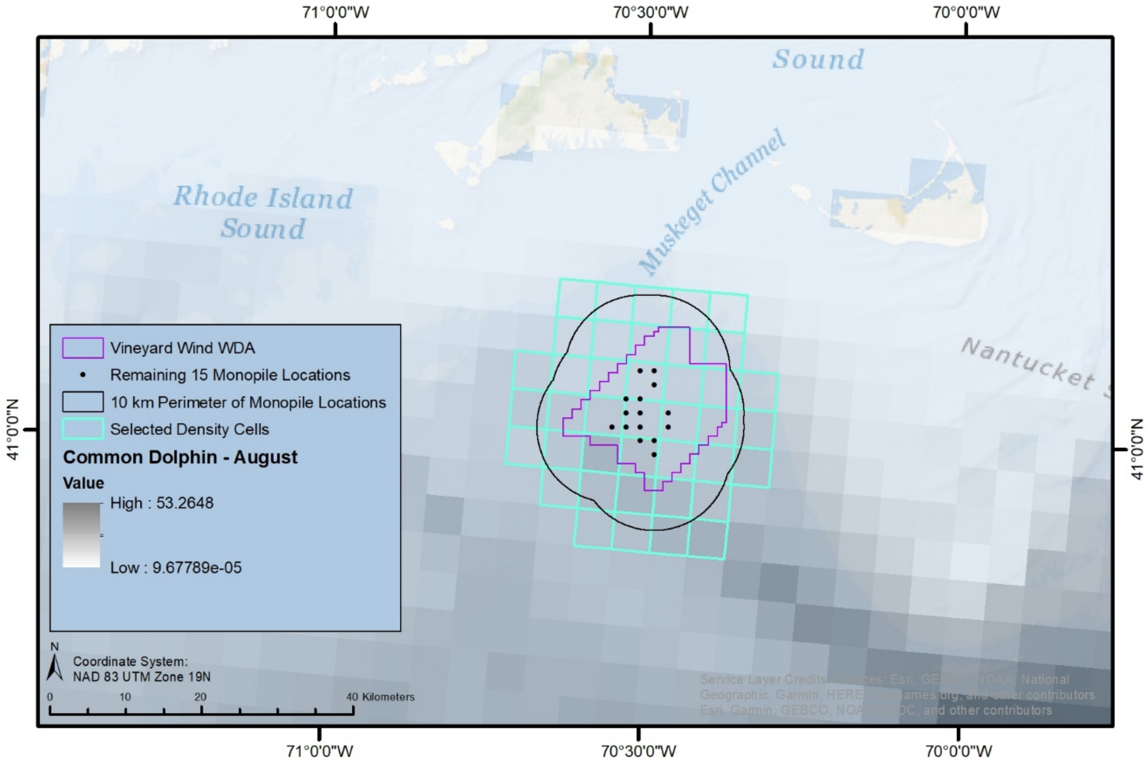


Figure 7. Location of the remaining monopile foundations to be installed and the 10 km (6.2 mi) perimeter used to select the marine mammal density grid cells from Roberts et al. (2016; 2023) for calculating average monthly marine mammal densities.

Table 9. Maximum and monthly marine mammal density estimates within a 10-km (6.2 mi) buffered polygon around the remaining 15 MP foundations to be installed, calculated from Duke/MGEL habitat-based density models (Roberts et al. 2016; 2023).

Species	Maximum Monthly Density (Ind./km^2)	Maximum Density Month	Monthly Average Densities (Individuals/km^2)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mysticetes (LF hearing group)														
Fin whale*	0.0036	Jul	0.0023	0.0012	0.0009	0.0019	0.0025	0.0023	0.0036	0.0034	0.0012	0.0003	0.0005	0.0017
Humpback whale	0.0022	Jun	0.0004	0.0003	0.0005	0.0012	0.0025	0.0022	0.0015	0.0013	0.0017	0.0018	0.0019	0.0005
Minke whale	0.0180	Jun	0.0016	0.0017	0.0017	0.0096	0.0196	0.0180	0.0080	0.0051	0.0041	0.0032	0.0007	0.0012
North Atlantic right whale*	0.0043	Dec	0.0077	0.0088	0.0085	0.0084	0.0051	0.0009	0.0004	0.0003	0.0005	0.0009	0.0014	0.0043
Sei whale*	0.0008	Nov	0.0004	0.0002	0.0004	0.0010	0.0016	0.0003	0.0001	0.0001	0.0001	0.0002	0.0008	0.0007
Odontocetes (MF hearing group)														
Sperm whale*	0.0008	Sep	0.0001	0.0001	0.0001	0.0000	0.0002	0.0003	0.0003	0.0008	0.0008	0.0004	0.0003	0.0001
Atlantic white-sided dolphin	0.0204	Jun	0.0118	0.0067	0.0053	0.0095	0.0264	0.0204	0.0123	0.0085	0.0154	0.0185	0.0174	0.0182
Bottlenose dolphin	0.0080	Aug	0.0017	0.0003	0.0002	0.0007	0.0042	0.0068	0.0073	0.0080	0.0070	0.0061	0.0061	0.0058
Common dolphin	0.1467	Sep	0.0404	0.0118	0.0103	0.0218	0.0457	0.1022	0.0914	0.1104	0.1467	0.0829	0.0663	0.0739
Long-finned pilot whale	0.0010	Jun	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Risso's dolphin	0.0013	Dec	0.0001	0.0000	0.0000	0.0001	0.0005	0.0002	0.0003	0.0005	0.0005	0.0003	0.0008	0.0013
Odontocetes (HF hearing group)														
Harbor porpoise	0.0713	Dec	0.0965	0.0996	0.0928	0.0920	0.0657	0.0165	0.0161	0.0157	0.0167	0.0190	0.0212	0.0713
Pinnipeds (PW hearing group)														
Seals (gray and harbor)	0.1745	Dec	0.2378	0.2101	0.1518	0.1720	0.2255	0.0663	0.0086	0.0090	0.0187	0.0302	0.1093	0.1745

*Indicates species listed as endangered under the US Endangered Species Act.

6.2.2. Marine Mammal Mean Group Size

Density estimates inherently account for group size because the mean group size is a factor in the density estimate calculation. However, density surfaces, like those produced by Roberts et al. (2016; 2023), used to calculate mean densities in the LIA, spread individuals out in space as if they did not occur in groups. When calculating takes, in cases where the Level B density-based exposure estimate was less than the average group size, we assumed that if one group member were to be exposed, it is likely that all animals in the same group would receive a similar exposure level. Thus, for the requested Level B takes, we increased the value from the density-based exposure results to equal one mean group size, rounded up to the nearest integer, for species with predicted exposures of less than one mean group size.

The mean group sizes used in this application are shown in Table 10. Mean group sizes for all marine mammal species were based on the maximum mean group size from either Vineyard Wind's 6 years of PSO sighting data collected during the June–December period in the WDA or observations and analysis from the AMAPPS program (Palka et al. 2017; 2021). For all cetaceans except NARWs, we used the average of AMAPPS's seasonal (spring, summer, and fall to coincide with potential pile driving activities) group sizes for the RI/MA WEA from Tables 2-2 through 2-4 of Palka et al. (2021) Appendix III. For NARWs, Palka et al. (2021) do not provide groups sizes specific to the RI/MA WEA so we calculated mean group size using number of individuals divided by number of groups from the NE shipboard surveys as provided in Table 6-5 of Palka et al. (2021). For pinnipeds, we used the 2010–2013 AMAPPS NE shipboard and aerial at-sea seal sightings for gray and harbor seals as well as unknown seals from spring, summer, and fall of Table 19-1 of Palka et al. (2017), and calculated mean group size as total animals divided by total sightings. The majority of these sightings were of unknown seals and, as noted by Palka et al. (2017), could be harbor or grey seals or perhaps even harp or hooded seals. The average group size from Vineyard Wind's 6 years of PSO sighting data during the June–December period within the WDA is 1.0 for either seal species alone or both combined, so the value calculated from Palka et al. (2017) is used because it is more conservative. A single average group size of 1.4 was used for both seal species considered in this application.

Table 10. Mean group sizes of marine mammal species for which take is being requested.

Species	PSO Data[a] Mean Group Size	AMAPPS Mean Group Size	AMAPPS Source[b]
Mysticetes (LF hearing group)			
Fin whale*	1.7	1.2	Palka et al. (2021)
Humpback whale	1.9	1.2	Palka et al. (2021)
Minke whale	1.0	1.4	Palka et al. (2021)
North Atlantic right whale*	1.6	2.0	Table 6-5 of Palka et al. (2021)
Sei whale*	1.0	1.0	Palka et al. (2021)
Odontocetes (MF hearing group)			
Sperm whale*	-	2.0	Palka et al. (2021)
Atlantic white-sided dolphin	1.6	21.7	Palka et al. (2021)
Bottlenose dolphin	4.5	11.7	Palka et al. (2021)
Common dolphin	9.8	30.8	Palka et al. (2021)
Long-finned pilot whale	-	12.3	Palka et al. (2021)
Risso's dolphin	-	1.8	Palka et al. (2021)
Odontocetes (HF hearing group)			
Harbor porpoise	1.3	2.9	Palka et al. (2021)
Pinnipeds (PPW hearing group)			
Seals (gray and harbor)	1.0	1.4	Table 19-1 of Palka et al. (2017)

*Indicates species listed as endangered under the US Endangered Species Act.

[a] Except where indicated, AMAPPS mean group size is the average of seasonal group sizes for the Rhode Island/Massachusetts Wind Energy Area from Tables 2-2 through 2-4 of Palka et al. (2021) Appendix III.

[b] PSO data mean group size is from the June–December period during Vineyard Wind's 2016 and 2018–2021 site characterization surveys within the WDA (ESS Group Inc. 2016; Vineyard Wind 2018, 2019; EPI Group 2021; RPS 2022) and during the June–December 2023 Vineyard Wind construction campaign (Vineyard Wind 2023c, 2023d, 2023a, 2023e, 2023f, 2023b).

6.2.3. PSO Sighting Rates

For some species, observational data from PSOs aboard survey vessels indicate that density-based take estimates may be insufficient to account for the number of individuals of a species that may be encountered during the planned activities. Therefore, PSO sighting data were used as described here to calculate a daily sighting rate for comparison with the density-based estimates of take.

PSO data collected in June–December during 5 years of site characterization surveys (2016 and 2018–2021) within the WDA and during the 2023 Vineyard Wind 1 construction campaign in the WDA were analyzed to determine the average number of individuals of each species observed per vessel day (Table 11). To account for individuals not identified to the species level by PSOs (i.e. those recorded as "unidentified whale", "unidentified dolphin", "unidentified seal", etc.), the proportion of identified individuals of each species within each taxonomic group was calculated as shown in the column "Proportion of Total Individuals to Species Within Each Species Group" in Table 11. The identified and re-assigned unidentified individuals for each species were then summed as shown in the "Total Individuals Including Proportion of Unidentified" column of Table 11. This value was then divided by the total number of vessel days (i.e., 387) during which observations were conducted in the WDA in the June - December period from the 6 years of PSO sightings to calculate the number of individuals observed per vessel day as shown in the final column in Table 11. Vessel days is the sum of the number of days of observation for each vessel on which PSOs were making observations. This daily PSO sighting rate is then multiplied by the number of days of impact piling (i.e., 15) to arrive at PSO data-based exposure and take estimates.

Table 11. The number of individual marine mammals observed, with and without inclusion of unidentified individuals, and the estimated number of individuals observed per vessel day in the WDA during the June–December period of the 2016 and 2018–2021 site characterization surveys and 2023 construction activities.

Species	Identified Individuals	Proportion of Total Individuals Identified to Species Within Each Species Group	Unidentified Individuals Assigned to Species	Total Individuals Including Proportion of Unidentified	Individuals Observed Per Vessel Day Including Unidentified
Mysticetes					
Fin whale*	12	0.10	4.0	16.0	0.04
Humpback whale	56	0.47	18.8	74.8	0.19
Minke whale	36	0.30	12.1	48.1	0.12
North Atlantic right whale*	13	0.11	4.4	17.4	0.04
Sei Whale*	2	0.02	0.7	2.7	0.01
Unidentified Mysticetes					
Unidentified whales	40	-	-	-	-
Odontocetes					
Sperm whale*	0	-	-	-	-
Atlantic white-sided dolphin	8	0.00	0.7	8.7	0.02
Bottlenose dolphin	9	0.00	0.7	9.7	0.03
Common dolphin	2757	0.99	224.6	2981.6	7.70
Long-finned pilot whale	0	-	-	-	-
Risso’s dolphin	0	-	-	-	-
Harbor porpoise	4	1.00	-	-	0.01
Unidentified Odontocetes					
Unidentified dolphin	226	-	-	-	-
Pinnipeds					
Gray seal	18	0.75	0.8	18.8	0.05
Harbor seal	6	0.25	0.3	6.3	0.02
Unidentified Pinnipeds					
Unidentified seal	1	-	-	-	-

*Indicates species listed as endangered under the US Endangered Species Act.

6.3. Marine Mammal Acoustic Thresholds

To assess potential auditory injury or permanent threshold shift (PTS), Level A harassment, NMFS has provided technical guidance (NMFS 2018) that establishes dual criteria for five different marine mammal hearing groups, four of which occur in the WDA (Table 12). These are based on measured or assumed values for the onset of temporary threshold shift (TTS) in marine mammals. The two criteria are based on different acoustic metrics or ways of measuring sound, the peak sound pressure level (SPL_{pk}) and the cumulative sound exposure level (SEL_{cum}). The SPL_{pk} metric captures the potential for auditory injury caused by very intense, instantaneous sounds while the SEL_{cum} metric captures the potential for injury caused by fatiguing of the auditory system from sounds received over time (in this case, a maximum 24-hr period).

The marine mammal hearing groups are based on the frequencies of sound to which species in that group are most sensitive. The frequency-dependent hearing sensitivities of each group are characterized by frequency weighting functions that are applied to the sounds being modeled and represent the frequencies at which each hearing group is most susceptible to in terms of noise-induced hearing loss. Frequency weighting is applied when calculating distances to the SEL_{cum} threshold while SPL_{pk} is not frequency weighted, which is commonly referred to as unweighted or flat-weighted (Table 12).

Table 12. Marine mammal functional hearing groups and PTS onset (Level A harassment) thresholds as defined by NMFS (2018) for species present in the WDA.

Marine Mammal Hearing Group	Generalized Hearing Range	PTS onset (Level A) Thresholds (Impulsive Sounds)
Low-frequency cetaceans (LF)	7 Hz to 35 kHz	$L_{p,0\text{-}pk,flat}$: 219 dB $L_{E,p,LF,24h}$: 183 dB
Mid-frequency cetaceans (MF)	150 Hz to 160 kHz	$L_{p,0\text{-}pk,flat}$: 230 dB $L_{E,p,MF,24h}$: 185 dB
High-frequency cetaceans (HF)	275 Hz to 160 kHz	$L_{p,0\text{-}pk,flat}$: 202 dB $L_{E,p,HF,24h}$: 155 dB
Phocid pinnipeds (underwater) (PW)	50 Hz to 86 kHz	$L_{p,0\text{-}pk,flat}$: 218 dB $L_{E,p,PW,24h}$: 185 dB

Peak sound pressure level (L_p) is in units of dB re 1 µPa and cumulative sound exposure level ($L_{E,24h}$) is in units of dB re 1 $\mu Pa^2 \cdot s$.

Scientific recommendations for revisions to these classifications were published by Southall et al. (2019). This publication proposes a new nomenclature and classification for the marine mammal hearing groups, but the proposed thresholds and weighting functions do not differ in effect from those in NMFS (2018). The hearing groups and nomenclature proposed by Southall et al. (2019) have not yet been incorporated into the NMFS guidelines.

The received level at which marine mammals may behaviorally respond to anthropogenic sounds varies by numerous factors including the frequency content, predictability, and duty cycle of the sound as well as the experience, demography, and behavioral state of the marine mammals ((Richardson et al. 1995; Southall et al. 2007; Ellison et al. 2012)). Despite this variability, there is a practical need for a reasonable and specific threshold. NMFS currently defines the threshold for behavioral harassment, Level B take, as 160 dB re 1 µPa SPL_{rms} for impulsive sounds such as those produced by impact pile driving.

6.4. Ranges to Acoustic Exposure Thresholds

Acoustic ranges to Level A and Level B thresholds were estimated in the 2018 acoustic assessment for various levels of sound attenuation (Pyć et al. 2018). Ranges with 6 dB sound attenuation were used to assess impacts and for monitoring and mitigation protocols for the active IHA (86 FR 33810). As noted above, an SFV study was conducted during 2023 Vineyard Wind 1 pile installation activities to validate results of the 2018 acoustic assessment. In that study, acoustic monitoring was performed during installation of 12 monopile foundations using impact pile driving between 6 Jun 2023 and 7 Sep 2023.

As described in Section 6.1, for the purpose of determining ranges to acoustic thresholds, five of the 12 in situ acoustically monitored monopiles from the SFV study were selected for detailed analysis. These five monopiles were installed with the hydrosound damper, DBBC, and enhanced BBC maintenance procedure that will be used for installation of the remaining 15 MP foundations, and therefore are the most relevant to this IHA request. As noted in Section 6.1, the water depth and bottom type are similar throughout the Lease Area and therefore sound propagation in the LIA is not expected to differ from where the SFV data were collected in 2023. The maximum range to the Level B threshold, with attenuation, from the five most representative monopiles was 5,720 m, which is greater than the 4,121 m range with 6 dB attenuation from the 2018 modeling. This range was used in calculating Level B take to ensure adequate take is requested. The SFV Level A ranges estimated in the 2018 acoustic modeling study were confirmed by the SFV, and therefore, the ranges from the 2018 modeling report are used in this request. Table 13 lists the Level A and Level B acoustic ranges used in the take estimates.

Table 13. Ranges to Level A and Level B acoustic thresholds used in the take request.

Marine Mammal Hearing Group	Range (km) to Level A SEL_{cum} threshold	Range (km) to Level B SPL_{rms} threshold
Low-frequency cetaceans (LF)	3.191	5.720
Mid-frequency cetaceans (MF)	0.043	5.720
High-frequency cetaceans (HF)	0.071	5.720
Phocid pinnipeds (underwater) (PW)	0.153	5.720

Level A ranges are from the 2018 acoustic modeling with 6 dB broadband sound attenuation (Pyć et al. 2018). Level B range is the maximum range with absorption for the five most representative monopiles acoustically monitored in the SFV study.

For estimating potential Level A takes, results of the animal movement and exposure modeling conducted in 2018 were used. Because newer density estimates than those used in the 2018 exposure modeling are available from Roberts et al. (2016; 2023), the raw results of the 2018 modeling (i.e., mean number of modeled animats exposed per day with installation of one 9.6 m monopile) were used as a baseline to which the new densities were applied. The average number of simulated animats exposed from the two modeled sites was used. The updated densities from the LIA were then applied to the raw animat numbers to estimate real-world number of animals that could be exposed per day in the LIA using the typical procedure for animal movement modeling. Additional details are available in Appendix B of (Pyć et al. 2018). The procedure involves dividing the real-world density by the modeled density, and then multiplying this by the number of simulated animats to get a daily exposure estimate for each species. The result is then multiplied by the number of days (i.e., 15) of pile installation to get a total Level A take estimate. The calculation uses the following equation.

$$\text{Total number of real world animals exposed above the Level A threshold } (\mathrm{SEL}_{\mathrm{cum}}) = \text{number of simulated animats exposed (7-day average)} \times \frac{\text{real-world density (animals/km}^2\text{)}}{\text{modeled density (animats/km}^2\text{)}} \times \text{number of days}$$

For estimating potential Level B takes, the maximum range to the 160 dB threshold from the 5 most representative monopiles in the SFV study was used (i.e., 5.72 km) with the following equation.

$$\text{Density-based Level B exposure estimate} = \text{ensonified area (km}^2\text{)} \times \text{real-world density (animals/km}^2\text{)} \times \text{number of days}$$

The ensonified area was calculated as the area of a circle with diameter equal to the Level B range as π x 5.72^2. The density-based Level B number of takes per day was then estimated by multiplying the ensonified area by the Roberts et al. (2016; 2023) density for the maximum density month for each species using the average density within a 10-km perimeter around the LIA (Table 9). This average daily exposure estimate was then multiplied by the number of days of pile driving (i.e., 15) to obtain a maximum density-based Level B exposure estimate for each species.

6.5. Exposure and Take Estimates

As a conservative measure, when estimating Level B take with the density-based method, it was assumed that all 15 remaining monopile foundations would be installed during the month with the maximum density for each species. Table 14 shows the results of the exposure estimates using the three methods – density-based, PSO sighting rate, and group size – as well as the resultant maximum Level B take. The PSO data exposure estimate was calculated using the data from the last column of Table 11 (Individuals Observed per PSO Monitoring Day Including Unidentified). These were multiplied by the number of days of piling (i.e., 15). Mean group size is the maximum groups size from the AMAPPS data and the PSO data, as described in Section 6.2.2.

