

DEPARTMENT OF COMMERCE**National Oceanic and Atmospheric Administration**

[RTID 0648-XA661]

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Construction of the South Fork Offshore Wind Project

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed incidental harassment authorization; request for comments on proposed authorization and possible renewal.

SUMMARY: NMFS has received a request from South Fork Wind, LLC (South Fork Wind) to take marine mammals incidental to construction of a commercial wind energy project southeast of Rhode Island, within the Rhode Island-Massachusetts Wind Energy Area (RI/MA WEA). Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an incidental harassment authorization (IHA) to incidentally take marine mammals during the specified activities. NMFS is also requesting comments on a possible one-time, one-year renewal that could be issued under certain circumstances and if all requirements are met, as described in Request for Public Comments at the end of this notice. NMFS will consider public comments prior to making any final decision on the issuance of the requested MMPA authorizations and agency responses will be summarized in the final notice of our decision.

DATES: Comments and information must be received no later than March 10, 2021.

ADDRESSES: Comments should be addressed to Jolie Harrison, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service and should be sent to ITP.Esch@noaa.gov.

Instructions: NMFS is not responsible for comments sent by any other method, to any other address or individual, or received after the end of the comment period. Comments, including all attachments, must not exceed a 25-megabyte file size. Attachments to comments will be accepted in Microsoft Word or Excel or Adobe PDF file formats only. All comments received are a part of the public record and will generally be posted online at www.fisheries.noaa.gov/permit/

incidental-take-authorizations-under-marine-mammal-protection-act without change. All personal identifying information (e.g., name, address) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT:

Carter Esch, Office of Protected Resources, NMFS, (301) 427-8421. Electronic copies of the application and supporting documents, as well as a list of the references cited in this document, may be obtained online at: www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act. In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:**Background**

The MMPA prohibits the “take” of marine mammals, with certain exceptions. Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq.*) direct the Secretary of Commerce (as delegated to NMFS) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed incidental take authorization may be provided to the public for review.

Authorization for incidental takings shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses (where relevant). Further, NMFS must prescribe the permissible methods of taking and other “means of effecting the least practicable adverse impact” on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stocks for taking for certain subsistence uses (referred to in shorthand as “mitigation”); and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth.

The definitions of all applicable MMPA statutory terms cited above are included in the relevant sections below.

National Environmental Policy Act

To comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) and NOAA Administrative Order (NAO) 216-6A, NMFS must review our proposed action (*i.e.*, the issuance of an incidental harassment authorization) with respect to potential impacts on the human environment. In compliance with NEPA, as implemented by the regulations published by the Council on Environmental Quality (40 CFR parts 1500-1508 (1978)), the Bureau of Ocean Energy Management (BOEM) prepared an Environmental Impact Statement (EIS) to consider the direct, indirect and cumulative effects to the human environment resulting from the South Fork Wind project. NMFS is a cooperating agency on BOEM’s EIS. Accordingly, NMFS plans to adopt the Bureau of Ocean Energy Management’s (BOEM) Environmental Impact Statement (EIS), provided our independent evaluation of the document finds that it includes adequate information analyzing the effects of the proposed IHA issuance on the human environment. BOEM’s draft EIS was made available for public comment from January 8, 2021 to February 22, 2021 and is available at: www.boem.gov/South-Fork-Wind.

NMFS will review all comments submitted in response to this notice prior to concluding our NEPA process or making a final decision on the IHA request.

This project is covered under Title 41 of the Fixing America’s Surface Transportation Act, or “FAST-41.” FAST-41 includes a suite of provisions designed to expedite the environmental review for covered infrastructure projects, including enhanced interagency coordination as well as milestone tracking on the public-facing Permitting Dashboard. The dashboard for this project is available at <https://www.permits.performance.gov/permitting-projects/south-fork-wind-farm-and-south-fork-export-cable>.