Table 14. Estimated Level B exposures and maximum estimated Level B take for the installation of 15 monopile foundations, assuming all 15 foundations are installed during the maximum density month during June to December for each species.

Species	Max Density Exposure Estimate	PSO Data Exposure Estimate	Mean Group Size	Estimated Maximum Level B Take†
Mysticetes (LF hearing group)				
Fin whale*	5.5	0.6	1.7	6
Humpback whale	3.4	2.9	1.9	4
Minke whale	27.8	1.9	1.4	28
North Atlantic right whale*	6.6	0.7	2.0	7
Sei whale*	1.2	0.1	1.0	2
Odontocetes (MF hearing group)				
Sperm whale*	1.3	-	2.0	2
Atlantic white-sided dolphin	31.5	0.3	21.7	32
Bottlenose dolphin	12.4	0.4	11.7	13
Common dolphin	226.2	115.6	30.8	227
Long-finned pilot whale	1.6	-	12.3	13
Risso's dolphin	2.0	-	1.8	3
Odontocetes (HF hearing group)				
Harbor porpoise	109.9	0.2	2.9	110
Pinnipeds (PW hearing group)				
Gray seal	240.8	0.7	1.4	241
Harbor seal	28.2	0.2	1.4	29

*Indicates species listed as endangered under the US Endangered Species Act.

†For readability, exposure estimates are shown to 1 decimal place, but these estimates are calculated to two decimal places and rounded up to calculate take. In this table the max density based exposure estimate for Risso's dolphin is actually 2.03, which is rounded up to 3 in the take estimate.

As noted above, Level A exposure estimates were based on the 2018 acoustic modeling study. The mean daily number of animats estimated to be exposure above Level A thresholds was scaled by the real-world density for each species, using the maximum density month and assuming all remaining 15 monopile foundations are installed during that month. Table 15 shows the resulting maximum modeled exposure estimate and resulting take estimate. Note that for NARW, the modeling shows a very low but non-zero possibility for Level A take. However, as demonstrated by the ongoing construction, there were no sightings or acoustic detections of NARWs during the pile driving monitoring program. The mitigation measures applied during construction will ensure no Level A take of a NARW occurs and no Level A take is requested for this species.

Table 15. Estimated Level A exposures and take based on exposure modeling for the installation of 15 monopile foundations using impact piling, assuming all 15 foundations are installed during the maximum density month for each species.

Species	Max Modeled Exposure Estimate	Max Modeled Level A Take Estimate†
Mysticetes (LF hearing group)		
Fin whale*	0.598	1
Humpback whale	1.111	2
Minke whale	0.372	1
North Atlantic right whale*	0.503	1
Sei whale*	0.144	1
Odontocetes (MF hearing group)		
Sperm whale*	0.000	0
Atlantic white-sided dolphin	0.000	0
Bottlenose dolphin	0.000	0
Common dolphin	0.000	0
Long-finned pilot whale	0.000	0
Risso's dolphin	0.000	0
Odontocetes (HF hearing group)		
Harbor porpoise	2.758	3
Pinnipeds (PW hearing group)		
Gray seal	0.000	0
Harbor seal	0.028	1

*Indicates species listed as endangered under the US Endangered Species Act.
†Max Modeled Level A Take Estimate is based on the exposure modeling. However, no Level A take is anticipated or being requested for right whales.

6.6. Number of Takes Requested

The requested Level A and Level B take for impact pile driving installation of the remaining 15 monopile foundations in the LIA is shown in Table 16. This table also shows the total Level A plus Level B take as a percentage of each species' NMFS stock abundance. In all cases, except the NARW, this amounts to ≤2% of the species' stock size. For the small NARW stock, the requested take is only 2.1% of stock abundance and only Level B take is requested.

Table 16. Summary of the requested Level A and Level B take from impact pile driving of the remaining 15 monopile foundations for Vineyard Wind 1.

Species	NMFS Stock Abundance	Requested Take Level A Take	Level B Take	Total Take	Percent of NMFS Stock Abundance
Mysticetes (LF hearing group)					
Fin whale*	6,802	1	6	7	0.1
Humpback whale	1,396	2	4	6	0.4
Minke whale	21,968	1	28	29	0.1
North Atlantic right whale*	338	0	7	7	2.1
Sei whale*	6,292	1	2	3	0.0
Odontocetes (MF hearing group)					
Sperm whale*	4,349	0	2	2	0.0
Atlantic white-sided dolphin	93,233	0	32	32	0.0
Bottlenose dolphin	62,851	0	13	13	0.0
Common dolphin†	172,974	0	465	465	0.3
Long-finned pilot whale	39,215	0	13	13	0.0
Risso's dolphin	35,215	0	3	3	0.0
Odontocetes (HF hearing group)					
Harbor porpoise	95,543	3	110	113	0.1
Pinnipeds (PW hearing group)					
Gray seal	27,300	0	241	241	0.9
Harbor seal	61,336	1	29	30	0.0

*Indicates species listed as endangered under the US Endangered Species Act.

†For common dolphins, although the density-based exposure estimate suggests 227 individuals of this species could be taken by Level B harassment, the requested take is based on an average group size of 30.8, which is rounded up to 31 and then multiplied by 15 piling days. This assumes one average group size could be seen every day of impact piling, as a conservative measure, to account for the frequency with which this species is sighted in this area and the possibility that some group sizes are larger than average.

7. Anticipated Impact of the Activity

7.1. Characteristics of Pile Driving Sounds

Impact pile driving produces impulsive sounds with peak levels typically above L_{pk} 200 dB re 1 µPa near the source (Tougaard et al. 2008). Pile driving generates sounds that are relatively broadband (Madsen et al. 2006). Measurements found that most acoustic energy production occurs between 60 –160 Hz (Kusel et al. 2024), though energy can range up to 10 kHz near the source (Blackwell 2005; Bailey et al. 2010). The dominant frequency range of pile driving is related to differences in the size, shape, and thickness of the piles. These pulsed sounds are typically high energy with fast rise times and sharp peaks, which can result in both Level B and Level A sound exposures, depending on proximity to the sound source and a variety of environmental and biological conditions (Nedwell et al. 2007; Dahl et al. 2015).

7.2. Potential Effects of Pile Driving on Marine Mammals

All marine mammals use sound as a critical way to carry out life-sustaining functions, such as foraging, navigating, communicating, and avoiding predators. Marine mammals also use sound to learn about their surrounding environment by gathering information from other marine mammals, prey species, phenomena such as wind, waves, and rain, as well as anthropogenic sounds (Richardson et al. 1995). The effects of sounds from pile driving could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment (TTS or PTS), or non-auditory physical or physiological effects (Richardson et al. 1995; Nowacek et al. 2007; Southall et al. 2007). The level of impact on marine mammals will vary depending on the species and its sensitivity to sound, life stage, orientation, and distance between the marine mammal and the activity, the intensity and duration of the activity, and environmental conditions affecting sound propagation.

7.2.1. Masking

Masking is the obscuring of sounds of interest by interfering sounds, generally at similar frequencies. Introduced underwater sound will, through masking, reduce the effective listening area and/or communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Erbe et al. 2016; Tennessen and Parks 2016; Guan and Miner 2020). Conversely, if little or no overlap occurs between the introduced sound and the frequencies used by the species, communication is not expected to be disrupted. Also, if the introduced sound is present only infrequently, communication is not expected to be disrupted much, if at all. In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Madsen et al. 2002; Branstetter et al. 2013b; Branstetter et al. 2013a; Branstetter et al. 2016; Erbe et al. 2016; Sills et al. 2017).

In the event that masking would occur, it could impact biological functions such as communication, navigation, socializing, mating, foraging, and predator detection (Paiva et al. 2015). Although masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, there are few specific studies on this related to impact pile driving. Low-frequency cetaceans such as baleen whales are likely to be more susceptible to masking by the low-frequency noise produced by pile driving (Richardson et al. 1995); however, to date, most studies have considered impacts from a different impulsive source, seismic airguns. Sounds from seismic surveys, which are impulsive like impact pile driving sounds, have been estimated to substantially reduce the communication space of baleen whales (Gedamke 2011; Wittekind et al. 2016). Similarly, David (2006) speculated that noise generated by pile driving with a 6 metric ton diesel hammer has the potential to mask bottlenose dolphin vocalizations at 9 kHz within 6.2 to 9.3 mi (10 to 15 km) from the source if the vocalization is strong and up to 24.9 mi (40 km) if the call is weak. The biological repercussions of a loss of listening area or communication space, to the extent that this occurs, are unknown.

Some cetaceans, including baleen whales, continue calling in the presence of impulsive sounds from pile driving (Fernandez-Betelu et al. 2021) and seismic pulses (Greene and Richardson 1988; McDonald et al. 1995; Smultea et al. 2004; Holst et al. 2005; Holst et al. 2006; Dunn and Hernandez 2009; Holst et al. 2011; Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Cerchio et al. 2014; Sciacca et al. 2016). Studies on sperm whales found that they continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006; Jochens et al. 2008;

Holst et al. 2011; Nieukirk et al. 2012). Dolphins and porpoises are also commonly heard calling while airguns are operating (Gordon et al. 2003; Holst et al. 2005; Potter et al. 2007; Holst et al. 2011).

Other cetaceans are known to increase the source level of their calls, shift their peak frequencies, or otherwise modify their vocal behavior (increase or decrease call rates) in response to pulsed sounds from pile driving (Fernandez-Betelu et al. 2021), airguns (Clark and Gagnon 2006; Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013; Blackwell et al. 2015), or vessel noise (e.g., (Richardson et al. 1995; Lesage et al. 1999; Nieukirk et al. 2005; Scheifele et al. 2005; Parks et al. 2007; Di Iorio and Clark 2009; Hanser et al. 2009; Holst et al. 2009; Parks et al. 2009; Parks et al. 2010; McKenna 2011; Castellote et al. 2012; Melcón et al. 2012; Parks et al. 2012; Risch et al. 2012; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Wang et al. 2015; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Parks et al. 2016; Bittencourt et al. 2017). Similarly, harbor seals have been shown to increase the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017). This behavior could, in turn, minimize potential impacts of masking. However, Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. It is not known how often these types of vocal responses occur upon exposure to impulsive sounds. If marine mammals exposed to sounds sometimes respond by changing their vocal behavior, this adaptation, along with directional hearing and preadaptation to tolerate some masking by natural sounds (Richardson et al. 1995) would all reduce the importance of masking. Some studies have found evidence of reduced calling (or at least reduced call detection rates) in the presence of seismic pulses. Bowhead whales (*Balaena mysticetus*) in the Beaufort Sea have been observed to decrease their calling rates in response to seismic operations, although movement out of the area also contributes to the lower call detection rate (Blackwell et al. 2013; Blackwell et al. 2015). Among the odontocetes, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994).

Given the higher duty cycle of impact pile driving (one strike every ~two seconds) compared to most airgun surveys (one pulse every ~10 seconds), there may be a somewhat greater potential for masking to occur during pile driving. However, in this Project, pile driving is not expected to occur for more than approximately two hours at one time, based on the 2023 construction. Compared to the 24 hour per day operation of airguns during most seismic surveys, the total time during which masking might occur would be much reduced. Madsen et al. (2006) argued that significant masking effects would be unlikely during impact pile driving given the intermittent nature of these sounds and short signal duration.

Low-frequency cetaceans such as baleen whales are likely to be more susceptible to masking by low-frequency noise, such as from pile driving and vessel sounds. In contrast, masking effects from those activities are expected to be negligible in the case of smaller odontocetes and pinnipeds, given that sounds important to them occur predominantly at higher frequencies. For example, the harbor porpoise produces echolocation clicks of 110–150 kHz (Møhl and Andersen 1973; Teilmann et al. 2002) with source levels of 135–177 dB re 1 µPa at 1 m and the common bottlenose dolphin produces echolocation clicks of 110–130 kHz with source levels of 218–228 dB re 1 µPa (Richardson et al. 1995). Significant masking effects would be unlikely during impact pile driving given the intermittent nature of these sounds and short signal duration (Madsen et al. 2006).

7.2.2. Behavioral Disturbance

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Marine mammals’ behavioral responses to noise range from no response to mild aversion, to panic and flight (Southall et al. 2007). Behavioral reactions of marine mammals to sound are difficult to predict in the absence of site- and context-specific data; reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Southall et al. 2007; Ellison et al. 2012; Ellison et al. 2018). In some cases, behavioral responses to sound may in turn reduce the overall exposure to that sound (Finneran 2015; Wensveen et al. 2015). If a marine mammal reacts to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (New et al. 2013).

Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, it is common practice to estimate how many mammals would be present within a particular distance of human activities and/or exposed to a particular level of anthropogenic sound (see Section 6). In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner. One of the reasons for this is that the selected distances/isopleths are based on limited studies indicating that some animals exhibited short-term reactions at this distance or sound level, whereas the calculation assumes that all animals exposed to this level would react in a biologically significant manner.

Similar to masking studies, there is little information available on behavioral responses of baleen whales to impact pile driving sounds, but a number of studies have considered impacts from seismic airguns. Baleen whales generally tend to avoid impulsive sounds from operating airguns, but avoidance radii vary greatly among species, locations, whale activities, oceanographic conditions affecting sound propagation, etc. (Richardson et al. 1995; Gordon et al. 2003). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to intense sound pulses from airguns often react by moving away from and/or around the sound source. Some of the major studies and reviews on this topic are Gordon et al. (2003); Johnson et al. (2007); Ljungblad et al. (1988); Malme et al. (1984); Malme et al. (1985); Malme et al. (1988); McCauley et al. (1998); McCauley et al. (2000); Miller et al. (1999); Miller et al. (2005); Moulton and Holst (2010); Nowacek et al. (2007); Richardson et al. (1986); Richardson et al. (1995); Richardson et al. (1999; 2010); Richardson and Malme (1993); Stone (2015); Stone and Tasker (2006); and Weir (2008). Studies of bowhead, humpback, and gray whales have shown that impulsive sounds from seismic airguns with received levels of 160–170 dB re 1 μPa SPL seem to cause obvious avoidance behavior in a substantial portion of the animals exposed (Richardson et al. 1995; 2015). A study conducted across 880,000 km^2 (546,806 mi^2) of the East Atlantic Ocean saw an 88% (82-92%) reduction in sightings of baleen whales and a 53% (41-63%) reduction in toothed whale sightings during active seismic surveys when compared to control surveys (Kavanagh et al. 2019). However, this reflected a redistribution of the animals within the entire study area where overall sighting densities remained unaffected (Kavanagh et al. 2019). Studies near the United Kingdom, Newfoundland and Angola, in the Gulf of Mexico, off Central America, and Alaska have shown localized avoidance of seismic surveys by these species (whales), although, dolphins, porpoises and seals are often seen by observers on active seismic vessels, occasionally at close distances (e.g., bow riding).

While most baleen whales often show only slight overt responses to operating airgun arrays (Stone and Tasker 2006; Weir 2008; Stone 2015; Kavanagh et al. 2019), strong avoidance reactions by several species of baleen whales have been observed. Experiments with a single airgun (327.7–1,638 cubic centimeters [20–100 cubic inches] in size) showed that bowhead, humpback, and gray whales

(*Eschrichtius robustus*) all showed localized avoidance (Malme et al. 1984; Malme and Miles 1985; Malme et al. 1986; Richardson et al. 1986; Malme et al. 1988; McCauley et al. 1998; McCauley et al. 2000; Kavanagh et al. 2019). More recent studies have shown that some species of baleen whale (bowhead and humpback whales in particular) at times show strong avoidance at received levels lower than 160–170 dB re 1 μPa SPL.

When observing migrating bowhead, humpback, and gray whales, the changes in behavior appeared to be of little or no biological consequence to the animals—they simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995; Dunlop et al. 2017). The largest documented avoidance radii involved migrating bowhead whales, which avoided an operating seismic vessel by 12.4–18.6 mi (20–30 km) (Miller et al. 1999; Richardson et al. 1999). Groups of humpback whales migrating towards feeding grounds have been observed responding to seismic activity by changing the magnitude and rates of typical behaviors (singing, socializing with conspecifics, using social signals, and migratory travel), specifically through change in movement patterns, dive/respiratory parameters and rates of breaching (Dunlop et al. 2017; Dunlop et al. 2020). Groups of both humpbacks and female-calf groups exposed to the active seismic array made a 0.6 mi (1 km) per hour slower progression during southern migration compared to most unexposed baseline groups (largely due to divergence off their normal course rather than a slowing down of travel speed) (Dunlop et al. 2017). Similarly, in response to the seismic airgun array, adult pairs reduced their migration speed by 2.5 km (1.55 mi) per hour, which resulted in traveling at a speed of approximately half of their initial travel time (Dunlop et al. 2017). Resting female-calf pairs have been found to show avoidance responses at received levels as low as 129 dB re 1μPa^{2}s while migrating humpback whales demonstrated changes in migration at received levels of 144-151 dB re 1μPa^{2}s (McCauley 2003; Dunlop et al. 2017). In contrast to migrating whales, feeding bowhead whales show much smaller avoidance distances (Miller et al. 2005; Harris et al. 2007), presumably because moving away from a food concentration has greater cost to the whales than does a course deviation during migration. As with masking, because the relative time of pile driving is short, a typical pile driving operation is less than 2 hours, or about 8% of a 24-hour period, the temporal exposure when animals may interact with the acoustics from piling is also very short, therefore further limiting the overall impact.

Most studies specific to behavioral responses of marine mammals to offshore wind developments have been conducted on harbor porpoise (Tougaard et al. 2003; Tougaard et al. 2005; Leopold and Camphuysen 2008; Tougaard et al. 2009a; Tougaard et al. 2009b; Bailey et al. 2010; Thompson et al. 2010; Brandt et al. 2011; Scheidat et al. 2011; Dähne et al. 2013a; Thompson et al. 2013; Dähne et al. 2017; Benhemma-Le Gall et al. 2021), harbor and gray seals (Blackwell et al. 2004; Caltrans 2004; Edrén et al. 2004; Teilmann et al. 2006; Tougaard et al. 2006; Edrén et al. 2010; Skeate et al. 2012; Russell et al. 2016; Whyte et al. 2020; Hastie et al. 2021), and dolphins (Würsig and Green 2002; Paiva et al. 2015; Graham et al. 2017; Fernandez-Betelu et al. 2021). These studies showed some avoidance during periods of construction activity, but then continued use of the area after construction activities were completed. Captive studies of harbor porpoise have shown an increase in swim speeds and a possible decrease in foraging efficiency in captive animals exposed to playbacks of impact pile driving sounds as well as stronger reactions to the higher frequency sounds in pile driving (Kastelein et al. 2018a; Kastelein et al. 2019b; Kastelein et al. 2022). Similarly, studies near the United Kingdom, Newfoundland and Angola, in the Gulf of Mexico, off Central America, and Alaska have shown localized avoidance of seismic surveys by these species, although, dolphins, porpoises and seals are often seen by observers on active seismic vessels, occasionally at close distances (e.g., bow riding). Overall, odontocete and pinniped reactions to impulsive sounds from large arrays of airguns are variable and, at least for delphinids and some porpoises, seem to be confined to a smaller radius than has been observed for some mysticetes. Thus, avoidance responses by these species are expected to be relatively minor and temporary, resulting in minimal overall impacts.

7.2.3. Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to intense sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to intense sounds (Southall et al. 2007; Finneran 2015; Kastelein et al. 2018b). There are empirical data on the sound exposures that elicit onset of TTS in captive bottlenose dolphins, belugas, porpoise, and three species of pinnipeds (Finneran 2015). The majority of these data concern non-impulse sound, but there are some limited published data concerning TTS onset upon exposure to pile driving (Kastelein et al. 2015a; Kastelein et al. 2016), a single pulse of sound from a water gun (Finneran et al. 2002), and to multiple pulses from an airgun (Finneran 2015). No TTS was detected when spotted or ringed seals were exposed to impulsive sounds (Reichmuth et al. 2016). A detailed review of TTS data from marine mammals can be found in Southall et al. (Southall et al. 2007; Southall et al. 2019). In general, harbor seals and harbor porpoise appear to be more susceptible to TTS than other pinnipeds or cetaceans (Finneran 2015). There have not been any field studies that have examined TTS or permanent hearing damage (i.e., PTS) in free-ranging marine mammals exposed to anthropogenic sounds. However, some studies have shown that bottlenose dolphins can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (Nachtigall and Supin 2014; Nachtigall and Supin 2015; Nachtigall et al. 2016; Nachtigall et al. 2018; Finneran 2020; Kastelein et al. 2020).