Summary of Request

On March 15, 2019, NMFS received a request from South Fork Wind for an IHA to take marine mammals incidental to construction of an offshore wind energy project southeast of Rhode Island. Following a delay of the project, South Fork Wind submitted an updated version of the application on June 3, 2020, and then a revised version September 14, 2020. The application was deemed adequate and complete on September 15, 2020. However, on December 15, 2020, South Fork Wind

submitted a subsequent application due to changes to the project scope. NMFS deemed the application adequate and complete on December 16, 2020. South Fork Wind's request is for take of 16 species of marine mammals by harassment. Neither South Fork Wind nor NMFS expects serious injury or mortality to result from this activity and, therefore, an IHA is appropriate.

Description of Proposed Activity

Overview

South Fork Wind proposes to construct a 90–180 megawatt (MW) offshore wind energy project in Lease Area OCS–A 0517, southeast of Rhode Island. The project would consist of installation of up to 16 monopiles to support 15 offshore wind turbine generators (WTGs) and one offshore substation (OSS) (Figure 1). The project also includes offshore and onshore cabling, and onshore operations and maintenance facilities. Take of marine mammals may occur incidental to the construction of the project due to in-water noise exposure resulting from impact pile driving activities associated

with installation of WTG and OSS foundations, vibratory pile driving associated with the installation and removal of a temporary cofferdam nearshore, and high-resolution geophysical (HRG) surveys of the inter-array cable and export cable construction area.

Dates and Duration

Construction of the project is planned to commence between April 2022 and May 2022; however, as with many construction projects, permitting and construction delays may occur and the activity may take place at any point during the period of effectiveness for the IHA, subject to the following timing constraints. Up to 30 days of impact pile driving to install the WTGs and OSS may occur between May 1, 2022 and December 31, 2022; no impact pile driving activities would occur from January 1, 2023 through April 30, 2023. A cofferdam may potentially be installed for the sea-to-shore cable connection and, if required, would be installed between October 1, 2022 and May 31, 2023. Installation and

extraction of the cofferdam are each expected to take 1 to 3 days of vibratory pile driving. Up to 60 days of HRG surveys would be conducted throughout the 12-month construction timeframe.

Specific Geographic Region

South Fork Wind's proposed activity would occur in the 55.4 square kilometer (km²) (13,700 acre) South Fork Wind Lease Area OCS–A 0517 (SFWF; Figure 1 here, and see Figure 1 in the IHA application for more detail), within the Rhode Island-Massachusetts WEA. At its nearest point, the SFWF would be just over 30 kilometers (km) (19 miles (mi)) southeast of Block Island, Rhode Island, and 56 km (35 mi) east of Montauk Point, New York. Water depths in the SFWF range from approximately 33–41 meters (m) (108–134 feet (ft)). The South Fork export cable route (SFEC) would connect SFWF to one of two landing locations on Long Island, New York, where a temporary cofferdam may be constructed where the SFEC exits the seabed.