TTS is the mildest form of hearing impairment that can occur during exposure to an intense sound (Kryter 1985). While experiencing TTS, the hearing threshold rises, and a sound must be more intense in order to be heard. It is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or “injury” (Southall et al. 2007; Le Prell et al. 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. However, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman et al. 2016). These findings have raised some questions as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015; Tougaard et al. 2016; Houser 2021). When PTS occurs, there is physical damage to the sound receptors in the ear, due to neural cell damage and loss of hair cell bodies (Koschinski 2011). In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter 1985). Physical damage to a mammal’s hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times. Rise time is the time interval required for sound pressure to increase from the baseline pressure to peak pressure. Permanent damage can also occur from the accumulation of sound energy over time.

Kastelein et al. (2015b; 2016) reported TTS in the hearing threshold of captive harbor porpoise during playbacks of pile driving sounds. TTS was measured in two captive harbor porpoises after being exposed to recorded impact pile driving sounds with an average received single-strike sound exposure level (SEL_{ss}) of 145 dB re 1 $\mu Pa^2 s$, with exposure duration ranging from 15 minutes to 6 hours (SEL_{cum} ranged from 173 to 187 dB re 1 $\mu Pa^2 s$). Although the pulses had most of their energy in the low frequencies, multiple pulses caused reduced hearing at higher frequencies in the porpoise. It is generally assumed that the effect on hearing is directly related to total received energy; however, this assumption is likely an over-simplification (Finneran 2012). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran 2012, 2015; Supin et al. 2016; Kastelein et al. 2019a).

Unlike during studies with captive animals, during Project activities an animal would be able to move away from the sound source, as avoidance behavior has been demonstrated for many marine mammals subjected to loud sounds, thereby reducing the potential for impacts to their hearing ability. There is no specific evidence that exposure to pulses from pile driving or other activities in unrestricted environments is likely to lead to PTS for any marine mammals. Using data from tagged harbor seals, Whyte et al. (2020) estimated that TTS occurrence would be low for free-ranging harbor seals exposed to pile driving sounds. Based on simulation, Schaffeld et al. (2020) reported that TTS in harbor porpoises could only be avoided during multiple exposures to pile driving pulses, if a combination of exclusion zones regulations, previous deterrence by scaring devices, and a soft start were employed as mitigation measures. Similarly, Thompson et al. (2020) recommended a combination of deterrent devices, minimizing hammer energy, and extended soft starts to minimize risks to marine mammals from pile driving. It has been predicted that harbor porpoises and harbor seals could be exposed to TTS without the use of noise mitigation systems (Dähne et al. 2013b; Stöber and Thomsen 2019).

Bailey et al. (2010) measured pile driving sounds during the construction of a wind farm in Scotland and predicted the expected peak broadband sound levels associated with TTS; the peak broadband pressure levels estimated to cause TTS onset in mid-frequency cetaceans (at 224 $dB_{0\text{-}pk}$ re 1 μPa) and pinnipeds (212 $dB_{0\text{-}pk}$ re 1 μPa) would occur within 10 m of pile driving and 40 m, respectively. Through extrapolation of research focused on TTS onset in marine mammals, Bailey et al. (2010) showed that pile driving sounds may cause PTS. Based on regulatory criteria, the peak broadband pressure levels estimated to cause PTS onset in mid-frequency cetaceans (230 $dB_{0\text{-}pk}$ re 1 μPa) and pinnipeds (218 $dB_{0\text{-}pk}$ re 1 μPa) would occur within 5 m and 20 m, respectively (Bailey et al. 2010). Based on the closest measurement of pile-driving noise recorded at 100 m, Bailey et al (2010) indicated that no form of injury or hearing impairment should have occurred at distances greater than 100 m from piling activity.

The SFV study of impact pile driving sounds conducted during the 2023 Vineyard Wind construction campaign, using the five most representative monopiles, measured ranges to Level A peak thresholds, with attenuation, of 10 m for low- and mid-frequency cetaceans and for phocid pinnipeds, and ranges of 10-50 m for high-frequency cetaceans. Ranges to Level A SEL_{cum} thresholds, with attenuation, were measured as 880-2,370 m for low-frequency cetaceans, 10 m for mid-frequency cetaceans, 10-200 m for high-frequency cetaceans, and 10-110 m for phocid pinnipeds.

Although it is unlikely that pile driving activities would cause PTS in many marine mammals, caution is warranted given the limited knowledge about noise-induced hearing damage in marine mammals, the lack of knowledge about TTS and PTS thresholds in many species, and the seemingly greater susceptibility of certain species (e.g., harbor porpoise and harbor seal) to TTS and presumably also PTS. The avoidance reactions of some marine mammals, along with commonly applied monitoring and mitigation measures would reduce the probability of exposure of marine mammals to sounds intense enough to induce PTS.

The criteria used in exposure estimation (Section 6) (NMFS 2018) reflect the most recent scientific review and conclusions of NMFS regarding sound levels that could cause PTS. Based on the PTS onset exposure estimates (Table 15), the number of marine mammals that may experience hearing impairment is quite small, even when planned mitigation measures are not considered. Taking into account that extensive monitoring and mitigation measures will be applied (Section 11), the likelihood of the Project causing PTS in a marine mammal is negligible.

7.3. Population Level Effects

NMFS provides best available estimates of abundance (N_{best}) for all marine mammal stocks under their jurisdiction in their annual Stock Assessment Reports (Hayes et al. 2023). In some cases, NMFS considers these to be underestimates because the full known range of the stock was not surveyed, the estimate did not include availability-bias correction for submerged animals, or there may be uncertainty regarding population structure (Hayes et al. 2017).

As seen in Table 16 above, for all species except the NARW, the requested take amounts to ≤1% of the species' stock size. For the small NARW stock, the requested take is only 2.1% of stock abundance and only Level B take is requested. Thus, overall, the estimated exposures expressed as percentages of species populations indicate very low potential for impacts. The impacts of the requested take are not anticipated to affect the fitness, reproduction, or survival of any individuals, and population-level effects are unlikely.

8. Anticipated Impacts on Subsistence Uses

NOAA Office of Protected Resources defines "subsistence" as the use of marine mammals taken by Alaskan Natives for food, clothing, shelter, heating, transportation, and other uses necessary to maintain the life of the taker or those who depend upon the taker to provide them with such subsistence. The Vineyard Wind 1 Project Area is located off the Northeast coast of the United States in the Atlantic Ocean. There are no traditional subsistence hunting areas in the region and thus no subsistence uses of marine mammals may be impacted by this action.

9. Anticipated Impacts on Habitat

Vineyard Wind has thoroughly analyzed impacts to habitat from the Project in its site characterization and impact assessment. These are summarized in Volume III of the COP (Vineyard Wind 2020) and final designs are detailed in the Final Design Reports (FDRs). The potential habitat impacts reviewed in the COP can be divided into two categories – short-term impacts and longer-term impacts. Short-term impacts to marine mammal habitat are sediment suspension resulting from cable-laying activities and sound introduced into the environment from impact pile driving. Longer-term impacts to marine mammal habitat are creation of hard substrate around MP foundations, loss of habitat from the footprint of the installations and the introduction of structures into the water column. These habitat alterations are discussed in more detail in Sections 10.1 and 10.2 below. The remaining foundations to be installed are 15 MP foundations; the total footprint of these 15 MP foundations is only 0.001 km^2 (0,24 acres) of the 675 km^2 (166,886 acre) Lease Area. The MP foundations will add structure to the water column with spacing of 1.9 km (1.0 nm).

10. Anticipated Effects of Habitat Impacts on Marine Mammals

10.1. Short-Term Habitat Alterations

In order to assess the impacts of cable-laying activities, a set of computer simulation models were used. Details of these models are provided in Appendix III-A of the COP, Volume III (Vineyard Wind 2020) and a summary of the results are included here. The remaining cable-laying activities include placement of inter-array cables that connect WTGs to the ESP and cable burial using a jet trencher. The model results indicate that most of the suspended sediment mass would settle out quickly and would not be transported for significant distances by the currents. Thus, potential impacts from suspended sediments resulting from cable laying are not expected to result in takes of marine mammals. The model showed localized, short-term impacts to marine mammal prey but concluded that these would not result in declining prey availability.

The altered soundscape resulting from pile driving is likely to have the greatest impact on the marine mammal community. Modeling of pile driving installation activities indicates that there is potential for both marine mammals and the fish and invertebrates that they prey upon to experience sound exposure at levels that may cause behavioral response, including aversion and avoidance. Expected habitat displacement or avoidance of construction activities during WTG and ESP installation is based on modeled sound levels and studies of other wind energy projects. This model prediction is consistent with research data that indicate significant avoidance behavior and displacement during pile driving (Richardson et al. 1995; Carstensen et al. 2006; Tougaard et al. 2009a; Brasseur et al. 2010; Brandt et al. 2011; Dähne et al. 2013c; Bailey et al. 2014; Bergström et al. 2014).

Research suggests that this displacement is temporally limited to the construction phase (Bergström et al. 2014). The proposed LIA configuration of MP foundations includes a minimum 1.9 km (1.0 nm) spacing between structures, allowing access and transit through the WDA during construction. Based on the results of other wind energy project monitoring studies, re-occupation of habitat in the LIA is expected to occur at levels equivalent to or higher than the region around the Project post-construction and during operation.

10.2. Longer-Term Habitat Alterations

Longer-term habitat alterations resulting from the LIA include the creation of hard substrate around MP foundations, loss of habitat from the footprint of the installations and the introduction of structures into the water column. These are intended to remain in place throughout the life of the Project. As discussed in Section 9, the overall footprint of the remaining MP foundations to be installed is very small relative to the Lease Area. Further, there is abundant similar habitat in adjacent areas that is available to marine mammals and their prey.

Creation of hard bottom habitat and introduction of structures into the water column may benefit some marine mammal species that are attracted to the physical structures, which in turn may increase prey availability. Numerous surveys at offshore wind farms, oil and has platforms off California and in the Gulf of Mexico (Claisse et al. 2014; Ajemian et al. 2015; Love et al. 2015), and artificial reef sites have documented increased abundance of smaller odontocete, and pinniped species attracted to the increase in pelagic fish and benthic prey availability (Petersen and Malm 2006; Wilhelmsson et al. 2006; Inger et al. 2009; Hammar et al. 2010; Lindeboom et al. 2011; Scheidat et al. 2011; Mikkelsen et al. 2013; Bailey et al. 2014; Russell et al. 2014; Arnould et al. 2015). Fujii (2015, 2016) observed that feeding habits of major fish species were closely associated with an offshore oil platform in the North Sea. Increased prey is not limited to fish aggregation and production. Additionally, offshore platforms may generate sufficient illumination to affect the local distribution of phototaxic prey invertebrates including zooplankton (Keenan et al. 2007; McConnell et al. 2010). Bergström et al. (2014) summarized probable impacts of wind energy project construction and operation on marine mammals, fish, and benthos, and concluded that there is a moderate level of certainty of significant positive habitat gain for fish arising from wind energy project habitat modification. Other studies suggest that there are little to no differences in species' presence inside and outside wind farms post-construction and during operation (Tougaard & Henrikson, 2009).

Studies examining harbor seal distribution around wind farms have shown seal numbers inside the wind farm to be recovered following construction; however, fewer seals were present on the nearby land sites (Snyder and Kaiser 2009; Vallejo et al. 2017). Harbor porpoise activity around the Danish wind farm "Nysted" showed a significant decline in echolocation activity following construction that gradually increased but did not return to baseline levels (Hammar et al. 2010; Teilmann and Carstensen 2012), while no change in activity was observed around the Danish wind farm "Rodsand II" after construction (Hammar et al. 2010). Russell et al. (2014) conducted a tagging study of Harbor and Grey Seals living near two active wind energy project areas on the British and Dutch coasts of the North Sea. The tag data strongly suggested that the associated wind energy structures were used for foraging, and the directed movements showed that animals could effectively navigate to and between structures (Russell et al. 2014). Studies of harbor porpoise activity within operational wind farms showed that relatively more porpoises were found in the wind farm area compared to reference sites, with statistically positive linkage to the wind energy project (Todd et al. 2007). Similarly, Projects to restore artificial reefs noted an increase in the presence of harbor porpoises at the new artificial reef site compared to surrounding habitats, and it was hypothesized they were following prey species (Mikkelsen et al. 2013). Where certain vessels and/or vessel-based activities are excluded from portions of the area for periods of time, the Project may provide shelter for marine mammals (Scheidat et al. 2011).

A negative effect of habitat gain may emerge if the infrastructure functions as introduction habitat for invasive species (Bulleri and Airoldi 2005; Page et al. 2006). The opportunistic use of artificial substrata (oil and gas platforms) by non-indigenous coral species in the Gulf of Mexico is well documented, with growing concern related to a spread of these species to the Atlantic as marine infrastructure increases (Sammarco et al. 2010). Over the lifetime of the Project's operation, more structurally complex habitats that might develop in artificial infrastructure are likely to have greater species diversity and abundance.

Currently there are no quantitative data on how large whale species (i.e., mysticetes) may be impacted by offshore wind farms (Kraus et al. 2019). Navigation through the Project Area is not expected to be impeded by the presence of the WTG and ESP foundations. Additionally, wakes in water currents created by the presence of the foundations are not expected to affect pelagic fish, plankton, or benthic species, so marine mammals foraging on these species are unlikely to be adversely affected. Given the likely benefits to some marine mammal species from increased prey abundance and the uncertain, but likely minimal negative impacts on large whales from the presence of the widely spaced foundations, overall impacts to marine mammal habitat are anticipated to be negligible.

11. Mitigation Measures to Protect Marine Mammals and Their Habitat

Mitigation and monitoring measures implemented during Project construction can decrease the potential impacts to marine mammals by reducing the zone of potential exposure and therefore the likelihood of Level B and Level A sound exposures and reduce the likelihood of vessel strike. Vineyard Wind will continue to comply with the enhanced monitoring and mitigation requirements as summarized in Table 17 below and as detailed in the approved Pile Driving Monitoring and Mitigation Plan. Clearance zones in Table 18 are based on the average measured distance to the NMFS Level A harassment threshold from the five monopiles installed with the most representative[2] NAS operating during the 2023 Sound Field Verification campaign. The distances to the Level A thresholds are based on measured distances to the NMFS Level A harassment thresholds plus some additional distance for certain species hearing groups to exclude any areas that are within the double Big Bubble Curtain (DBBC), as it is unlikely that an animal would breach the DBBC. Visual observation capability, practical and safe offshore implementation, and practicability of the mitigation measures are also considered. The proposed clearance and shutdown zones are shorter than the SEL_{cum} Level A harassment radii shown in Table 13 because, in order for a marine mammal to experience Level A exposure, the animal would need to remain within the indicated distance for the entire duration of pile driving within a 24 hour period. Large mysticete whales generally avoid areas of intense anthropogenic sounds (Richardson et al. 1995; Gordon et al. 2003; Nowacek et al. 2007; Southall et al. 2007; Southall et al. 2016; Dunlop et al. 2017; Kavanagh et al. 2019), so it is very unlikely that individual whales would remain within the 3.2 km distance for that long. Also, the natural movement patterns of most marine mammals mean the clearance zones assume longer than expected exposure durations for the SEL_{cum} criteria.

Noise attenuation systems, such as bubble curtains, are used to decrease the sound levels in the water near a source. Bubbles create a local impedance change that acts as a barrier to sound transmission. The size of the bubbles determines their effective frequency band, with larger bubbles needed for lower frequencies. There are a variety of noise abatement systems including bubble curtain systems (confined or unconfined bubbles), evacuated sleeve systems, encapsulated bubble systems (HydroSound Dampers), and Hemholtz resonators. Several recent studies summarizing the effectiveness of NAS have shown that broadband sound levels are likely to be reduced by anywhere from 7 to 17 dB, depending on the environment, pile size, and the size, configuration and number of systems used (Buehler et al. 2015; Bellmann et al. 2020). The single bubble curtain applied in shallow water environments regularly achieves 7-8 dB broadband attenuation (Lucke et al. 2011; Rustemeier et al. 2012; Bellmann 2014, 2019). More recent in situ measurements during installation of large monopiles (~8 m) for WTGs in comparable water depths and conditions indicate that attenuation levels of 10 dB are readily achieved for a single bubble curtain (Bellmann 2019; Bellmann et al. 2020). Large bubble curtains tend to perform better and more

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[2] Throughout the review of the interim SFV results, Vineyard Wind was able to refine the NAS design and implement adaptive mitigation by adding an additional BBC (DBBC) and improving the maintenance protocol of the BBCs. The final, NMFS approved, adaptive mitigation, which has been utilized on all monopile installations upon completion of the SFV campaign, includes the use of the HSD with the DBBC inclusive of the enhanced BBC maintenance schedule. The following piles were installed and measured using this NAS design, AQ38, AT39, AV38, AN37, and AU38, and are thus the monopiles analyzed to determine the distances to exclusion zones. The final noise attenuation system (NAS) design used for monopile installation includes one HSD and a DBBC. The final NAS will be utilized at all times when pile driving is underway, unless prohibited for human safety reasons, to reduce sound levels such that they do not exceed the Level B threshold at a range of 5,720 m, as shown by the 2023 SFV study and assumed in this application.

reliably, particularly when deployed with two rings (Koschinski and Ludemann 2013; Bellmann 2014; Nehls et al. 2016). A California Department of Transportation study tested several small, single, bubble curtain systems and found that the best attenuation systems resulted in 10-15 dB of attenuation (Buehler et al. 2015). Combinations of systems (e.g., double big bubble curtain, hydrodimer plus single big bubble curtain) potentially achieve much higher attenuation. The final noise attenuation system (NAS) design used for monopile installation includes one HSD and a double Big Bubble Curtain (DBBC). The final NAS will be utilized at all times when pile driving is underway, unless prohibited for human safety reasons[3], with a target sound reduction of 6 dB. The continued use of the full NAS system will provide the anticipated noise levels documented in this application. In the unlikely event that the NAS system does not function as expected, Vineyard Wind will expand the exclusion zone sizes to match the noise levels based on the 2024 thorough SFV results and conduct additional thorough SFV until the results of the additional studies demonstrate that the noise levels have returned to the anticipated levels.. To ensure proper performance of the DBBC, the enhanced maintenance procedures described in the Sound Reduction section of Table 17 will be followed. Should a single compressor malfunction, the operating personnel will adjust the air supply and operating pressure to maximize sound attenuation performance. Any malfunctioning BBC will be repaired prior to use at the next foundation installation.

Several mitigation and monitoring measures are in place to minimize the potential for vessel strikes and are outlined in Table 17 below.

Table 17. Proposed monitoring and mitigation measures for remaining monopile installation.

Monitoring & mitigation measure	Description
Seasonal Restrictions	▪ Vineyard Wind will establish a restriction on pile driving between December 1 and Mayl 31[1] ▪ Any pile driving that may occur in December will include enhanced monitoring as detailed below. ▪ Pile driving will not occur in December unless approved by BOEM and NMFS.
Daily Restrictions	▪ Pile driving will not commence until at least 1 hour after (civil) sunrise ▪ Pile driving will not be initiated within 1.5 hours of (civil) sunset
Operational Restrictions	▪ No more than one monopile will be driven per day
Sound Reduction	▪ Vineyard Wind will implement noise attenuation mitigation to reduce sound levels such that they do not exceed the Level B threshold at a range of 5,720 m, as shown by the 2023 SFV study and assumed in this application ▪ Noise attenuation technology will be implemented including a double Big Bubble Curtain (DBBC) and one Hydro-sound Damper (HSD) maintained with the maintenance protocol and arranged in a circular fashion on the seabed and ensuring 100%

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[3] There are numerous unexpected situations that could arise during offshore works that jeopardize human safety. Examples include, but are not necessarily limited to, holding the pile in the pile gripper for extended periods of time creating stress on the crane and other equipment that could result in damage to the vessel, its equipment, and potential injury to crew. Another example includes sudden changes in sea state conditions necessitating advancing installation to protect the crew against injury.

Monitoring & mitigation measure	Description
	seafloor contact with air bubbles distributed 100 percent around the piling perimeter for the full depth of the water column. ▪ Vineyard Wind will follow the enhanced BBC maintenance protocol, implemented from the installation of foundation AQ-38 onwards, is an adjustment from typical bubble curtain operations in the North Sea where hoses are usually drilled after every third deployment but is done after every deployment here to maximize performance considering siltier sediments in the Lease Area. The enhanced BBC maintenance protocol includes, but is not necessarily limited to: - Perform DBBC hose hole inspection and clearance (which involves drilling of holes to remove accumulated sediment) prior to BBC hose deployment; - Conduct pressure testing of DBBC hoses prior to the arrival of the installation vessel; - Visually inspect the DBBC performance and coverage before and during DBBC operations supporting pile installation; - Minimize the disturbance of the DBBC hoses once deployed to the seafloor; - Ensure DBBC operators are trained in the proper balancing of air flow to the bubblers; and - Submit DBBC inspection/performance reports to NMFS within 72 hours following the performance test. In the unlikely event that the NAS system does not function as expected, Vineyard Wind will expand the exclusion zone sizes to match the noise levels based on the 2024 thorough SFV results and conduct additional thorough SFV until the results of the additional studies demonstrate that the noise levels have returned to the anticipated levels.
Alternative Monitoring	▪ Vineyard Wind will deploy alternative monitoring technologies (night vision, thermal, infrared, fixed cameras) to the PSOs actively monitoring on visual watches and use PAM in the event of unexpected, poor visibility conditions (i.e., due to fog, precipitation, darkness), as determined by the lead PSO on duty. These technologies will include: - Fixed camera technology: ▪ Two FLIR fixed cameras mounted aboard the main installation vessel, including two monitors ▪ One FLIR fixed camera mounted aboard each PSO Support Vessel, including one monitor - Hand-held technology: ▪ Night vision devices, ▪ Thermal clip-on's and/or ▪ Thermal monocular
Protected Species Observers (PSOs)	▪ Three PSOs will be on active duty at all times on the installation vessel as well as on each of the PSO support vessels ▪ During pile driving operations, a minimum of nine PSOs will serve watch on-duty when pile driving is underway under all circumstances. Two PSO Support Vessels will employ a minimum of three PSOs each, on-duty, to serve watch during pile driving along

Monitoring & mitigation measure	Description
	with the three PSOs on the main installation vessel under all circumstances. At all times, at least one of the three on-duty PSOs will serve as Lead PSO. ▪ The PSO monitoring team will coordinate visual monitoring such that the PSO Support Vessels are located at the best vantage point (i.e., distance from the installation vessel) to observe and document marine mammal sightings in proximity to the exclusion zones. ▪ Vineyard Wind or its Contractor will submit a list of PSOs for deployment on the Project to NMFS for review and approval. ▪ PSOs may not perform any other duty while on watch ▪ PSOs may not exceed four consecutive watch hours; must have a minimum two-hour break between watches; and may not exceed a combined watch schedule of more than 12 hours in a 24-hour period ▪ PSOs will be located at the best vantage point(s) during vessel transit and on the piling platform in order to observe the extent of the clearance zone, while considering human safety ▪ PSOs will monitor available NARW reporting systems (e.g., WhaleAlert app, Whalemap app, Sighting Advisory System, USCG Channel 16) for the presence of NARWs ▪ PSOs will enter all monitoring data into an Excel data sheet and basic detection information (e.g., spatial information) for marine mammal detections into Mysticetus software ▪ PSOs will be equipped with daytime visual monitoring equipment to aid the naked eye including hand-held reticule binoculars (7x) and high-magnification (25x) binoculars (i.e., “big eyes”), digital single-lens reflex camera equipment. This equipment is part of the standard suite of visual monitoring equipment utilized by PSOs throughout the monitoring campaign (i.e., June – December).
Clearance Zones (radius from pile center)	▪ See Table 18 for a summary of species-specific clearance zones and clearance duration. However, at any time of year, a visual detection of a NARW at any distance by a PSO on the pile driving or PSO Support Vessel will trigger a delay in pile driving. Minimum visual clearance zone[4] is 4,000 m ▪ At any time of year, a PAM detection (75% confidence[5]) of a NARW within the PAM clearance zone will be treated as a visual detection, triggering a delay in pile driving ▪ Prior to pile driving, a localized PAM detection of a marine mammal inside the species-specific clearance zone (Table 18), or a detection that cannot be confirmed to be outside of the species-specific clearance zone, will result in a delay ▪ Clearance zones will be visible and monitored for 60 minutes immediately prior to pile driving.
Monitoring Zones (radius from pile center)	▪ See Table 18 for a summary of PAM monitoring zones
Pre-piling Clearance Timing	▪ See Table 18 below for a summary of species-specific clearance delay duration ▪ Clearance zones will be visible and monitored for 60 minutes immediately prior to pile driving. Mitigation is triggered if animals are observed within 30 minutes of piling ▪ Vineyard Wind will use PSOs and PAM analysts to monitor for NARWs 60 minutes prior to, during, and 30 minutes after all pile driving, additional monitoring may be conducted, as described below
Soft-start	▪ Soft-start will be implemented to begin pile driving

Monitoring & mitigation measure	Description
	▪ The soft start process shall consist of 4-6 single hammer strikes at less than 40 percent of the maximum hammer energy followed by at least one minute delay before the subsequent hammer strikes. This process shall be conducted at least 3 times (e.g. 4-6 single strikes, delay, 4-6 single strikes, delay, 4-6 single strikes, delay) for a minimum of 20 minutes.
Passive Acoustic Monitoring (PAM)	▪ A PAM system will be deployed and operated to monitor the PAM clearance and monitoring zones[6] ▪ A minimum of 3 and maximum of 4 buoys will be deployed at any given time and will depend on the location of the active pile driving operation to monitor pile driving operations in real-time. Buoy locations are spaced on equilateral triangles with approximately four (4) nautical mile (approximately7.5 km) sides spaced around the Lease area. ▪ The PAM system will not be located on the installation vessel to avoid interference. The closest location of a hydrophone relative to the pile will be approximately 1 km away. ▪ A team of trained PAM analysts will monitor for acoustic detections ▪ Prior to pile driving, under all circumstances, a PAM analyst will review the previous 24 hours of PAM data for situational awareness. ▪ During pile driving, a minimum of one acoustic PAM analyst will be on active duty (remote onshore based) from 60 minutes before, during and for 30 minutes after all pile installation activity concludes. ▪ PAM will be used in support of visual observations but not as the sole clearance method for exclusion zone establishment during periods of reduced visibility. ▪ A PAM detection that is localized to within the relevant exclusion zone will trigger delay/shutdown but the minimum visibility zone will still be maintained. A PAM detection that may be within (i.e., cannot be confirmed outside of) the clearance or shutdown zone will also trigger a delay/shutdown.
Shut downs	▪ If a marine mammal is detected (visual or acoustic[7]) entering or within the shutdown zone (Table 18) (or acoustically detected and localized within the shutdown zone or cannot be confirmed to be outside of the shutdown zone) after pile driving has commenced, the PSO will request an immediate shutdown of the hammer. If a NARW is observed at any distance, the PSO will request an immediate shutdown of the hammer. If the shutdown is deemed to be not technically feasible due to human safety concerns or to maintain installation feasibility, then the potential to reduce hammer energy will be considered and implemented if the lead engineer determines it is technically feasible while considering the safety of the vessel crew. ▪ Following a shutdown, pile driving may not commence, until either the animal has voluntarily left and been visually confirmed beyond the relevant CZ, or, when additional time has elapsed without re-detection, as follows: - 30 minutes have elapsed without re-detection for mysticetes (including NARW), for sperm whales, Risso's dolphins and pilot whales - 15 minutes have elapsed without re-detection for all other marine mammals

Monitoring & mitigation measure	Description
Vessel Strike Avoidance[2]	▪ Vineyard Wind will deploy a Visual Observer (VO) or Trained Lookout (TL) on all vessels ▪ Vessel will take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area), if marine mammals are sighted. ▪ If a marine mammal is sighted within the relevant separation distance, the vessel will reduce speed, turn away from the animal, and shift the engine to neutral, not engaging the engines until animals are clear of the area. ▪ Vessels will not divert or alter course to approach any marine mammal. ▪ Vessel Speed Restrictions: ▪ Year-round: o An observer (e.g., a VO/TL/PSO) who has undergone marine mammal training will be stationed on vessels transiting to and from the WDA if traveling over 10 knots o 500 m (1640 feet) will be maintained between all transiting vessels and NARW o If the 500-meter vessel strike avoidance zone is not fully visible (e.g., visibility is obscured due to fog, rain, darkness), as safety permits, vessels will slow down to 10 knots or less. However, outside of Right whale Slow Zones, Dynamic Management Areas, and Seasonal Management Areas, vessels employing PSOs, equipped with appropriate alternative monitoring equipment (inclusive of PAM monitoring), may implement the AMP and may transit over 10 knots. o Vessel speeds will be immediately reduced to 10 knots or less when a mother/calf pair, pods, or large assemblages of delphinid cetaceans are observed within 100 m of an underway vessel. ▪ November 1 – May 14 (does not apply to pile driving, only vessel transits): o Vessels, regardless of size, will travel at less than 10 knots within the WDA o When transiting to or from the WDA (this will not apply to any transiting in Nantucket Sound, which has been demonstrated by best available science to not provide consistent habitat for NARW) Vineyard Wind will either travel at or below 10 knots or will implement visual surveys with a visual observer to ensure the transit corridor is clear of NARW ▪ December 1 – December 31 (in addition to the measures listed for November 1 – May 14 and year-round above) o All vessels will travel at or below 10 knots within the transit corridor unless visual surveys and simultaneous real-time PAM demonstrate that NARW are not present in the transit corridor ▪ Seasonal Management Area (SMA)

Monitoring & mitigation measure	Description
	- All vessels (including CTVs) must transit at 10 knots or less in any SMA ▪ Dynamic Management Areas (DMAs) - All vessels (including CTVs) will reduce speeds within a DMA to 10 knots or less] ▪ Right whale Slow Zone: - All vessels (including CTVs) will reduce speeds within any right whale Slow Zone to 10 knots or less ▪ Throughout the year, except as provided above in a DMA, Right whale Slow Zone, or Seasonal Management Area, CTVs may transit over 10 knots if visual surveys with a dedicated visual observer and simultaneous real-time PAM demonstrate that NARW are not present in the transit corridor prior to and during transits ▪ Species specific vessel strike avoidance - Whales: 500 m (1640 feet) will be maintained between all vessels and NARWs and between all vessels and non-NARW whales (including Kogia spp., and beaked whales) - Delphinoid Cetaceans and Pinnipeds: 50 m of separation distance will be maintained between vessels and small cetaceans (delphinoids) and pinnipeds, except for voluntary approaches (e.g., bow riding dolphins).
November 1 to November 30	▪ PAM will be operated 24 hours before pile driving begins ▪ If a NARW is observed or detected within 60 minutes prior to piling, pile driving will be delayed until the following day unless a follow up vessel-based survey, is conducted, to confirm the zone is clear of NARWs ▪ If three (3) or more NARWs are visually observed at any distance, no pile driving will occur until the following day

Monitoring & mitigation measure	Description
December 1 to December 31	▪ Pile driving will not occur in the month of December unless it is necessary to complete the installation of the remaining MPs in the LIA and is approved by BOEM and NMFS. ▪ Enhanced monitoring will include: - PAM will be operated 24/7 on days when pile driving is planned. PAM will also be operated the day before pile driving is planned for situational awareness. - A vessel-based survey, will be utilized to confirm the clearance zone (any distance for visual sightings or 10 km for acoustic detections, see Table 18) is clear of NARWs prior to pile driving. The survey will be supported by a team of nine PSOs coordinating visual monitoring across two PSO Support Vessels and the main pile driving platform to extend visual monitoring capabilities - Vessel-based survey will be conducted by the two PSO Support, which will be positioned at the same distance on either side of the pile driving vessel Each vessel will transit along a steady course along parallel track lines, in opposite directions. Each transect line will be surveyed at a similar speed, not to exceed 10 knots, and will take approximately 30 minutes to one (1) hours to complete each transect where each vessel will each transit in a linear North/South direction to the pile. The parallel, but opposite movement of the vessels ensure continuous coverage of the zones surrounding the pile driving vessel. - If a NARW is sighted at any distance during the vessel-based survey, piling operations will not be conducted that day unless an additional vessel-based survey is conducted, similar to the survey described in the previous bullet, but with an additional transect added (four [4] in total, one transect run North to South, where each PSO Support Vessel will move parallel to the other vessel, but in the opposite direction, followed by another transect which will run perpendicular East to West, each vessel again traveling parallel but in the opposite direction).,, to confirm no NARWs are observed ▪ If three (3) or more NARWs are visually observed at any distance, no pile driving will occur until the following day
Communication	▪ Whenever multiple project vessels are operating, any visual sighting/observation of an ESA-listed marine mammal will be communicated to all project vessels to increase situational awareness ▪ Any protected species detections will be communicated to the Lead PSO immediately via VHF radio/or alternative communication platform. The Lead PSO will notify the Pile Driving Operations Manager and Client Representative.

Monitoring & mitigation measure	Description
Sound Source Verification (SFV)	▪ Vineyard Wind will conduct SFV on the first monopile installed in the LIA, and at least one complete SFV on a monopile if monopiles are installed in the month of December ▪ Abbreviated SFV will be conducted on the remainder of all foundations installed ▪ Vineyard Wind will submit all interim results of the SFV plan for NMFS review ▪ In the unlikely event that the NAS system does not function as expected, Vineyard Wind will expand the exclusion zone sizes to match the noise levels based on the 2024 thorough SFV results and conduct additional thorough SFV until the results of the additional studies demonstrate that the noise levels have returned to the anticipated levels.

[1] This restriction is intended to minimize the amount of pile driving that occurs when the migratory NARW is likely to be in the Offshore Project Area and thus limit sound exposure for this endangered species. Density data from Roberts et al. (2016; 2023) and survey data (both visual and acoustic) from Kraus et al. (2016) suggest that the highest density of NARWs in the WDA occurs annually in February/March. Over 93% of the sightings in the Kraus et al. (2016) study occurred from January through April, with no NARWs sighted from May through August.

[2] These measures do not apply in cases where compliance would create an imminent and serious Health, Safety, and Environmental (HSE) threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of that maneuverability restriction, cannot comply. These measures do not apply to any vessel towing gear or any vessel that is navigationally constrained.

[3] Table 18 below provides a summary of the minimum visual clearance zone and duration for each species group as well as the PAM clearance and monitoring zone

[4] The minimum visual clearance zone is the minimum distance that must be visible prior to initiating pile driving, as defined by the lead PSO.

[5] Development of automated detectors includes description or training as part of the set-up phase followed by, often, extensive testing. During the testing phase, detections (and signals without detections) are manually reviewed to establish detector performance (true and false positive rates, and true and false negative rates). Detectors with >75% confidence were used for this project.

[6] PAM clearance zone refers to the zone that is monitored prior to initiating pile driving. PAM detections of marine mammals localized inside clearance zones will result in a delay of pile driving. PAM monitoring zone is the zone within which PAM monitoring will occur continuously prior to, during, and after pile driving activities. PAM shutdown zone is the zone within which shutdown will occur, when technically safe and feasible, if an acoustic detection is localized within this zone.

[7] An acoustic detection of a marine mammal localized within the relevant shutdown zone will trigger a shutdown when technically safe and feasible. A PAM detection that may be within (i.e., cannot be confirmed outside of) the shutdown zone will also trigger a shutdown.

Table 18 provides a summary of the visual clearance zone and delay durations to be observed if marine mammals are sighted prior to pile driving. As well, the table provides the species-specific shutdown zones, PAM clearance and monitoring zones.

Table 18. Exclusion zones for pile driving[4]

	Visual Clearance Zone		Shut-down Zone	Passive Acoustic Monitoring Zones	
Species/Species Group	Clearance Zone (CZ)	Clearance Delay Duration [1]		PAM CZ	PAM Monitoring Zone
North Atlantic right whale (NARW)	Any distance	June 1 – October 31: Until 30 minutes (min) of visual monitoring confirms no further detection of NARW(s) November 1 – December 31: Postpose piling until the following day or conduct a vessel-based survey (see Table 17).	Any distance	10 km	
Unidentified large whale	Any unidentified large whale sighted at any distance that cannot be identified to species as not a NARW is treated as a NARW for purposes of clearance and delay	See above	Any unidentified large whale sighted at any distance that cannot be identified to species as not a NARW is treated as a NARW for purposes of a shutdown in pile driving	-	-
Mysticetes- humpback, fin, minke, sei	500 m	30 mins	500 m	500 m	
Sperm whales	500 m	30 mins	500 m	500 m	
Risso's dolphins and pilot whales	160 m	30 mins	160 m	160 m	
Pinnipeds	160 m	15 mins	160 m	160 m	
Harbor porpoise	160 m	15 mins	160 m	160 m	

[1] Pile driving may commence when either the marine mammal(s) has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, when 30 minutes have elapsed without re-detection (for mysticetes, sperm whales, Risso's dolphins and pilot whales) or 15 minutes have elapsed without re-detection (for all other marine mammals).

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[4] Clearance and shutdown zones correspond to the Level A harassment threshold, except for the NARW and unidentified large whale, or are slightly larger. This increase helps accommodate the size of the bubble curtain as it is unlikely that an animal would enter the curtain, however, the Level A harassment zones for HFCs and MFCs are typically smaller than the radial distance to the edge of the furthest bubble curtain.

12. Arctic Plan of Cooperation

This section of the application relates to mitigation measures to protect subsistence uses of marine mammals and must be completed only where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, in which case an Arctic Plan of Cooperation must be submitted. The proposed activities will take place off the US northeast coast in the Atlantic Ocean and, therefore, will not have an adverse effect on the availability of marine mammals for subsistence uses.

13. Monitoring and Reporting

13.1. Visual Monitoring

As detailed in Table 17 above, PSO visual monitoring requirements include shift schedule restrictions, low visibility monitoring requirements, training requirements, NMFS approval criteria, vantage point restrictions, exclusion zone monitoring requirements, and data recording requirements. Vineyard Wind will deploy PSOs aboard the installation vessel and two PSO Support Vessels to conduct visual monitoring for pile driving operations.

When a marine mammal sighting is made during pile driving activities, the following observational data will be recorded by PSOs:

- Location of the animal (decimal degrees) including bearing, distance, direction of travel/first approach, pace, initial and final heading
- Vessel activity, heading of the vessel (degrees), and speed
- Environmental factors such as water depth, swell height, wind speed/direction, sea state, precipitation, visibility, cloud cover, glare
- Species identification including common name, scientific name, or family and certainty of identification, number (by age and total) and composition of group. Description (include features such as overall size; shape of head; color and pattern; size, shape, and position of dorsal fin; height, direction, and shape of blow, etc.)
- Distance and bearing of each marine mammal observed relative to the pile being driven for each sighting (if pile driving was occurring at time of sighting). Animal's closest distance from the pile being driven (meters) and estimated time spent within the harassment zone (HH:MM), if applicable. Time at closest approach to vessel in UTC (HH:MM), at closest approach to pile being driven in UTC (HH:MM), and if relevant the time the animal entered exclusion zone in UTC (HH:MM), animal left EZ in UTC (HH:MM). Additionally, as applicable, the animals occurrence within the relevant Level A or Level B harassment zone. Duration of detection
- Detection narrative (note behavior, especially changes in relation to construction activity [in sequential order using behavioral codes] and distance from vessel). If any bow-riding behavior observed, record total duration during detection (HH:MM)
- Description of any mitigation-related actions called for but not implemented in response to a sighting (e.g., delay, shutdown, etc.), including time, location, and the reason why the mitigation related action was not implemented
- Detections with PAM

- Watch Status (sighting made by PSO on watch, opportunistic, crew)
- Mitigation, did a shutdown/power down occur? If so, time shutdown was called for in UTC (HH:MM), time equipment was shut down in UTC (HH:MM), time pile driving restarted in UTC (HH:MM). Event was communicated to other project vessels (Y/N)
- Photograph taken (Y/N)
- In addition to marine mammal data, Protected Species Observers will also collect relevant project information,
- operations data, port call logistics, and information regarding monitoring effort.
- During vessel transits, when monitoring is required, designated observers (VOs/TLs) will be stationed at the best vantage point to monitor the separation distance between the vessel and any sighted marine mammal. When a marine mammal is observed during vessel transit, the following information will be recorded on the Visual Observer Log
- Time, date, and location of sighting
- Vessel activity, heading, and speed
- Environmental conditions such as water depth, sea state, and visibility
- Species identification
- Initial distance species was observed from the vessel and closest point of approach; and
- Any vessel strike avoidance measures taken in response to the sighting

13.2. Passive Acoustic Monitoring

As summarized above in Table 17, passive acoustic monitoring will be used to monitor the clearance, monitoring, and shutdown zones during pile driving activities. Data will be reviewed shoreside by trained PAM analysts and detection information relayed to the PSO team and all other project vessels in near real-time. PAM will also be used to support monitoring during limited visibility conditions and is detailed in Section 11. Near real-time simultaneous PAM is also used to monitor the primary transit corridor, for CTV operations above 10 knots.