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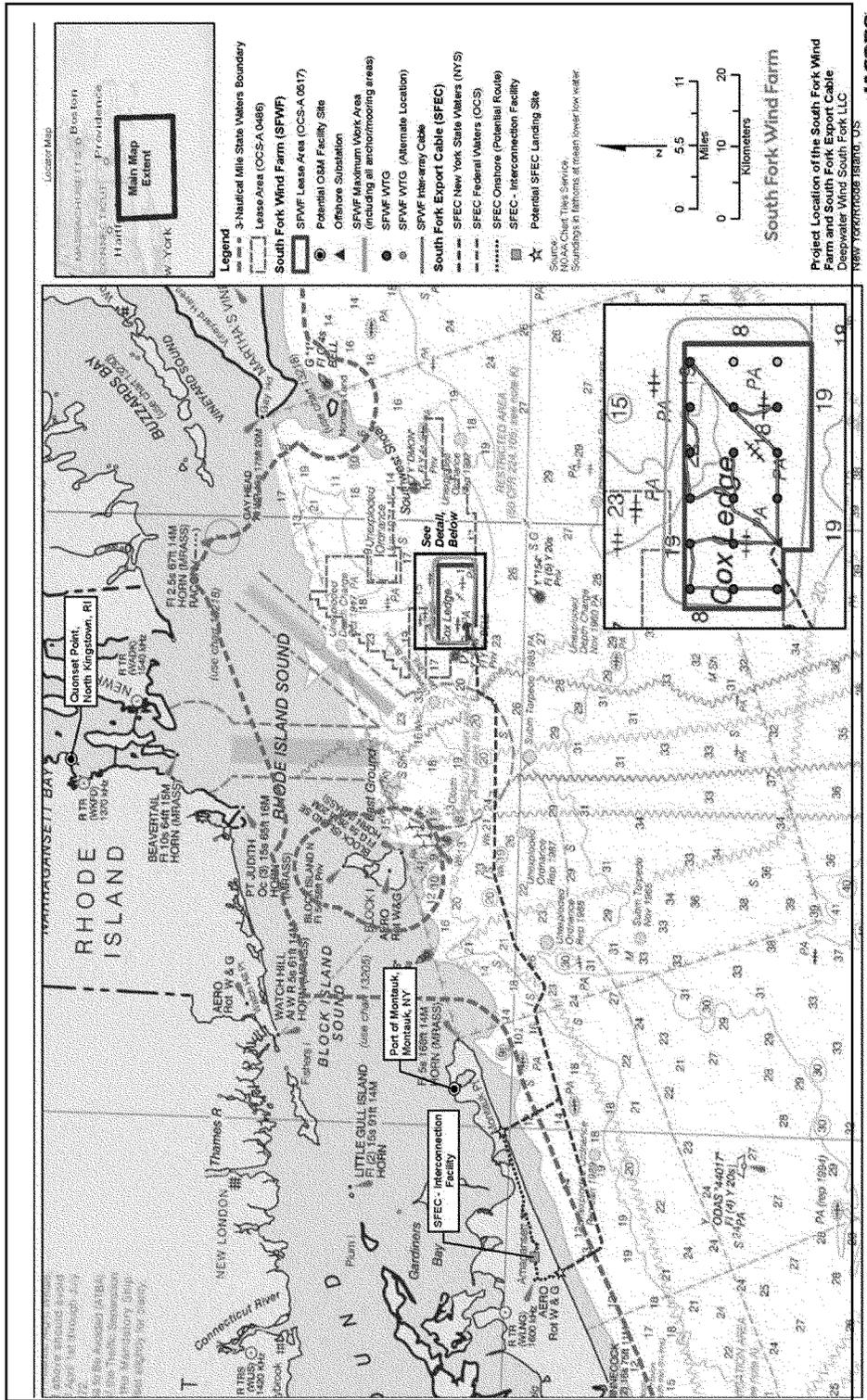


Figure 1. Location of Lease Area OSC-A 0517, South Fork Wind Farm (SFWF), and potential export cable routes (SFEC)

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Detailed Description of Specific Activity

South Fork Wind is proposing to construct a 90–180 MW commercial

wind energy project in Lease Area OCS-A 0517, southeast of Rhode Island. The Project would consist of the installation of up to 16 monopiles to support 15

offshore WTGs and one OSS, an onshore substation, offshore onshore cabling, and onshore operations and maintenance facilities. WTGs would be arranged in a grid-like pattern with spacing of 1.9 km (1.15 mi; 1 nautical miles (nm)) between turbines. Each WTG would interconnect with the OSS via an inter-array submarine cable system. The offshore export cable transmission system would connect the OSS to an existing mainland electric grid in East Hampton, New York. A temporary cofferdam may be installed where the offshore export cable conduit exits from the seabed to contain drilling returns and prevent the excavated sediments from silting back into the Horizontal Directional Drill (HDD) exit pit. The final location of the cofferdam will be dependent upon the selected cable landing site. Construction of the WTGs and OSS, including pile driving, could occur on any day from May 1, 2022 through December 31, 2022. Cofferdam installation and extraction requiring vibratory pile driving could occur for up to 3 days from October 2022 through May, 2023. HRG surveys would be conducted throughout the 12-month project timeframe. Activities associated with the construction of the project are described in more detail below.