During near real-time PAM deployments, in support of pile driving activities, the following data will be recorded:

- Location of hydrophone, site name, recorder, and platform type
- Bottom depth and depth of recording unit
- Time zone for sound files and recorded date/times in data and metadata
- Duration of recordings
- Deployment/retrieval dates and times
- Recording schedule
- Hydrophone and recorder sensitivity
- Calibration curve for each recorder
- Bandwidth/sampling rate, sample bit-rate of recordings

- Detection range of equipment for frequency bands

For each near real-time detection, the following data will be recorded:

- Species identification, if possible
- Call type and number of calls
- Temporal aspects of vocalization
- Confidence of detection
- Comparison with any concurrent visual sightings
- Location and/or directionality of call relative to acoustic recorder or construction activities
- Location of recorder and construction activities at the time of the call
- Name and version of detection or sound analysis software used, with protocol reference
- Minimum and maximum frequencies viewed/monitoring/used in detection
- Name of PAM analyst on duty

Additional data will be recorded and included in the weekly and monthly pile driving reports including:

- Date, PAM team names
- Time clearance PAM monitoring began (UTC), time PAM monitoring ended (UTC), and duration of clearance
- PAM detection data (as noted above)
- Type of recording (continuous/duty cycled)
- A record of the PAM analysts review of any acoustic detections
- Location or directionality of detected calls including references to location of coincident human sound-producing activities, including the uncertainty area and ho it was estimated

13.3. Reporting

The subsections below provide a summary of the reporting requirements Vineyard Wind is committed to following.

13.3.1. NARW Sighting Reports

Vineyard Wind will report NARW(s) observed during any project-related activity or during vessel transit, by PSOs or personnel on any vessel, to the NOAA Fisheries 24-hour Stranding Hotline and USCG via channel 16 immediately. The report will include the date and time of sighting, location, project name, and number of NARWs observed.

13.3.2. NARW Acoustic Detection Reports

Acoustic detections of NARWs will be reported as soon as feasible, but no longer than 24 hours after the detection to NMFS via the 24-hour reporting template and sent to ne.rw.survey@noaa.gov. At the conclusion of acoustic monitoring, the long-term detection template, inclusive of the full detection data and metadata, will be reported to the NMFS North Atlantic right whale Passive Acoustic Reporting System website via nmfs.pacmdata@noaa.gov.

13.3.3. Injured or Dead Marine Mammal Reporting

Dead or injured marine mammal sightings will be reported to the NMFS immediately via the NMFS Greater Atlantic Stranding Coordinator for the New England/Mid-Atlantic area (866-755-6622) and the U.S. Coast Guard via Channel 16. Within 24 hours Vineyard Wind will report the observation to NMFS Office of Protected Resources at (301-427-8401). The report will include the

- Time, date, location of first discovery
- Species identification
- Condition of the animal
- Observed behaviors of the animal (if alive)
- Photographs/video footage of the animal (if available)
- General circumstances under which the animal was discovered.

If a project vessel, while conducting activities covered by the authorization, strikes a marine mammal, Vineyard Wind will immediately report the vessel strike to the NMFS Greater Atlantic Stranding Coordinator for the New England/Mid-Atlantic area (866-755-6622) as well as the U.S. Coast Guard via Channel 16. The incident must also be immediately reported to NMFS Office of Protected Resources (301-427-8401). The report will include the

- time, date, and location of the incident
- Species identification and description of the animal involved including the estimated size and length of the animal
- Vessel information including vessel speed during and leading up to the incident, vessel course/heading and what operations were being conducted (if applicable)
- Status of all sound sources in use
- Description of avoidance measures/requirements that were in place at the time of the strike and any additional measures that were taken, if any, to avoid the strike
- Environmental conditions immediately preceding the strike (wind speed and direction, sea state, cloud cover, visibility)
- Description of the behavior of the marine mammal immediately preceding and following the strike
- Description of the presence and behavior of all other marine mammals immediately preceding the strike, if applicable
- Estimated fate of the animal
- Photographs or video footage of the animal, to the extent practicable

13.3.4. Pile Driving Monitoring Reports

During pile driving activities, draft weekly reports will be submitted to NMFS documenting the daily start and stop of all pile driving activities, any mitigation actions or if mitigation actions could not be undertaken, the start and stop of associated observation periods by the PSOs, details on the deployment of PSOs, and a record of all observations of marine mammals.

Draft monthly reports will be submitted to NMFS including a summary of the information provided in the draft weekly reports and project activities carried out over the previous month. Details include reports of vessel transits, piles installed, and all observations of marine mammals.

A final report will be submitted to NMFS that summarizes construction activities for the entire two-year monopile installation campaign including all visual and acoustic detections of marine mammals during pile driving operations within 90 calendar days of the completion of monitoring. Vineyard Wind will respond to the agency's comments within thirty days of receipt.

The draft weekly, draft monthly, and final report will be submitted to NMFS PR.ITP.MonitoringReports@noaa.gov and itp.daly@noaa.gov. Additionally, upon project completion, raw acoustic data will be submitted to NCEI.

Vineyard Wind will submit bubble curtain inspection/performance reports to NMFS within 72 hours following the performance test.

13.3.5. IHA Training Log Report

Prior to initiation of project activities, Vineyard Wind will submit a log of all required training for personnel, including all vessel crews and captains, as well as PSOs. This report will be submitted to NMFS at itp.daly@noaa.gov.

13.3.6. Adaptive Mitigation

Vineyard Wind will provide a written report of any technical issues that prevent full compliance with the authorization prior to the initiation of the activity to NMFS. As available, the report will include a description of the technical issue, the requirement potentially impacted, marine mammal detection information (if applicable), and the adaptive mitigation measures proposed in place of the impacted requirement, to the maximum extent practicable.

While such technical issues may arise during construction, unless necessary due to installation feasibility or to avoid imminent risk to human health and in consideration of safety, all technical issues will be addressed and resolved such that full compliance is achievable with the Authorization.

14. Suggested Means of Coordination

Vineyard Wind 1 will coordinate the planned marine mammal monitoring program associated with construction activities off the U.S. east coast (as summarized in Section 11) with other parties that may have interest in the area and/or be conducting marine mammal studies in the same region during these activities. Vineyard Wind regularly engages with regional stakeholders to ensure any use of the Lease Area for marine mammal research is deconflicted. To date, Vineyard Wind has executed three Deconfliction Plan agreements with various Federally funded research initiatives (e.g., Project WOW) and serves as an industry advisor on various User Advisory Board for regional studies.

15. Literature Cited

81 FR 4838. 2016. Endangered and threatened species; critical habitat for endangered North Atlantic right whale; final rule. p. Available online at https://www.greateratlantic.fisheries.noaa.gov/regs/2016/January/16narwchfinalrule.pdf.

81 FR 62260. 2016. Endangered and threatened species; identification of 14 distinct population segments of the humpback whale (*Megaptera novaeangliae*) and revision of species-wide listing; final rule. p. Available online at https://www.gpo.gov/fdsys/pkg/FR-2016-09-08/pdf/2016-21276.pdf.

86 FR 33810. 2021. Takes of marine mammals incidental to specified activities; taking of marine mammals incidental to construction of the Vineyard Wind offshore wind project. 42 p. Available online at https://www.govinfo.gov/content/pkg/FR-2021-06-25/pdf/2021-13501.pdf. Accessed 06 Nov 2023.

87 FR 79072. 2022. Takes of marine mammals incidental to specified activities; taking marine mammals incidental to the Revolution Wind offshore wind farm project offshore Rhode Island. Proposed rule. 102 p.

[ACS] American Cetacean Society. 2018. Pilot whale. Available online at http://www.acsonline.org/index.php?option=com_content&view=article&id=65:pilotwhale&catid=20:site-content. Accessed 2018 Aug 2.

[BOEM] Bureau of Ocean Energy Management. 2014. Commercial wind lease issuance and site assessment activities on the Atlantic Outer Continental Shelf offshore Massachusetts. OCS EIS/EA BOEM 2014-603. 310 p. + Appx.

[BOEM] Bureau of Ocean Energy Management. 2021. Vineyard Wind 1 offshore wind energy project final environmental impact statement. OCS EIS/EA BOEM 2012-0012.

[CeTAP] Cetacean and Turtle Assessment Program. 1982. A characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf. Final report of the Cetacean and Turtle Assessment Program. University of Rhode Island, Kingston, RI. Under Contract AA551-CT8-48. 570 p.

[DoN] U.S. Department of the Navy. 2005. Marine resources assessment for the northeast operating areas: Atlantic City, Narragansett Bay, and Boston. Final Report. N. News, Norfolk, VA. N62470-02-D-9997.

[MassWildlife] Massachusetts Division of Fisheries and Wildlife. 2023. List of endangered, threatened, and special concern species. Available online at https://www.mass.gov/info-details/list-of-endangered-threatened-and-special-concern-species. Accessed 2023 Nov 23.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2011. 2010 Annual report to the inter-agency agreement M10PG00075/0001: a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 70 p.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2012. 2011 Annual report to the inter-agency agreement M10PG00075/0001: a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 166 p.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2013. 2012 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 121 p.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2014. 2013 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 204 p.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2015. 2014 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 197 p.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2016. 2015 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II. Available online at https://repository.library.noaa.gov/view/noaa/22720/noaa_22720_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2017. 2016 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II. 153 p. Available online at https://repository.library.noaa.gov/view/noaa/22663/noaa_22663_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2018. 2017 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II. 141 p. Available online at https://repository.library.noaa.gov/view/noaa/22419/noaa_22419_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2019. 2018 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II. 119 p. Available online at https://repository.library.noaa.gov/view/noaa/22040/noaa_22040_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2020. 2019 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II. 111 p. Available online at https://repository.library.noaa.gov/view/noaa/26467/noaa_26467_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2021. 2020 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS III. 36 p. Available online at https://repository.library.noaa.gov/view/noaa/29491/noaa_29491_DS1.pdf. Accessed 2023 Nov 20.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2022. 2021 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS III. 116 p. Available online at https://repository.library.noaa.gov/view/noaa/41734/noaa_41734_DS1.pdf. Accessed 2023 Nov 20.

[NMFS-GARFO] National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. 2021. Endangered Species Act section 7 consultation biological opinion for the construction, operation, maintenance, and decommissioning of the Vineyard Wind Offshore Energy Project (Lease OCS-A 0501). GARFO-2021-01265 -- [CORRECTED] (reinitiation of GARFO-2019-00343). 483 p. Available online at https://doi.org/10.25923/h9hz-3c72.

[NMFS] National Marine Fisheries Service. 1991. Final recovery plan for the humpback whale *Megaptera novaeangliae*. Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 105 p.

[NMFS] National Marine Fisheries Service. 2008. Final environmental impact statement to implement vessel operational measures to reduce ship strikes to North Atlantic right whales. 850 p. Available online at http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/feis.pdf.

[NMFS] National Marine Fisheries Service. 2018. 2018 revision to: technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Office of Protected Resources Nat. Mar. Fish. Serv., Silver Spring, MD. 167 p.

[NMFS] National Marine Fisheries Service. 2023a. Sei whale *Balaenoptera borealis* overview. Available online at https://www.fisheries.noaa.gov/species/sei-whale. Accessed 2023 Nov 23.

[NMFS] National Marine Fisheries Service. 2023b. Humpback whale *Megaptera novaeangliae* overview. Available online at https://www.fisheries.noaa.gov/species/humpback-whale. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023c. Short-beaed common dolphin *Delphinus delphis* overview. Available online at https://www.fisheries.noaa.gov/species/short-beaked-common-dolphin. Accessed 2023 Nov 25.

[NMFS] National Marine Fisheries Service. 2023d. 2017-2023 minke whale unusual mortality event along the Atlantic coast. Available online at https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2023-minke-whale-unusual-mortality-event-along-atlantic-coast. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023e. Long-finned pilot whale *Globicepala melas* overview. Available online at https://www.fisheries.noaa.gov/species/long-finned-pilot-whale. Accessed 2023 Nov 24.

[NMFS] National Marine Fisheries Service. 2023f. Gray seal *Halichoerus grypus* overview. Available online at https://www.fisheries.noaa.gov/species/gray-seal. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023g. Fin whale (*Balaenoptera physalus*) overview. Available online at https://www.fisheries.noaa.gov/species/fin-whale. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023h. North Atlantic right whale *Eubalaena glacialis* overview. Available online at https://www.fisheries.noaa.gov/species/north-atlantic-right-whale. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023i. Risso's dolphin *Grampus griseus* overview. Available online at https://www.fisheries.noaa.gov/species/rissos-dolphin. Accessed 2023 Nov 25.

[NMFS] National Marine Fisheries Service. 2023j. Common bottlenose dolphin (*Tursiops truncatus*) overview. Available online at https://www.fisheries.noaa.gov/species/common-bottlenose-dolphin. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023k. 2016-2023 humpback whale unusual mortality event along the Atlantic coast. Available online at https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2023-humpback-whale-unusual-mortality-event-along-atlantic-coast. Accessed 2023 Nov 21.

[NMFS] National Marine Fisheries Service. 2023l. Minke whale *Balaenoptera acutorostrata* overview. Available online at https://www.fisheries.noaa.gov/species/minke-whale. Accessed 2023 Nov 20.

[NMFS] National Marine Fisheries Service. 2023m. Harbor seal *Phoca vitulina* overview. Available online at https://www.fisheries.noaa.gov/species/harbor-seal. Accessed 2023 Nov 26.

Agler, B.A., R.L. Schooley, S.E. Frohock, S.K. Katona, and I.E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. J Mammal 74(3):577-587.

Aguilar, A. 1986. A review of old Basque whaling and its effect on the right whales (*Eubalaena glacialis*) of the North Atlantic. Reports of the International Whaling Commission Special Issue 10:191-199.

Ajemian, M.J., J.J. Wetz, B. Shipley-Lozano, J.D. Shively, and G.W. Stunz. 2015. An analysis of artificial reef fish community structure along the northwestern Gulf of Mexico shelf: potential impacts of "rigs-to-reefs" programs. PLoS One 10(5):e0126354. doi: 10.1371/journal.pone.0126354.

Arnould, J.P.Y., J. Monk, D. Ierodiaconou, M.A. Hindell, J. Semmens, A.J. Hoskins, D.P. Costa, K. Abernathy, and G.J. Marshall. 2015. Use of anthropogenic sea floor Structures by Australian fur seals: potential positive ecological impacts of marine industrial development? PLoS One 10(7):e0130581. doi: 10.1371/journal.pone.0130581.

Bailey, H., B. Senior, D. Simmons, J. Rusin, G. Picken, and P.M. Thompson. 2010. Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. Marine Pollution Bulletin 60(6):888-897.

Bailey, H., K.L. Brookes, and P.M. Thompson. 2014. Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. Aquatic Biosystems 10:8.

Baird, R.W. and P.J. Stacey. 1991. Status of the Risso's dolphin, *Grampus griseus*, in Canada. Canadian Field-Naturalist 105(2):233-242.

Bellmann, M.A. 2014. Overview of existing noise mitigation systems for reducing pile-driving noise. Presented at inter-noise 2014, Melbourne, Australia, 16-19 November, 2014.

Bellmann, M.A. 2019. Results from noise measurements in European offshore wind farms. Presentation at Orsted Underwater Noise Mini Workshop. Presented at Orsted Underwater Noise Mini Workshop, Washington, D.C.

Bellmann, M.A., A. May, T. Wendt, S. Gerlach, P. Remmers, and J. Brinkmann. 2020. Underwater noise during percussive pile driving: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Available online at https://www.itap.de/media/experience_report_underwater_era-report.pdf.

Benhemma-Le Gall, A., I.M. Graham, N.D. Merchant, and P.M. Thompson. 2021. Broad-Scale Responses of Harbor Porpoises to Pile-Driving and Vessel Activities During Offshore Windfarm Construction. Frontiers in Marine Science 8:735.

Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N. Åstrand Capetillo, and D. Wilhelmsson. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environmental Research Letters 9(3):034012. doi: 10.1088/1748-9326/9/3/034012.

Bigg, M.A. 1981. Harbor seal - *Phoco vitulina* and *P. largha*. p. 1-27 *In:* S.H. Ridgway and R.J. Harrison (eds.). Handbook of marine mammals. Vol. 2: seals. Academic Press, London, U.K.

Bittencourt, L., I.M.S. Lima, L.G. Andrade, R.R. Carvalho, T.L. Bisi, J. Lailson-Brito, and A.F. Azevedo. 2017. Underwater noise in an impacted environment can affect Guiana dolphin communication. Marine Pollution Bulletin 114(2):1130-1134. doi: https://doi.org/10.1016/j.marpolbul.2016.10.037.

Blackwell, S.B., J.W. Lawson, and M.T. Williams. 2004. Tolerance by ringed seals (Phoca hispida) to impact pipe driving and construction sounds at an oil production island. Journal of Acoustical Society of America 115(5):2346-2357.

Blackwell, S.B. 2005. Underwater measurements of pile driving sounds during the Port MacKenzie dock modifications, 13-16 August 2004. Rep. from Greeneridge Sciences, Inc., Goleta, CA, and LGL Alaska Research Associates, Inc., Anchorage, AK, in association with HDR Alaska, Inc., Anchorage, AK, for Knik Arm Bridge and Toll Authority, Anchorage, AK, Department of Transportation and Public Facilities, Anchorage, AK, and Federal Highway Administration, Juneau, AK. Greeneridge Report 328-1. 33 p.

Blackwell, S.B., C.S. Nations, T.L. McDonald, C.R. Greene, A.M. Thode, M. Guerra, and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. Marine Mammal Science 29(4):E342-E365. doi: 10.1111/mms.12001.

Blackwell, S.B., C.S. Nations, T.L. McDonald, A.M. Thode, D. Mathias, K.H. Kim, C.R. Greene, Jr., and A.M. Macrander. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. PLoS One 10(6):e0125720. doi: 10.1371/journal.pone.0125720.

Bowles, A.E., M. Smultea, B. Wursig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from Heard Island Feasibility Test. Journal of the Acoustical Society of America 96(4):2469-2484.

Brandt, M.J., A. Diederichs, K. Betke, and G. Nehls. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series 421:205-216. doi: 10.3354/meps08888.

Branstetter, B.K., J.S. Trickey, K. Bakhtiari, A. Black, and H. Aihara. 2013a. Auditory masking patterns in bottlenose dolphins (*Tursiops truncatus*) with natural, anthropogenic, and synthesized noise. Journal of the Acoustical Society of America 133(3):1811-1818. doi: 10.1121/1.4789939].

Branstetter, B.K., J.S. Trickey, H. Aihara, J.J. Finneran, and T.R. Liberman. 2013b. Time and frequency metrics related to auditory masking of a 10 kHz tone in bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America 134(6):4556-4565. doi: 10.1121/1.4824680.

Branstetter, B.K., K.L. Bakhtiari, J.S. Trickey, and J.J. Finneran. 2016. Hearing mechanisms and noise metrics related to auditory masking in bottlenose dolphins (*Tursiops truncatus*). p. 109-116 *In:* A. Popper and A. Hawkins (eds.). The effects of noise on aquatic life II. Springer, New York, NY.

Brasseur, S., T. Van Polanen Petel, G. Aarts, E. Meesters, E. Dijkman, and P. Reijnders. 2010. Grey seals (*Halichoerus grypus*) in the Dutch North Sea: population ecology and effects of wind farms. IMARES Wageningen UR, The Netherlands. Report number C137/10. 72 p.

Bröker, K.C., C. Vanman, and B. Martin. 2013. Monitoring of marine mammals and the sound scape during a seismic survey in two license blocks in the Baffin Bay, West Greenland, in 2012. Presented at Abstracts of the 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand.

Brown, M.W., D. Fenton, K. Smedbol, C. Merriman, K. Robichaud-Leblanc, and J.D. Conway. 2009. Recovery strategy for the North Atlantic right whale (*Eubalaena glacialis*) in Atlantic Canadian waters [Final]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. vi + 66 p.

Buehler, D., R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015. Technical guidance for assessment and mitigation of the hydroacoustic effects of pile driving on fish. California Department of Transportation, Sacramento, CA. Contract No. 43A0306. 532 p.

Bulleri, F. and L. Airoldi. 2005. Artificial marine structures facilitate the spread of a non-indigenous green alga, Codium fragile ssp. tomentosoides, in the north Adriatic Sea. Journal of Applied Ecology 42(6):1063-1072. doi: 10.1111/j.1365-2664.2005.01096.x.

Burns, J.J. 2002. Harbor seal and spotted seal *Phoca vitulina* and *P. largha*. p. 552-560 *In:* W.F. Perrin, B. Wursig, and J.G.M. Thewissen (eds.). Encyclopedia of marine mammals. Academic Press, San Diego, CA.

Caltrans. 2004. Revised marine mammal monitoring plan—San Francisco-Oakland Bay Bridge east span seismic safety project. 04-SF-80 KP12.2/KP 14.3, 04-ALA-80 KP 0.0/KP 2.1. p.