Cable Laying

Cable burial operations will occur both in the SFWF for the inter-array cables connecting the WTGs to the OSS and in the SFEC for the cables carrying power from the OSS to land. Inter-array cables will connect the 15 WTGs to the OSS. A single offshore export cable will connect the OSS to the shore. The offshore export and inter-array cables will be buried beneath the seafloor at a target depth of up to 1.2–2.8 m (4–6 ft). Installation of the offshore export cable is anticipated to last approximately 2 months. The estimated installation time for the inter-array cables is approximately 4 months. All cable burial operations will follow installation of the monopile foundations, as the foundations must be in place to provide connection points for the export cable and inter-array cables. Installation days are not continuous and do not include equipment preparation or down time that may result from weather or maintenance. Equipment preparation is not considered a source of marine mammal disturbance or harassment.

Some dredging may be required prior to cable laying due to the presence of sand waves. The upper portions of sand waves may be removed via mechanical or hydraulic means in order to achieve the proper burial depth below the stable

sea bottom. The majority of the export and inter-link cable is expected to be installed using simultaneous lay and bury via jet plowing. Jet plowing entails the use of an adjustable blade, or plow, which rests on the sea floor and is towed by a surface vessel. The plow creates a narrow trench at the desired depth, while water jets fluidize the sediment within the trench. The cable is then fed through the plow and is laid into the trench as it moves forward. The fluidized sediments then settle back down into the trench and bury the cable. The majority of the inter-array cable is also expected to be installed via jet plowing after the cable has been placed on the seafloor. Other methods, such as mechanical plowing or trenching, may be needed in areas of coarser or more consolidated sediment, rocky bottom, or other difficult conditions in order to ensure a proper burial depth. The jet plowing tool may be based from a seabed tractor or a sled deployed from a vessel. A mechanical plow is also deployed from a vessel. More information on cable laying associated with the proposed project is provided in South Fork Wind's Construction and Operations Plan (SFWF COP; South Fork Wind, 2020). As the only potential impacts from these activities is sediment suspension, the potential for take of marine mammals to result from these activities is so low as to be discountable and South Fork Wind did not request, and NMFS does not propose to authorize, any takes associated with cable laying. Therefore, cable laying activities are not analyzed further in this document.

Construction-Related Vessel Activity

During construction of the project, South Fork Wind anticipates that an average of approximately 5–10 vessels will operate during a typical work day in the SFWF and along the SFEC. Many of these vessels will remain in the SFWF or SFEC for days or weeks at a time, potentially making only infrequent trips to port for bunkering and provisioning, as needed. The actual number of vessels involved in the project at one time is highly dependent on the project's final schedule, the final design of the project's components, and the logistics needed to ensure compliance with the Jones Act, a Federal law that regulates maritime commerce in the United States.

Existing vessel traffic in the vicinity of the project area southeast of Rhode Island is relatively high and marine mammals in the area are expected to be habituated to vessel noise. 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 relatively low speeds. Project-related vessels would be required to adhere to several mitigation measures designed to reduce the potential for marine mammals to be struck by vessels associated with the project; these measures are described further below (see Proposed Mitigation). As part of various construction related activities, including cable laying and construction material delivery, dynamic positioning thrusters may be utilized to hold vessels in position or move slowly. Sound produced through use of dynamic positioning thrusters is similar to that produced by transiting vessels, and dynamic positioning thrusters are typically operated either in a similarly predictable manner or used for short durations around stationary activities. Sound produced by dynamic positioning 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, further reducing the potential for startle or flight responses on the part of marine mammals. Construction-related vessel activity, including the use of dynamic positioning thrusters, is not expected to result in take of marine mammals and South Fork Wind did not request, and NMFS does not propose to authorize, any takes associated with construction related vessel activity. Accordingly, these activities are not analyzed further in this document.

Installation of WTGs and OSS

Monopiles are the only foundation type proposed for the project. A monopile is a single, hollow cylinder fabricated from steel that is secured in the seabed. The 16 monopiles installed to support the 15 WTG and single OSS would be 11.0 m (33.0 ft) in diameter, up to 95 m (311.7 ft) in length and driven to a maximum penetration depth of 50 m (164 ft). A schematic diagram showing potential heights and dimensions of the various components of a monopile foundation are shown in Figure 3.1–2 of the SFWF COP (South Fork Wind, 2020), available online at: <https://www.boem.gov/renewable-energy/state-activities/south-fork>.

The monopile foundations would be installed by one or two heavy lift or jack-up vessels. The main installation vessel(s) will likely remain at the SFWF during the installation phase (approximately 30 days) and transport vessels, tugs, and/or feeder barges would provide a continuous supply of foundations to the SFWF. If appropriate vessels are available, the foundation

components could be picked up directly in the marshalling port by the main installation vessel(s).

Within the SFWF, the main installation vessel would upend the monopile with a crane, and place it in the gripper frame, before lowering the monopile to the seabed. The gripper frame, depending upon its design, may be placed on the seabed scour protection materials to stabilize the monopile’s vertical alignment before and during piling. Scour protection is included to protect the foundation from scour development, which is the removal of the sediments near structures by hydrodynamic forces, and consists of the placement of stone or rock material around the foundation. The scour protection would consist of engineered rock placed around the base of each monopile in a 68 m (222 ft) diameter circle, using either a fallpipe vessel or stone dumping vessel. Once the monopile is lowered to the seabed, the crane hook would be released, and the hydraulic hammer would be picked up and placed on top of the monopile.

All monopoles would be installed with an impact hammer. Impact pile driving entails the use of a hammer that utilizes a rising and falling piston to repeatedly strike a pile and drive it into the ground. Using a crane, the installation vessel would upend the monopile, place it in the gripper frame, and then lower the monopile to the seabed. The gripper frame would stabilize the monopile’s vertical alignment before and during piling. Once the monopile is lowered to the seabed, the crane hook would be released and the hydraulic hammer would be picked up and placed on top of the monopile. A temporary steel cap called a helmet would be placed on top of the pile to minimize damage to the head during impact driving. The largest hammer South Fork Wind expects to use for driving monopiles produces up to 4,000 kilojoules (kJ) of energy (however, required energy may ultimately be far less than 4,000 kJ). As described in the Proposed Mitigation section below, South Fork Wind would utilize a sound attenuation device (e.g., bubble curtain) during all impact pile driving.

The intensity (i.e., hammer energy level) of impact pile driving would be

gradually increased based on the resistance that is experienced from the sediments. The strike rate for the monopile foundations is estimated to be 36 strikes per minute. Two pile driving scenarios (for 16 11 m piles), were considered for SFWF (Table 1). The standard pile driving scenario would require an estimated 4,500 strikes for the pile to reach the target penetration depth, with an average installation time of 140 minutes for one pile. In the event that a pile location presents denser substrate conditions and requires more strikes to reach the target penetration depth, a difficult-to-drive pile scenario was considered, in which 8,000 strikes and approximately 250 minutes would be required to install 1 pile.

Impact pile driving activities at SFWF will take place between May 1, 2022 and December 31, 2022. There are two piling scenarios that are considered possible within the current engineering design. The standard scenario assumes that a pile is driven every other day such that 16 monopiles piles would be installed over a 30-day period. A more aggressive schedule is considered for the maximum design scenario in which six piles are driven in a week (7 days) such that the 16 piles are installed over a 20-day period. Only one pile would be driven per 24 hours (hrs), irrespective of the selected scenario. Please see Table 1 for a summary of impact pile driving activity.

Installation and Removal of Temporary Cofferdam

Before cable-laying HDD begins, a temporary cofferdam may be installed at the endpoint of the HDD starting point, where the SFEC conduit exits from the seabed. The cofferdam would be less than 600 m (1,969 ft) offshore from the mean high water line (MHWL), in 7.6 to 12.2 m (25 to 40 ft) water depth, depending on the final siting point. The cofferdam, up to 22.9 m (75 ft) by 7.7 m (25 ft), would serve as containment for the drilling returns during the HDD installation to keep the excavation free of debris and silt. The cofferdam may be installed as either a sheet pile structure into the seafloor or a gravity cell structure placed on the seafloor using ballast weight. Installation of a gravity cell cofferdam would not result in incidental take of marine mammals and

is, therefore, not analyzed further in this document. Installation of the 19.5 m (64 ft) long, 0.95 centimeters (cm) (0.375 inches (in)) thick Z-type sheet pile cofferdam and drilling support would be conducted from an offshore barge anchored near the cofferdam.