Cañadas, A. and P.S. Hammond. 2008. Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. Endangered Species Research 4(3):309-331.

Carstensen, J., O.D. Henriksen, and J. Teilmann. 2006. Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). Marine Ecology Progress Series 321:295-308.

Castellote, M., C.W. Clark, and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147(1):115-122. doi: 10.1016/j.biocon.2011.12.021.

Cerchio, S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. PLoS One 9(3):e86464. doi: 10.1371/journal.pone.0086464.

Charif, R.A., Y. Shiu, C.A. Muirhead, C.W. Clark, S.E. Parks, and A.N. Rice. 2020. Phenological changes in North Atlantic right whale habitat use in Massachusetts Bay. Global Change Biology 26(2):734-745. doi: https://doi.org/10.1111/gcb.14867.

Cipriano, F. 2018. Atlantic white-sided dolphin *Lagenorhynchus acutus*. p. 42-44 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.). Encyclopedia of Marine Mammals, 3rd edition. Academic Press, San Diego, CA.

Claisse, J.T., D.J. Pondella, II, M. Love, L.A. Zahn, C.M. Williams, J.P. Williams, and A.S. Bull. 2014. Oil platforms off California are among the most productive marine fish habitats globally. Proceedings of the National Academy of Sciences 11(43):15462-15467.

Clark, C.W. and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. p.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222. doi: 10.3354/meps08402.

Cranford, T.W. and P. Krysl. 2015. Fin whale sound reception mechanisms: skull vibration enables low-frequency hearing. PLoS One 10(1):e0116222.

Cunha, H.A., R.L. de Castro, E.R. Secchi, E.A. Crespo, J. Lailson-Brito, A.F. Azevedo, C. Lazoski, and A.M. Sole-Cava. 2015. Molecular and morphological differentiation of common dolphins (*Delphinus* sp.) in the Southwestern Atlantic: testing the two species hypothesis in sympatry. PLoS One 10(11):e0140251. doi: 10.1371/journal.pone.0140251.

Dahl, P.H., C.A.F. de Jong, and A.N. Popper. 2015. The Underwater Sound Field from Impact Pile Driving and Its Potential Effects on Marine Life. Acoustics Today 11(2):18-25.

Dahlheim, M. and M. Castellote. 2016. Changes in the acoustic behavior of gray whales *Eschrichtius robustus* in response to noise. Endangered Species Research 31:227-242. doi: 10.3354/esr00759.

Dähne, M., A. Gilles, K. Lucke, V. Peschko, S. Adler, K. Krügel, J. Sundermeyer, and U. Siebert. 2013a. Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. Environmental Research Letters 8(2):025002. doi: 10.1088/1748-9326/8/2/025002.

Dähne, M., U.K. Verfuß, A. Brandecker, U. Siebert, and H. Benke. 2013b. Methodology and results of calibration of tonal click detectors for small odontocetes (C-PODs). Journal of the Acoustical Society of America 134(3):2514-2522. doi: 10.1121/1.4816578].

Dähne, M., D.A. Giles, K. Lucke, V. Peschko, S. Adler, J. Krugel, J. Sundermeyer, and U. Siebert. 2013c. Effects of pile-driving on harbour porpoises (Phocoena phocoena) at the first offshore wind farm in Germany. Environmental Research Letters 8:025002.

Dähne, M., J. Tougaard, J. Carstensen, A. Rose, and J. Nabe-Nielsen. 2017. Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Marine Ecology Progress Series 580:221-237. doi: 10.3354/meps12257.

David, J.A. 2006. Likely sensitivity of bottlenose dolphins to pile-driving noise. Water and Environment Journal 20(1):48-54. doi: https://doi.org/10.1111/j.1747-6593.2005.00023.x.

Davies, J.L. 1957. The geography of the gray seal. J Mammal 38:297-310.

Davies, K.T.A., A.S.M. Vanderlaan, R.K. Smedbol, and C.T. Taggart. 2015. Oceanographic connectivity between right whale critical habitats in Canada and its influence on whale abundance indices during 1987–2009. Journal of Marine Systems 150:80-90. doi: 10.1016/j.jmarsys.2015.05.005.

Davies, K.T.A., M.W. Brown, P.K. Hamilton, A.R. Knowlton, C.T. Taggart, and A.S.M. Vanderlaan. 2019. Variation in North Atlantic right whale *Eubalaena glacialis* occurrence in the Bay of Fundy, Canada, over three decades. Endangered Species Research 39:159-171. doi: 10.3354/esr00951.

Davies, K.T.A. and S.W. Brillant. 2019. Mass human-caused mortality spurs federal action to protect endangered North Atlantic right whales in Canada. Marine Policy 104:157-162. doi: 10.1016/j.marpol.2019.02.019.

Davis, G.E., M.F. Baumgartner, J.M. Bonnell, J. Bell, C. Berchok, J. Bort Thornton, S. Brault, G. Buchanan, R.A. Charif, D. Cholewiak, C.W. Clark, P. Corkeron, J. Delarue, K. Dudzinski, L. Hatch, J. Hildebrand, L. Hodge, H. Klinck, S. Kraus, B. Martin, D.K. Mellinger, H. Moors-Murphy, S. Nieukirk, D.P. Nowacek, S. Parks, A.J. Read, A.N. Rice, D. Risch, A. Sirovic, M. Soldevilla, K. Stafford, J.E. Stanistreet, E. Summers, S. Todd, A. Warde, and S.M. Van Parijs. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (Eubalaena glacialis) from 2004 to 2014. Scientific Reports 7(1):13460. doi: 10.1038/s41598-017-13359-3.

Davis, G.E., M.F. Baumgartner, P.J. Corkeron, J. Bell, C. Berchok, J.M. Bonnell, J. Bort Thornton, S. Brault, G.A. Buchanan, D.M. Cholewiak, C.W. Clark, J. Delarue, L.T. Hatch, H. Klinck, S.D. Kraus, B. Martin, D.K. Mellinger, H. Moors-Murphy, S. Nieukirk, D.P. Nowacek, S.E. Parks, D. Parry, N. Pegg, A.J. Read, A.N. Rice, D. Risch, A. Scott, M.S. Soldevilla, K.M. Stafford, J.E. Stanistreet, E. Summers, S. Todd, and S.M. Van Parijs. 2020. Exploring movement patterns and changing distributions of baleen whales in the western

North Atlantic using a decade of passive acoustic data. Global Change Biology 26(9):4812-4840. doi: https://doi.org/10.1111/gcb.15191.

Di Iorio, L. and C.W. Clark. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6(1):51-54.

Di Iorio, L. and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters 6(1):51-54. doi: 10.1098/rsbl.2009.0651.

Donovan, G.P. 1991. A review of IWC Stock Boundaries. Reports of the International Whaling Commission (Spec. Iss. 13):39-68.

Dufault, S., H. Whitehead, and M. Dillon. 1999. An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus*) worldwide. Journal of Cetacean Research and Management 1(1):1-10.

Dunlop, R., R.D. McCauley, and M. Noad. 2020. Ships and air guns reduce social interactions in humpback whales at greater ranges than other behavioral impacts. Marine Pollution Bulletin 154:111072.

Dunlop, R.A., M.J. Noad, R.D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2017. Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. Journal of Experimental Biology 220(16):2878-2886. doi: 10.1242/jeb.160192.

Dunn, R.A. and O. Hernandez. 2009. Tracking blue whales in the eastern tropical Pacific with an ocean-bottom seismometer and hydrophone array. Journal of the Acoustical Society of America 126(3):1084-1094. doi: 10.1121/1.3158929.

Edrén, S.M., J. Teilmann, R. Dietz, and J. Carstensen. 2004. Effect of the construction of Nysted Offshore Wind Farm on seals in Rødsand seal sanctuary based on remote video monitoring. Technical report to Energi E2 A/S for the Ministry of the Environment, Denmark. 31 p. Ministry of the Environment, Denmark.

Edrén, S.M., S.M. Andersen, J. Teilmann, J. Carstensen, P.B. Harders, R. Dietz, and L.A. Miller. 2010. The effect of a large Danish offshore wind farm on harbor and gray seal haul-out behavior. Marine Mammal Science 26(3):614-634. doi: 10.1111/j.1748-7692.2009.00364.x.

Ellison, W.T., B.L. Southall, C.W. Clark, and A.S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26(1):21-28. doi: 10.1111/j.1523-1739.2011.01803.x.

Ellison, W.T., B.L. Southall, A.S. Frankel, K. Vigness-Raposa, and C.W. Clark. 2018. An acoustic scene perspective on spatial, temporal, and spectral aspects of marine mammal behavioral responses to noise. Aquatic Mammals 44(3):239-243. doi: 10.1578/AM.44.3.2018.239.

EPI Group. 2021. Protected species observation report. Massachusetts survey/Vineyard Wind LLC. EPI Report No. 10292 - *Ventus*, *Striker*, *Odyssey*.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: a review and research strategy. Marine Pollution Bulletin 103:15-38. doi: 10.1016/j.marpolbul.2015.12.007.

Erbe, C., R. Dunlop, K.C.S. Jenner, M.-N.M. Jenner, R.D. McCauley, I. Parnum, M. Parsons, T. Rogers, and C. Salgado-Kent. 2017. Review of underwater and in-air sounds emitted by Australian and Antarctic marine mammals. Acoustics Australia 45(2):179-241. doi: 10.1007/s40857-017-0101-z.

ESS Group Inc. 2016. Vineyard Wind protected species observer report. 2016 geophysical and geotechnical surveys. Vineyard Wind Lease Area - Massachusetts OCS. Prepared for Vineyard Wind LLC, Princeton, NJ by ESS Group, Inc., East Providence, RI in association with Smultea Environmental Sciences and Gardline Geosurvey Limited. ESS Project No. O207-001.01.

Fernandez-Betelu, O., I.M. Graham, K.L. Brookes, B.J. Cheney, T.R. Barton, and P.M. Thompson. 2021. Far-field effects of impulsive noise on coastal bottlenose dolphins. Frontiers in Marine Science 8:664230.

Finneran, J. 2020. Conditional attenuation of dolphin monaural and binaural auditory evoked potentials after preferential stimulation of one ear. Journal of Acoustical Society of America 147(4):2302-2313.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111(6):2929-2940. doi: 10.1121/1.1479150.

Finneran, J.J. 2012. Auditory effects of underwater noise in odontocetes. p. 197-202 *In:* A.N. Popper and A. Hawkins (eds.). The effects of noise on aquatic life. Advances in Experimental Medicine and Biology, vol. 730. Springer Science+Business Media, New York.

Finneran, J.J. 2015. Noise-induced hearing loss in marine mammals: a review of temporary threshold shift studies from 1996 to 2015. The Journal of the Acoustical Society of America 138(3):1702-1726. doi: 10.1121/1.4927418.

Fujii, T. 2015. Temporal variation in environmental conditions and the structure of fish assemblages around an offshore oil platform in the North Sea. Marine Environmental Research 108:69-82. doi: 10.1016/j.marenvres.2015.03.013.

Fujii, T. 2016. Potential influence of offshore oil and gas platforms on the feeding ecology of fish assemblages in the North Sea. Marine Ecology Progress Series 542:167-186. doi: 10.3354/meps11534.

Ganley, L.C., S. Brault, and C.A. Mayo. 2019. What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance. Endangered Species Research 38:101-113. doi: 10.3354/esr00938.

Gedamke, J. 2011. Ocean basin scale loss of whale communication space: potential impacts of a distant seismic survey. Presented at 19th Biennal Conference of Biology and Marine Mammals, Tampa, Florida.

Gervaise, C., Y. Simard, N. Roy, B. Kinda, and N. Menard. 2012. Shipping noise in whale habitat: characteristics, sources, budget, and impact on belugas in Saguenay-St. Lawrence Marine Park hub. Journal of the Acoustical Society of America 132(1):76-89. doi: 10.1121/1.4728190.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift, and N.M. Thompson Duprey. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34. doi: 10.4031/002533203787536998.

Gospić, N.R. and M. Picciulin. 2016. Changes in whistle structure of resident bottlenose dolphins in relation to underwater noise and boat traffic. Marine Pollution Bulletin 105(1):193-198. doi: https://doi.org/10.1016/j.marpolbul.2016.02.030.

Gowans, S. and H. Whitehead. 1995. Distribution and habitat partitioning by small odontocetes in the Gully, a submarine canyon on the Scotian Shelf. Canadian Journal of Zoology 73(9):1599-1608. doi: 10.1139/z95-190.

Graham, I.M., E. Pirotta, N.D. Merchant, A. Farcas, T.R. Barton, B. Cheney, G.D. Hastie, and P.M. Thompson. 2017. Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. Ecosphere 8(5):e01793. doi: https://doi.org/10.1002/ecs2.1793.

Greene, C.R., Jr. and W.J. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. Journal of the Acoustical Society of America 83(6):2246-2254.

Guan, S. and R. Miner. 2020. Underwater noise characterization of down-the-hole pile driving activities off Biorka Island, Alaska. Marine Pollution Bulletin 160(111664). doi: 10.1016.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A. to Nova Scotia, Canada). Marine Mammal Science 18(4):920-939. doi: https://doi.org/10.1111/j.1748-7692.2002.tb01082.x.

Hammar, L., S. Andersson, and R. Rosenberg. 2010. Adapting Offshore Wind Power Foundations to Local Environment. S.E.P. Agency.

Hammill, M.O., V. Lesage, Y. Dubé, and L.N. Measures. 2001. Oil and gas exploration in the southeastern Gulf of St. Lawrence: a review of information on pinnipeds and cetaceans in the area. Fisheries and Oceans Canada, Ottawa, ON. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/115. 39 p.

Hamran, E.T. 2014. Distribution and vocal behavior of Atlantic white-sided dolphins (*Lagenorhynchus acutus*) in northern Norway. M.Sc. thesis. University of Nordland.

Hanser, S.F., L.R. Doyle, A. Szabo, F.A. Sharpe, and B. McCowan. 2009. Bubble-net feeding humpback whales in Southeast Alaska change their vocalization patterns in the presence of moderate vessel noise. Presented at Abstracts of the 18th Biennial Conference on the Biology of Marine Mammals, Quebec, Canada.

Harris, R., T. Elliott, and R.A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006 TA4319-1).

Hastie, G., P. Lepper, J.C. McKnight, R. Milne, D.J.F. Russell, and D. Thompson. 2021. Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. Journal of Applied Ecology 58(9):1854-1863.

Hatch, L.T., C.W. Clark, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. Conservation Biology 26(6):983-994. doi: 10.1111/j.1523-1739.2012.01908.x.

Hayes, S., E. Josephson, K. Maze-Foley, and e. Rosel PE. 2020. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2019. Woods Hole, MA. NOAA Technical Memorandum NMFS-NE- 271.

Hayes, S., E. Josephson, K. Maze-Foley, and P. Rosel, editors. 2021. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2020. Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-271.

Hayes, S., E. Josephson, K. Maze-Foley, P. Rosel, and J. Wallace, editors. 2022. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2021. Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-288.

Hayes, S.A., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2017. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2016. U.S. Dep. Commer., Woods Hole, MA. NOAA Tech. Memo. NMFS-NE-241. 274 p.

Hayes, S.A., E. Josephson, K. Maze-Foley, and P.E. Rosel, editors. 2018. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2017. U.S. Dep. Commer., Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-245. 373 p.

Hayes, S.A., E. Josephson, K. Maze-Foley, P.E. Rosel, J. McCordic, and J. Wallace, editors. 2023. US Atlantic and Gulf of Mexico marine mammal stock assessments 2022. U.S. Dep. Commer., Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-245. 257 p.

Heiler, J., S.H. Elwen, H.J. Kriesell, and T. Gridley. 2016. Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. Animal Behaviour 117:167-177. doi: 10.1016/j.anbehav.2016.04.014.

Hoelzel, A.R., C.W. Potter, and P.B. Best. 1998. Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin. Proc. R. Soc. B 265(1402):1177-1183. doi: 10.1098/rspb.1998.0416.

Holst, M., M. Smultea, W.R. Koski, and B. Haley. 2005. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's Marine Seismic Program off the Northern Yucatán Peninsula in the Gulf of Mexico, January-Feburary 2004. Palisades, NY. Lamont-Doherty Earth Observatory of Columbia University.

Holst, M., W.J. Richardson, W.R. Koski, M. Smultea, B. Haley, M.W. Fitzgerald, and M. Rawson. 2006. Effects of large and small-source seismic surveys on marine mammals and sea turtles. Presented at AGU Spring Meeting Abstracts, Baltimore, MD.

Holst, M., D.P. Noren, V. Veirs, C.K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):EL27-EL32.

Holst, M., J. Beland, B. Mactavish, J.R. Nicolas, B. Hurley, and B. Dawe. 2011. Visual-acoustic survey of cetaceans during a seismic study near Taiwan, April-July 2009. Presented at Abstracts of the 19th Biennial Conference on the Biology of Marine Mammals, Tampa, FL.

Holt, M.M., D.P. Noren, R.C. Dunkin, and T.M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. Journal of Experimental Biology 218:1647-1654.

Houser, D. 2021. When is Temporary Threshold Shift Injurious to Marine Mammals. Journal of Marine Science and Engineering 9.

Inger, R., M.J. Attrill, S. Bearhop, A.C. Broderick, W. James Grecian, D.J. Hodgson, C. Mills, E. Sheehan, S.C. Votier, M.J. Witt, and B.J. Godley. 2009. Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology 46:1145-1153. doi: 10.1111/j.1365-2664.2009.01697.x.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. FAO, Rome, Italy. 320 p.

Jefferson, T.A., M.A. Webber, and R. Pitman. 2008. Marine mammals of the world: a comprehensive guide to their identification. Elsevier, London, UK.

Jensen, F.H., L. Bejder, M. Wahlberg, N. Aguilar Soto, M. Johnson, and P.T. Madsen. 2009. Vessel noise effects on delphinid communication. Marine Ecology Progress Series 395:161-175. doi: 10.3354/meps08204.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhardt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Wursig. 2008. Sperm whale seismic study in the Gulf of Mexico: synthesis report. New Orleans, LA. OCS Study MMS 2008-006. 341 p. U.S. Dept. of the Interior,.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Wursig, C.R. Martin, and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):1-19. doi: 10.1007/s10661-007-9813-0.

Jones, D.V. and D. Rees. 2020. Haul-out counts and photo-identification of pinnipeds in Chesapeake Bay and Eastern Shore, Virginia: 2018/2019 annual progress report. Final report. Prepared for U.S. Fleet Forces Command, Norfolk, Virginia.

Kastelein, R., R. Gransier, M. Marijt, and L. Hoek. 2015a. Hearing frequencies of a harbor porpoise (*Phocoena phocoena*) temporarily affected by played back offshore pile driving sounds. Journal of Acoustical Society of America 137(2):556-564.

Kastelein, R.A., R. Gransier, J. Schop, and L. Hoek. 2015b. Effects of exposure to intermittent and continuous 6-7 kHz sonar sweeps on harbor porpoise (*Phocoena phocoena*) hearing. Journal of the Acoustical Society of America 137(4):1623-1633. doi: 10.1121/1.4916590].

Kastelein, R.A., L. Helder-Hoek, J. Covi, and R. Gransier. 2016. Pile driving playback sounds and temporary threshold shoft in harbor porpoises (Phocoena phocoena): Effect of exposure duration. Journal of Acoustical Society of America 139(5):2842-2851.

Kastelein, R.A., S. Van de Voorde, and N. Jennings. 2018a. Swimming speed of a harbor porpoise (*Phocoena phocoena*) during playbacks of offshore pile driving sounds. Aquatic Mammals 44(1):92-99. doi: 10.1578/AM.44.1.2018.92.

Kastelein, R.A., L. Helder-Hoek, A. Kommeren, J. Covi, and R. Gransier. 2018b. Effect of pile-driving sounds on harbor seal (*Phoca vitulina*) hearing. Journal of the Acoustical Society of America 143(6):3583-3594. doi: 10.1121/1.5040493.

Kastelein, R.A., L. Helder-Hoek, and R. Gransier. 2019a. Frequency of greatest temporary hearing threshold shift in harbor seals (Phoca vitulina) depends on fatiguing sound level. Journal of Acoustical Society of America 145(3):1353-1362.

Kastelein, R.A., L.A.E. Huijser, S. Cornelisse, L. Helder-Hoek, N. Jennings, and C.A.F. de Jong. 2019b. Effect of pile-driving playback sound level on fish-catching efficiency in harbor porpoises (*Phocoena phocoena*). Aquatic Mammals 45(4):398-410. doi: 10.1578/am.45.4.2019.398.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, A.M. von Benda-Beckmann, F.P.A. Lam, C.A.F. de Jong, and D. Ketten. 2020. Lack of reproducibility of temporary hearing threshold shifts in a harbor porpoise after exposure to repeated airgun sounds. Journal of Acoustical Society of America 148:556-565.

Kastelein, R.A., C.A.F. de Jong, J. Tougaard, L. Helder-Hoek, and L.N. Defillet. 2022. Behavioral responses of a harbor porpoise (*Phocoena phocoena*) depend on the frequency content of pile-driving sounds. Aquatic Mammals 48(2):97-109. doi: 10.1578/am.48.2.2022.97.

Katona, S.K., V. Rough, and D.T. Richardson. 1993. A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland. Fourth edition, revised. Smithsonian Institution Press, Washington, D.C. 316 p.

Kavanagh, A.S., M. Nykanen, W. Hunt, N. Richardson, and M.J. Jessopp. 2019. Seismic surveys reduce cetacean sightings across a large marine ecosystem. Scientific Reports 9:19164. doi: 10.1038/s41598-019-55500-4.

Keenan, S.F., M.C. Benfield, and J.K. Blackburn. 2007. Importance of the artificial light field around offshore petroleum platforms for the associated fish community. Marine Ecology Progress Series 331:219-231.

Kenney, R.D., H.E. Winn, and M.C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979–1989: right whale (*Eubalaena glacialis*). Continental Shelf Research 15(4):385-414. doi: https://doi.org/10.1016/0278-4343(94)00053-P.

Kenney, R.D. and K.J. Vigness-Raposa. 2010. Marine mammals and sea turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby waters: an analysis of existing data for the Rhode Island Ocean Special Area Management Plan. p. 634-970 *In:* Rhode Island Coastal Resources Management Council (ed.). Rhode Island Ocean Special Area Management Plan Volume 2. Appendix A: technical reports for the Rhode Island Ocean Special Area Management Plan.

Ketten, D.R., S. Cramer, J. Arruda, D.C. Mountain, and A. Zosuls. 2014. Inner ear frequency maps: first stage audiograms models for mysticetes. Presented at The 5th International Meeting of Effects of Sound in the Ocean on Marine Mammals (ESOMM 2014), Amsterdam, Netherlands, 7-12 September 2014.

Koschinski, S. 2011. Underwater noise pollution from munitions clearance and disposal, possible effects on marine vertebrates, and its mitigation. Marine Technology Society Journal 45(6):80-88.

Koschinski, S. and K. Ludemann. 2013. Development of Noise Mitigation Measures in Offshore Wind Farm Construction. Commissioned by the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN). Nehmten and Hamburg, Germany. 96 p.

Kraus, S., R.D. Kenney, and L. Thomas. 2019. A Framework for Studying the Effects of Offshore Wind Development on Marine Mammals and Sea Turtles. Boston, MA. 48 p. Massachusetts Clean Energy Center and Bureau of Ocean Energy Management

Kraus, S.D., S. Leiter, K. Stone, B. Wikgren, C. Mayo, P. Hughes, R.D. Kenney, C.W. Clark, A.N. Rice, B. Estabrook, and J. Tielens. 2016. Northeast large pelagic survey collaborative aerial and acoustic surveys for large whales and sea turtles. U.S. Dep. of the Interior, Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2016-054. 117 p. + appx.

Kryter, K.D. 1985. The effects of noise on man.

Küsel, E.T., C. Graupe, T.J. Stephen, C. Lawrence, M.P. Cotter, and D.G. Zeddies. 2023. Underwater sound field verification: Vineyard Wind 1 final report. Document 03233, Version 1.0. Technical report by JASCO Applied Sciences for DEME Group.

LaBrecque, E., C. Curtice, J. Harrison, S.M. Van Parijs, and P.N. Halpin. 2015. 2. Biologically important areas for cetaceans within U.S. waters – east coast region. Aquatic Mammals 41(1):17-29. doi: 10.1578/am.41.1.2015.17.

Lavigueur, L. and M.O. Hammill. 1993. Distribution and seasonal movements of grey seals, *Halichoerus grypus*, born in the Gulf of St. Lawrence and eastern Nova Scotia shore. Canadian Field-Naturalist 107(3):329-340.

Le Prell, C.G., D. Henderson, R.R. Fay, and A. Popper. 2012. Noise induced hearing loss: scientific advances.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic. A guide to their identification. NOAA Technical Report NMFS CIRC 396.

Leopold, M. and K. Camphuysen. 2008. Did the pile driving during the construction of the offshore wind farm Egmond aan Zee, the Netherlands, impact porpoises? Wageningen IMARES Report.

Lesage, V., C. Barrette, M. Kingsley, C. S., and B. Sjare. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada. Marine Mammal Science 15(1):65-84.

Liberman, M.C., M. Epstein, S.S. Cleveland, H. Wang, and S.F. Maison. 2016. Toward a differential diagnosis of hidden hearing loss in humans. PLoS ONE 11(9):E0162726.

Lindeboom, H.J., H.J. Kouwenhoven, M.J.N. Bergman, S. Bouma, S. Brasseur, R. Daan, R.C. Fijn, D. de Haan, S. Dirksen, R. van Hal, R. Hille Ris Lambers, R. ter Hofstede, K.L. Krijgsveld, M. Leopold, and M. Scheidat. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters 6(3):035101. doi: 10.1088/1748-9326/6/3/035101.

Ljungblad, D.K., B. Wursig, S.L. Swartz, and J.M. Keene. 1988. Observations on the behavioral responses of bowhead whale (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. Arcttic 41(3):183-194.

Love, M.S., M.M. Nishimoto, S. Clark, and A.S. Bull. 2015. Analysis of fish populations at platforms off Summerland, California. U.S. Dep. of the Interior, Bureau of Ocean Energy Management Pacific OCS Region, Camarillo, CA. OCS Study 2015-019. 60 p.

Lucke, K., P.A. Lepper, M.-A. Blanchet, and U. Siebert. 2011. The use of an air bubble curtain to reduce the received sound levels for harbor porpoises (Phocoena phocoena). Journal of the Acoustical Society of America 130(5):3406-3412. doi: 10.1121/1.3626123].

Luís, A.R., M.N. Couchinho, and M.E. Santos. 2014. Changes in the acoustic behavior of resident bottlenose dolphins near operating vessels. Marine Mammal Science 30(4):1417-1426. doi: 10.1111/mms.12125.

Madsen, P.T., B. Mohl, B.K. Nielsen, and M. Wahlberg. 2002. Male sperm whale behaviour during exposures to distant seismic survey pulses. Aquatic Mammals 28(3):231-240.

Madsen, P.T., M. Wahlberg, J. Tougaard, K. Lucke, and P. Tyack. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Marine Ecology Progress Series 309:279-295.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. Phase II: January 1984 migration (5586). Cambridge, MA Available online at https://www.boem.gov/BOEMNewsroom/Library/Publications/1983/rpt5586.aspx.

Malme, C.I. and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. Presented at Proceedings of the Workshop on Effects of Explosives Use in the Marine Environment, Halifax, NS.

Malme, C.I., B. Wursig, J.E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 56(1988):393-600. OCS Study MMS 88-0048.

Malme, C.I., B. Wursig, J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. Fairbanks, AK. University of Alaska, Geophysical Institute.

Mansfield, A.W. 1966. The grey seal in eastern Canadian waters. Can. Audubon Mag. 28:161-166.

Martins, D.T.L., M.R. Rossi-Santos, and F.J.D. Lima Silva. 2016. Effects of anthropogenic noise on the acoustic behaviour of *Sotalia guianensis* (Van Bénéden, 1864) in Pipa, North-eastern Brazil. Journal of the Marine Biological Association of the United Kingdom 98(2):215-222. doi: 10.1017/S0025315416001338.

Matthews, L.P. 2017. Harbor seal (Phoca vitulina) reproductive advertisement behavior and the effects of vessel noise. Syracuse University. 139 p.

Mayo, C.A. and M.K. Marx. 1990. Surface foraging behaviour of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. Canadian Journal of Zoology 68:2214-2220.

Mayo, C.A., L. Ganley, C. Hudak, A, S. Brault, M. Marx, K, E. Burke, and M.W. Brown. 2018. Distribution, demography, and behavior of North Atlantic right whales (*Eubalaena glacialis*) in Cape Cod Bay, Massachusetts, 1998–2013. Marine Mammal Science 0(0). doi: 10.1111/mms.12511.

McCauley, R., J. Fewtrell, A. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, and K.A. McCabe. 2000. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid (R99-15). Western Australia. Available online at http://cmst.curtin.edu.au/publications/.

McCauley, R. 2003. High intensity anthropogenic sound damages fish ears. Journal of Acoustical Society of America 113(638). doi: 10.1121/1.1527962.

McCauley, R.D., M.N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise. Preliminary results of observations about a working seismic vessel and experimental exposures. The APPEA Journal 38(1):692-707.

McConnell, A., R. Routledge, and B.M. Connors. 2010. Effect of artificial light on marine invertebrate and fish abundance in an area of salmon farming. Marine Ecology Progress Series 419:147-156. doi: 10.3354/meps08822.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. Journal of the Acoustical Society of America 98(2 Pt. 1):712-721.

McKenna, M.F. 2011. Blue whale response to underwater noise from commerical ships. University of California, San Diego.

Melcón, M.L., A.J. Cummins, S.M. Kerosky, L.K. Roche, S.M. Wiggins, and J.A. Hildebrand. 2012. Blue whales respond to anthropogenic noise. PLoS One 7(2):e32681. doi: 10.1371/journal.pone.0032681.

Meyer-Gutbrod, E.L., C.H. Greene, K. Davies, and G.J. David. 2021. Ocean regime shift is driving collapse of the North Atlantic right whale population. Oceanography 34(3):22-31. doi: 10.5670/oceanog.2021.308.

Mikkelsen, L., K.N. Mouritsen, K. Dahl, J. Teilmann, and J. Tougaard. 2013. Re-established stony reef attracts harbour propoises Phocoena phocoena. Marine Ecology Progress Series 481:239-248.

Miller, B., R.E. Elliott, W.R. Koski, V.D. Moulton, and W.J. Richardson. 1999. Whales In W. J. Richardson (Ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. 5-1 to 5-109 p.

Miller, B., V.D. Moulton, A.R. Davis, M. Holst, P. Millman, A. MacGillivray, and D.E. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Columbus, OH. 511-542 p.

Møhl, B. and S. Andersen. 1973. Echolocation: High-frequency component in the click frequency of the harbour porpoise (Phocoena phocoena L.). Journal of the Acoustical Society of America 54:1368-1372.

Moulton, V.D. and M. Holst. 2010. Effects of seismic survey sound on cetaceans in the Northwest Atlantic. St. John's, Canada. 28 p. Natural Resources Canada.

Nachtigall, P.E., W. Au, J. Pawloski, and P.W.B. Moore. 1995. Risso’s dolphin (*Grampus griseus*) hearing thresholds in Kaneohe Bay, Hawaii. p. 49-53 *In:* R.A. Kastelein, J.A. Thomas, and P.E. Nachtigall (eds.). Sensory systems of aquatic mammals.

Nachtigall, P.E., M.M.L. Yuen, T.A. Mooney, and K.A. Taylor. 2005. Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. Journal of Experimental Biology 208(21):4181-4188. doi: 10.1242/jeb.01876.

Nachtigall, P.E. and A.Y. Supin. 2014. Conditioned hearing sensitivity reduction in a bottlenose dolphin (*Tursiops truncatus*). The Journal of Experimental Biology 217:2806-2813. doi: 10.1242/jeb.104091.

Nachtigall, P.E. and A.Y. Supin. 2015. Conditioned frequency-dependent hearing sensitivity reduction in the bottlenose dolphin (Tursiops truncatus). The Journal of Experimental Biology 218:999-1005. doi: 10.1242/jeb.114066.

Nachtigall, P.E., A.Y. Supin, J.-A. Estaban, and A.F. Pacini. 2016. Learning and extinction of conditioned hearing sensation change in the beluga whale (Delphinapterus leucas). Journal of Comparative Physiology A 202(2):105-113.

Nachtigall, P.E., A.Y. Supin, A.F. Pacini, and R.A. Kastelein. 2018. Four odontocete species change hearing levels when warned of impending loud sound. Integrative Zoology 13(2):160-165.

Nedwell, J.R., S.J. Parvin, B. Edwards, R. Workman, A.G. Brooker, and J.E. Kynoch. 2007. Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters. Newbury, UK. Report prepared by Subacoustech for COWRIE Ltd.

Nehls, G., A. Rose, A. Diederichs, M.A. Bellmann, and H. Pehlke. 2016. Noise Mitigation During Pile Driving Efficiently Reduces Disturbance of Marine Mammals. p. 755-762 The Effects of Noise on Aquatic Life II, vol. 875, Springer, NY.

New, L.F., J. Harwood, L. Thomas, C. Donovan, J.S. Clark, G. Hastie, P.M. Thompson, B. Cheney, L. Scott-Hayward, and D. Lusseau. 2013. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. Functional Ecology 27(2):314-322. doi: 10.1111/1365-2435.12052.

Nieukirk, S.L., D.K. Mellinger, J. Hildebrand, M.A. McDonald, and R.P. Dziak. 2005. Downward shift in the frequency of blue whale vocalizations. Presented at Abstracts of the 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

Nieukirk, S.L., D.K. Mellinger, S.E. Moore, K. Klinck, R.P. Dziak, and J. Goslin. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999-2009. Journal of the Acoustical Society of America 131(2):1102-1112. doi: 10.1121/1.3672648.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Rev. 37(2):81-115.

O'Brien, M., S.E. Beck, S. Berrow, M. Andre, M. Van der Schaar, I. O'Connor, and E.P. McKeown. 2016. The Use of Deep Water Berths and the Effect of Noise on Bottlenose Dolphins in the Shannon Estuary cSAC, New York, NY.

O'Brien, O., K. McKenna, B. Hodge, D. Pendleton, M. Baumgartner, and J. Redfern. 2020. Megafauna aerial surveys in the wind energy areas of Massachusetts and Rhode Island with emphasis on large whales: summary report campaign 5, 2018-2019. U.S. Dep. of the Interior Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2021-033.

O'Brien, O., K. McKenna, D. Pendleton, and J. Redfern. 2021. Megafauna aerial surveys in the wind energy areas of Massachusetts and Rhode Island with emphasis on large whales: interim report campaign 6A, 2020. U.S. Dep. of the Interior Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2021-054.

O'Brien, O., K. McKenna, D. Pendleton, and J. Redfern. 2022. Megafauna aerial surveys in the wind energy areas of Massachusetts and Rhode Island with emphasis on large whales: final report campaign 6B, 2020-2021. Massachusetts Clean Energy Center, Boston, MA.

O'Brien, O., K. McKenna, S. Hsu, D. Pendleton, L. Ganley, and J. Redfern. 2023. Megafauna aerial surveys in the wind energy areas of southern New England with emphasis on large whales: final report campaign 7, 2022. Bureau of Ocean Energy Management and Massachusetts Clean Energy Center, Boston, MA. OCS Study BOEM 2023-061.

Pace, R.M., III, R. Williams, S.D. Kraus, A.R. Knowlton, and H.M. Pettis. 2021. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice 3(2):e346. doi: https://doi.org/10.1111/csp2.346.

Pacini, A.F., P.E. Nachtigall, L.N. Kloepper, M. Linnenschmidt, A. Sogorb, and S. Matias. 2010. Audiogram of a formerly stranded long-finned pilot whale (*Globicephala melas*) measured using auditory evoked potentials. Journal of Experimental Biology 213(Pt 18):3138-3143. doi: 10.1242/jeb.044636.

Page, H.M., J.E. Dugan, C.S. Culver, and J.C. Hoesterey. 2006. Exotic invertebrate species on offshore oil platforms. Marine Ecology Progress Series 325:101-107.

Paiva, E., C. Salgado Kent, M. Gagnon, R. McCauley, and H. Finn. 2015. Reduced detection of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in an inner harbour channel during pile driving activities. Aquatic Mammals 41:455-468. doi: 10.1578/AM.41.4.2015.455.

Palka, D., L. Aichinger Dias, E. Broughton, S. Chavez-Rosales, D. Cholewiak, G. Davis, A. DeAngelis, L. Garrison, H. Haas, J. Hatch, K. Hyde, M. Jech, E. Josephson, L. Mueller-Brennan, C. Orphanides, N. Pegg, C. Sasso, D. Sigourney, M. Soldevilla, and H. Walsh. 2021. Atlantic Marine Assessment Program for Protected Species: FY15 – FY19. Washington DC: US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-051. 330 p.

Palka, D.L., S. Chavez-Rosales, E. Josephson, D. Cholewiak, H.L. Haas, L. Garrison, M. Jones, D. Sigourney, G. Waring, M. Jech, E. Broughton, M. Soldevilla, G. Davis, A. DeAngelis, C.R. Sasso, M.V. Winton, R.J. Smolowitz, G. Fay, E. LaBrecque, J.B. Leiness, Dettloff, M. Warden, K. Murray, and C. Orphanides. 2017. Atlantic Marine Assessment Program for Protected Species: 2010-2014. U.S. Dep. of the Interior, Bureau of Ocean Energy Management Atlantic OCS Region, Washington, D.C. OCS Study BOEM 2017-071. 211 p.

Papale, E., M. Gamba, M. Perez-Gil, V.M. Martin, and C. Giacoma. 2015. Dolphins adjust species-specific frequency parameters to compensate for increasing background noise. PLoS One 10(4):e0121711. doi: 10.1371/journal.pone.0121711.

Parks, S., K. Groch, P.A.C. Flores, R.S. Sousa-Lima, and I. Urazghildiiev. 2016. Humans, Fish, and Whales: How Right Whales Modify Calling Behavior in Response to Shifting Background Noise Conditions, New York, NY.

Parks, S.E., D.R. Ketten, J.T. O'Malley, and J. Arruda. 2007. Anatomical predictions of hearing in the North Atlantic right whale. The Anatomical Record 290:734-744. doi: 10.1002/ar.20527.

Parks, S.E., I. Urazghildiiev, and C.W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustical Society of America 125(2):1230-1239. doi: 10.1121/1.3050282.

Parks, S.E., D.N. Wiley, M.T. Weinrich, and A. Bocconcelli. 2010. Behavioral differences affect passive acoustic detectability of foraging North Atlantic right and humpback whales. Journal of the Acoustical Society of America 128(4):2483. doi: 10.1121/1.3508908.

Parks, S.E., J.D. Warren, K. Stamieszkin, C.A. Mayo, and D.N. Wiley. 2012. Dangerous dining: surface foraging of North Atlantic right whales increases risk of vessel collisions. Biology Letters 8:57-60. doi: 10.1098/rsbl.2011.0578.

Parks, S.E., D.A. Cusano, S.M. Van Parijs, and D.P. Nowacek. 2019. Acoustic crypsis in communication by North Atlantic right whale mother-calf pairs on the calving grounds. Biology Letters 15(10):20190485. doi: 10.1098/rsbl.2019.0485.

Payne, P.M., L.A. Selzer, and A.R. Knowlton. 1984. Distribution and density of cetaceans, marine turtles and seabirds in the shelf waters of the northeast U.S., June 1980–Dec. 1983, based on shipboard observations. National Marine Fisheries Service, Woods Hole, MA. NA81FAC00023:245.

Payne, P.M. and L.A. Selzer. 1989. The distribution, abundance and selected prey of the harbor seal, *Phoca vitulina*, in southern New England. Marine Mammal Science 5(2):173-192. doi: https://doi.org/10.1111/j.1748-7692.1989.tb00331.x.

Perrin, W.F. 2018. Common dolphin *Delphinus delphis*. p. 205-209 *In:* B. Wursig, J.G.M. Thewissen, and K.M. Kovacs (eds.). Encyclopedia of marine mammals, 3rd edition. Academic Press, San Diego, CA.

Petersen, J.K. and T. Malm. 2006. Offshore windmill farms: threats to or possibilities for the marine environment. A Journal of the Human Environment 35(2):75-80.

Potter, J.R., M. Thillet, C. Douglas, M.A. Chitre, Z. Doborzynski, and P.J. Seekings. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32(2):469-483.

Pyć, C., D. Zeddies, S. Denes, and M. Weirathmueller. 2018. Appendix III-M: REVISED DRAFT - supplemental information for the assessment of potential acoustic and non-acoustic impact producing factors on marine fauna during construction of the Vineyard Wind Project. Document 001639, Version 3.1. Technical report by JASCO Applied Sciences (USA) Inc. for Vineyard Wind.

Quintana-Rizzo, E., S. Leiter, T.V.N. Cole, M.N. Hagbloom, A.R. Knowlton, P. Nagelkirk, O. O□Brien, C.B. Khan, A.G. Henry, P.A. Duley, L.M. Crowe, C.A. Mayo, and S.D. Kraus. 2021. Residency, demographics, and movement patterns of North Atlantic right whales *Eubalaena glacialis* in an offshore wind energy development area in southern New England, USA. Endangered Species Research 45:251-268.

Rankin, S. and J. Barlow. 2005. Source of the North Pacific "boing" sound attributed to minke whales. Journal of the Acoustical Society of America 118(5):3346-3351. doi: 10.1121/1.2046747.

Record, N.R., J.A. Runge, D.E. Pendleton, W.M. Balch, K.T.A. Davies, A.J. Pershing, C.L. Johnson, K. Stamieszkin, R. Ji, Z. Feng, S.D. Kraus, R.D. Kenney, C.A. Hudak, C.A. Mayo, C. Chen, J.E. Salisbury, and C.R.S. Thompson. 2019. Rapid climate-driven circulation changes threaten conservation of endangered North Atlantic right whales. Oceanography 32(2). doi: 10.5670/oceanog.2019.201.

Reeves, R.R., B.S. Stewart, and S. Leatherwood. 1992. The Sierrra Club handbook of seals and sirenians. Sierra Club Books, San Francisco, CA. 358 p.

Reeves, R.R. and H. Whitehead. 1997. Status of the sperm whale, Physeter macrocephalus, in Canada. Canadian Field-Naturalist 111(2):293-307.

Reeves, R.R. and A.J. Read. 2003. Bottlenose dolphin, harbor porpoise, sperm whale and other toothed cetaceans. p. 397-424 *In:* G.A. Feldhammer, B.C. Thompson, and J.A. Chapman (eds.). Wild mammals of North America: Biology, Management, and Conservation, 2nd edition edition. The Johns Hopkins Press, Baltimore, MD.

Reichmuth, C., A. Ghoul, and J.M. Sills. 2016. Low-frequency temporary threshold shift not observed in spotted or ringed seals exposed to single air gun impulses. Journal of the Acoustical Society of America 140(4):2646-2658. doi: http://dx.doi.org/10.1121/1.4964470.

Rice, A.N., K.J. Palmer, J.T. Tielens, C.A. Muirhead, and C.W. Clark. 2014. Potential Bryde's whale (*Balaenoptera edeni*) calls recorded in the northern Gulf of Mexico. Journal of the Acoustical Society of America 135(5):3066-3076. doi: 10.1121/1.4870057].

Richardson, W.J., B. Wursig, and C.R.J. Green. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4):1117-1128.

Richardson, W.J. and C.I. Malme. 1993. Man-made noise and behavioral responses. Society for Marine Mammalogy:631-700.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA. 576 p.

Richardson, W.J., G.W. Miller, and C.R. Greene, Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea [abstract]. Journal of the Acoustical Society of America 106:2281. doi: 10.1121/1.427801.

Risch, D., P.J. Corkeron, W.T. Ellison, and S.M. Van Parijs. 2012. Changes in humpback whale song occurrence in response to an acoustic source 200 km away. PLoS One 7(1):e29741. doi: 10.1371/journal.pone.0029741.

Risch, D., U. Siebert, and S.M. Van Parijs. 2014. Individual calling behaviour and movements of North Atlantic minke whales (*Balaenoptera acutorostrata*). Behaviour 151(9):1335-1360.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, C.B. Khan, W.A. McLellan, D.A. Pabst, and G.G. Lockhart. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6:22615. doi: 10.1038/srep22615.

Roberts, J.J., T.M. Yack, and P.N. Halpin. 2022. Habitat-based marine mammal density models for the U.S. Atlantic. Version June 20, 2022. Available from https://seamap.env.duke.edu/models/Duke/EC/.

Roberts, J.J., T.M. Yack, and P.N. Halpin. 2023. Marine mammal density models for the U.S. Navy Atlantic Fleet Training and Testing (AFTT) study area for the Phase IV Navy Marine Species Density Database (NMSDD). Document version 1.3. Report prepared for Naval Facilities Engineering Systems Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, NC.

Rone, B.K. and I.I.I.R.M. Pace. 2012. A simple photograph-based approach for discriminating between free-ranging long-finned (*Globicephala melas*) and short-finned (*G. macrorhynchus*) pilot whales off the east coast of the United States. Marine Mammal Science 28(2):254-275. doi: https://doi.org/10.1111/j.1748-7692.2011.00488.x.

Rosel, P.E., L. Hansen, and A.A. Hohn. 2009. Restricted dispersal in a continuously distributed marine species: common bottlenose dolphins *Tursiops truncatus* in coastal waters of the western North Atlantic. Molecular Ecology 18(24):5030-5045. doi: 10.1111/j.1365-294X.2009.04413.x.

RPS. 2022. Vineyard Wind 1 HRG surveys 2021 protected species observer report. Prepared by RPS, Boston, MA for Vineyard Wind 1 LLC.

Russell, D.J.F., S.M.J.M. Brasseur, D. Thompson, G.D. Hastie, V.M. Janik, G. Aarts, B.T. McClintock, J. Matthiopoulos, S.E.W. Moss, and B. McConnell. 2014. Marine mammals trace anthropogenic structures at sea. Current Biology 24(14):R638-R639. doi: 10.1016/j.cub.2014.06.033.

Russell, D.J.F., G. Hastie, D. Thompson, V.M. Janik, P. Hammond, L. Scott-Hayward, J. Matthiopoulos, E.L. Jones, and B.J. McConnell. 2016. Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology 53(6):1642-1652.

Rustemeier, J., T. Grießmann, and R. Rolfes. 2012. Underwater sound mitigation of bubble curtains with different bubble size distributions. Acoustical Society of America 17(1):070055.

Sairanen, E.E. Baltic Sea underwater soundscape: Weather and ship induced sounds and the effect of shipping on harbor porpoise (Phocoena phocoena) activity. (M.Sc.). University of Helsinki, Finland. p. Available online at https://helda.helsinki.fi/bitstream/handle/10138/153043/Gradu_SairanenEeva(1).pdf?sequence=1.

Sammarco, P.W., S.A. Porter, and C.S. D. 2010. A new coral species introduced into the Atlantic Ocean - *Tubastraea micranthus* (Ehrenberg 1834) (Cnidaria, Anthozoa, Scleractinia): An invasive threat? Aquatic Invasions 5(2):131-140.

Schaffeld, T., J.G. Schnitzler, A. Ruser, B. Woelfing, J. Baltzer, and U. Siebert. 2020. Effects of multiple exposures to pile driving noise on harbor porpoise hearing during simulated flights—An evaluation tool. The Journal of the Acoustical Society of America 147(2):685-697. doi: 10.1121/10.0000595.

Scheidat, M., J. Tougaard, S. Brasseur, J. Carstensen, T. van Polanen Petel, J. Teilmann, and P. Reijnders. 2011. Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. Environmental Research Letters 6(2):025102. doi: 10.1088/1748-9326/6/2/025102.

Scheifele, P.M., S. Andrew, R.A. Cooper, M. Darre, F.E. Musiek, and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. Journal of the Acoustical Society of America 117(3):1486-1492. doi: 10.1121/1.1835508.

Schusterman, R.J., R.F. Balliet, and S. St. John. 1970. Vocal displays under water by the gray seal, the harbor seal, and the stellar sea lion. Psychonomic Science 18(5):303-305.

Sciacca, V., S. Viola, S. Pulvirenti, G. Riccobene, F. Caruso, E. De Domenico, and G. Pavan. 2016. Shipping noise and seismic airgun surveys in the Ionian Sea: potential impact on Mediterranean fin whale. Presented at The Effects of Noise on Aquatic Life, Dublin, Ireland, 10-16 July 2016.

Sergeant, D.E., A.W. Mansfield, and B. Beck. 1970. Inshore records of cetacea for eastern Canada, 1949–68. Journal of the Fisheries Research Board of Canada 27(11):1903-1915. doi: 10.1139/f70-216.

Sills, J.M., B.L. Southall, and C. Reichmuth. 2017. The influence of temporally varying noise from seismic air guns on the detection of underwater sounds by seals. Journal of the Acoustical Society of America 141(2):996-1008. doi: 10.1121/1.4976079].

Simard, Y., N. Roy, S. Giard, and F. Aulanier. 2019. North Atlantic right whale shift to the Gulf of St. Lawrence in 2015, revealed by long-term passive acoustics. Endangered Species Research 40:271-284.

Skeate, E.R., M.R. Perrow, and J.J. Gilroy. 2012. Likely effects of construction of Scroby Sands offshore wind farm on a mixed population of harbour *Phoca vitulina* and grey *Halichoerus grypus* seals. Marine Pollution Bulletin 64(4):872-881. doi: https://doi.org/10.1016/j.marpolbul.2012.01.029.

Smultea, M., M. Holst, W.R. Koski, and S. Stoltz Roi. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory’s seismic program in the southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004 TA2822-26).

Snyder, B. and M.J. Kaiser. 2009. Ecological and economic cost-benefit analysis of offshore wind energy. Renewable Energy 34(6):1567-1578. doi: https://doi.org/10.1016/j.renene.2008.11.015.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R.J. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33(4):411-522. doi: 10.1578/AM.33.4.2007.415.

Southall, B.L., D.P. Nowaceck, P.J.O. Miller, and P.L. Tyack. 2016. Experimental field studies to measure behavioral responses of cetaceans to sonar. Endangered Species Research 31:293-315.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. Aquatic Mammals 45(2):125-232. doi: 10.1578/am.45.2.2019.125.

Spalding, M.D., H.E. Fox, G.R. Allen, N. Davidson, Z.A. Ferdaña, M. Finlayson, B.S. Halpern, M.A. Jorge, A. Lombana, S.A. Lourie, K.D. Martin, E. McManus, J. Molnar, C.A. Recchia, and J. Robertson. 2007. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. BioScience 57(7):573-583. doi: 10.1641/B570707.

Stöber, U. and F. Thomsen. 2019. Effects of impact pile driving noise on marine mammals: A comparison of diferent noise exposure criteria. Acoustical Society of America 145(3252). doi: 10.1121/1.5109387.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management 8(3):255-263.

Stone, C.J. 2015. Marine mammal observations during seismic surveys from 1994-2010. Joint Nature Conservation Committee, Peterborough, UK. JNCC Report No. 463a. 64 p.

Supin, A.Y., V.V. Popov, D.I. Nechaev, E.V. Sysueva, and V.V. Rozhnov. 2016. Is sound exposure level a convenient metric to characterize fatiguing sounds? A study in beluga whales. p. 1123-1129 *In:* A. Popper and A. Hawkins (eds.). The effects on noise on aquatic life II. Springer, New York, NY.

Teilmann, J., M. Miller, R.A. Kirkrterp, R.A. Kastelein, B.K. Madsen, B.K. Nielsen, and W.L. Au. 2002. Characteristics of echolocation signals used by a harbour porpoise (Phocoena phocoena) in a target detection experiment. Aquatic Mammals 28:275-284.

Teilmann, J., J. Tougaard, and J. Carstensen. 2006. Summary on harbour porpoise monitoring 1999-2006 around Nysted and Horns Rev Offshore Wind Farms. Energi E2 A/S and Vattenfall A/S.

Teilmann, J. and J. Carstensen. 2012. Negative long term effects on harbour porpoises from a large scale offshore wind farm in the Baltic—evidence of slow recovery. Environmental Research Letters 7(4):045101. doi: 10.1088/1748-9326/7/4/045101.

Temte, J.L. 1994. Photoperiod control of birth timing in the harbour seal (*Phoca vitulina*). Journal of Zoology 233(3):369-384.

Tennessen, J.B. and S.E. Parks. 2016. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. Endangered Species Research 30:225-237. doi: 10.3354/esr00738.

Thode, A.M., K.H. Kim, S.B. Blackwell, C.R. Greene, C.S. Nations, T.L. McDonald, and A.M. Macrander. 2012. Automated detection and localization of bowhead whale sounds in the presence of seismic airgun surveys. Journal of the Acoustical Society of America 131(5):3726-3747. doi: 10.1121/1.3699247.

Thompson, P.M., D. Lusseau, T.R. Barton, D. Simmons, J. Rusin, and H. Bailey. 2010. Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin 60:1200-1208.

Thompson, P.M., G.D. Hastie, J. Nedwell, R. Barham, K.L. Brookes, L.S. Cordes, H. Bailey, and N. McLean. 2013. Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. Environmental Impact Assessment Review 43:73-85. doi: 10.1016/j.eiar.2013.06.005.

Thompson, P.M., I.M. Graham, B.J. Cheney, T.R. Barton, A. Farcas, and N.D. Merchant. 2020. Balancing risks of injury and disturbance to marine mammals when pile driving at offshore windfarms. British Ecological Society.

Thompson, P.O., W.C. Cummings, and S.J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

Todd, V.L.G., P. Lepper, and I.B. Todd. 2007. Do porpoises target offshore installations as feeding stations? Presented at Improving Environmental Performance: A Challenge for the Oil Industry, Amsterdam, the Netherlands.

Tollit, D.J., S.P.R. Greenstreet, and P.M. Thompson. 1997. Prey selection by harbour seals, *Phoca vitulina*, in relation to variations in prey abundance. Canadian Journal of Zoology 75:1508-1518.

Tougaard, J., J. Carstensen, O.D. Henriksen, H. Skov, and J. Teilmann. 2003. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef. Hedeselskabet, Roskilde.

Tougaard, J., J. Carstensen, H. Skov, and J. Teilmann. 2005. Behavioral reactions of harbour porpoises to underwater noise from pile drivings. Presented at 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

Tougaard, J., S. Tougaard, R.C. Jensen, T. Jensen, J. Teilmann, D. Adelung, N. Liebsch, and G. Muller. 2006. Harbour seals on Horns Reef before, during and after construction of Horns Rev Offshore wind farm. Esbierg, Denmark. Vattenfall A/S.

Tougaard, J., P.T. Madsen, and M. Wahlberg. 2008. Underwater noise from construction and operation of offshore wind farms. Bioacoustics 17:143-146.

Tougaard, J., J. Carstensen, J. Teilmann, H. Skov, and P. Rasmussen. 2009a. Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.)). Journal of the Acoustical Society of America 126(1):11-14. doi: 10.1121/1.3132523.

Tougaard, J., O.D. Henriksen, and L.A. Miller. 2009b. Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbor porpoises and harbor seals. Journal of the Acoustical Society of America 125(6):3766-3773. doi: 10.1121/1.3117444.

Tougaard, J., A.J. Wright, and P.T. Madsen. 2015. Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises. Marine Pollution Bulletin 90:196-208. doi: 10.1016/j.marpolbul.2014.10.051.

Tougaard, J., A.J. Wright, and P.T. Madsen. 2016. Noise Exposure Criteria for Harbor Porpoises. The Effects of Noise on Aquatic Life 2:1167-1173.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking Responses of Sperm Whales to Experimental Exposures of Airguns. G.o.M.O.R. U.S. Dept. of the Interior, New Orleans.

Tyack, P. and V.M. Janik. 2013. Effects of Noise on Acoustic Signal Production in Marine Mammals. In H. Brumm (Ed.),. Animal Communication and Noise:251-271.

Vallejo, G.C., K. Grellier, E.J. Nelson, R.M. McGregor, S.J. Canning, F.M. Caryl, and N. McLean. 2017. Responses of two marine top predators to an offshore wind farm. Ecology and evolution 7(21):8698-8708. doi: 10.1002/ece3.3389.

Van Parijs, S.M., P.J. Corkeron, J. Harvey, S.A. Hayes, D.K. Mellinger, P.A. Rouget, P.M. Thompson, M. Wahlberg, and K.M. Kovacs. 2003. Patterns in the vocalizations of male harbor seals. Journal of the Acoustical Society of America 113(6):3403-3410. doi: 10.1121/1.1568943.

Villadsgaard, A., M. Wahlberg, and J. Tougaard. 2007. Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. Journal of Experimental Biology 210(1):56-64. doi: 10.1242/jeb.02618.

Vineyard Wind. 2018. Final report of G&G survey activities and observations of protected species. Vineyard Wind Project. December 7, 2018. Submitted to Bureau of Ocean Energy Management, Sterling, VA. Prepared by Epsilon Associates, Inc., Maynard, MA for Vineyard Wind LLC, New Bedford, MA.

Vineyard Wind. 2019. Final report of G&G survey activities and observations of protected species. Vineyard Wind Project. March 7, 2019. Submitted to Bureau of Ocean Energy Management, Sterling, VA. Prepared by Geo SubSea LLC, Middletown, CT for Vineyard Wind LLC, New Bedford, MA.

Vineyard Wind. 2020. Draft construction and operations plan. Vineyard Wind Project. September 30, 2020. Submitted to Bureau of Ocean Energy Management. Prepared by Epsilon Associates, Inc., Maynard, MA. Vineyard WInd LLC, New Bedford, MA. Available online at https://www.boem.gov/renewable-energy/state-activities/vineyard-wind-1.

Vineyard Wind. 2023a. Vineyard Wind 1, LLC – monthly project activities report. Vineyard Wind 1 Project. August 2023.

Vineyard Wind. 2023b. Vineyard Wind 1, LLC – monthly project activities report. Vineyard Wind 1 Project. December 2023.

Vineyard Wind. 2023c. Vineyard Wind 1, LLC – monthly project activities report. Vineyard Wind 1 Project. June 2023.

Vineyard Wind. 2023d. Vineyard Wind 1, LLC – monthly Project Activities Report. Vineyard WInd 1 Project. July 2023.

Vineyard Wind. 2023e. Vineyard Wind 1, LLC – monthly project activities report. Vineyard Wind 1 Project. September 2023.

Vineyard Wind. 2023f. Vineyard Wind 1, LLC – monthly project activities report. Vineyard Wind 1 Project. October 2023.

Wang, Z.-T., P.E. Nachtigall, T. Akamatsu, K.-X. Wang, Y.-P. Wu, J.-C. Liu, G.-Q. Duan, H.-J. Cao, and D. Wang. 2015. Passive acoustic monitoring the diel, lunar, seasonal and tidal patterns in the biosonar activity of the Indo-Pacific humpback dolphins (*Sousa chinensis*) in the Pearl River Estuary, China. PLoS One 10(11):e0141807. doi: 10.1371/journal.pone.0141807.

Watkins, W.A., J.E. George, M.A. Daher, K. Mullin, D.L. Martin, S.H. Haga, and N.A. DiMarzio. 2000. Whale call data for the North Pacific, November 1995 through July 1999. Occurrence of calling whales and source locations from SOSUS and other acoustic systems. Woods Hole Oceanog. Inst. Tech. Rep. WHOI-00-02. 156 p.

Weilgart, L. 2014. Are We Mitigating Underwater-Noise Producing Activities Adequately?: A Comparision of Level A and Level B Cetacean Takes. p.

Weir, C.R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. Aquatic Mammals 34(1):71-83. doi: 10.1578/am.34.1.2008.71.

Wensveen, P.J., A.M. von Benda-Beckmann, M.A. Ainslie, F.-P.A. Lam, P.H. Kvadsheim, P.L. Tyack, and P.J.O. Miller. 2015. How effectively do horizontal and vertical response strategies of long-finned pilot whales reduce sound exposure from naval sonar? Marine Environmental Research 106:68-81. doi: https://doi.org/10.1016/j.marenvres.2015.02.005.

Whitehead, H. 2003. Sperm whales: social evolution in the ocean. University of Chicago Press, Chicago, IL. 431 p.

Whitehead, H. 2018. Sperm whale *Physeter macroephalus*. p. 919-925 *In:* B. Wursig, J.G.M. Thewissen, and K.M. Kovacs (eds.). Encyclopedia of Marine Mammals, 3rd edition. Academic Press, San Diego, CA.

Whitt, A.D., K. Dudzinski, and J.R. Laliberté. 2013. North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA, and implications for management. Endangered Species Research 20(1):59-69. doi: 10.3354/esr00486.

Whyte, k.f., D.J.F. Russell, C. Sparling, B. Binnerts, and G. Hastie. 2020. Estimating the effects of pile driving sounds on seals: pitfalls and possibilities. Journal of Acoustical Society of America 147(6):3948-3958.

Wilhelmsson, D., T. Malm, and M.C. Ohman. 2006. The influence of offshore windpower on demersal fish. ICES Journal of Marine Science 63(5):775-784. doi: 10.1016/j.icesjms.2006.02.001.

Wittekind, D., J. Tougaard, P. Stilz, M. Dahne, K. Lucke, C.W. Clark, A.M. von Benda-Beckmann, M.A. Ainslie, and U. Siebert. 2016. Development of a model to assess masking potential for marine mammals by the use of airguns in Antarctic waters. *In:* A. Popper and A. Hawkins (eds.). The effects of noise on aquatic life II. Springer, New York, NY.

Würsig, B. and C.R. Green, Jr. 2002. Underwater sounds near a fuel receiving facility in western Hong Kong: relevance to dolphins. Marine Environmental Research 54:129-145.