If the potential cofferdam is installed using sheet pile, a vibratory hammer will be used to drive the sidewalls and endwalls into the seabed to a depth of approximately 1.8 m (6 ft); sections of the shoreside endwall will be driven to a depth of up to 9 m (30 ft) to facilitate the HDD entering underneath the endwall. Cofferdam removal would consist of pile removal using a vibratory hammer, after HDD operations are complete and the conduit is installed (see Table 1 for a summary of potential vibratory pile driving activity).

Vibratory hammering is accomplished by rapidly alternating (~250 Hertz (Hz)) forces to the pile. A system of counter-rotating eccentric weights powered by hydraulic motors are designed such that horizontal vibrations cancel out, while vertical vibrations are transmitted into the pile. The vibrations produced cause liquefaction of the substrate surrounding the pile, enabling the pile to be driven into the ground using the weight of the pile plus the impact hammer. If the gravity cell installation technique is not practicable, South Fork Wind anticipates that any vibratory pile driving of sheet piles would occur for a total of 36 hrs (18 hrs for installation, 18 hrs for removal).

The source levels and source characteristics associated with vibratory driving would be generally similar to those produced through other concurrent use of vessels and related construction equipment. Any elevated noise levels produced through vibratory driving are expected to be of relatively short duration, and with low source level values. However, it is possible that if marine mammals are exposed to sound from vibratory pile driving, they may alert to the sound and potentially exhibit a behavioral response that rises to the level of take.

Installation of the Z-type sheet piles would occur primarily in daylight; however, it is possible that vibratory pile driving may continue past sunset if required by the construction schedule.

TABLE 1—SUMMARY OF PILE DRIVING ACTIVITIES FOR SFWF AND SFEC

Pile driving method	Pile size	Number of piles	Strikes/pile	Duration/pile	Number of piling days
Impact	11 m monopile	16	Standard pile: 4,500 Difficult pile: 8,000	Standard pile: 140 min Difficult pile: 250 min	Standard scenario: 30. Maximum scenario: 20.

TABLE 1—SUMMARY OF PILE DRIVING ACTIVITIES FOR SFWF AND SFEC—Continued

Pile driving method	Pile size	Number of piles	Strikes/pile	Duration/pile	Number of piling days
Vibratory	19.5 m long/0.95 cm thick Sheet pile.	* 80	.....	18 hours 18 hours	Installation: 1–3. Removal: 1–3.

* Approximation; the actual number will be based on final engineering design.

High-Resolution Geophysical Surveys

The HRG survey activities would be supported by vessels of sufficient size to accomplish the survey goals in each of the specified survey areas. Up to four vessels may work concurrently throughout the area considered in this proposal. HRG surveys would occur throughout the 12-month period of effectiveness for the proposed IHA. HRG equipment will either be deployed from remotely operated vehicles (ROVs) or mounted to or towed behind the survey vessel at a typical survey speed of approximately 4.0 knots (kn) (7.4 km) per hour. The geophysical survey activities proposed by South Fork Wind would include the following:

- Shallow Penetration Sub-bottom Profilers (SBPs; Compressed High-Intensity Radiated Pulses (CHIRPs)) to map the near-surface stratigraphy (top 0 to 5 m (0 to 16 ft) of sediment below seabed). A CHIRP system emits sonar pulses that increase in frequency over time. The pulse length frequency range can be adjusted to meet project variables. These are typically mounted on the hull of the vessel or from a side pole.
- Medium penetration SBPs (Boomers) to map deeper subsurface stratigraphy as needed. A boomer is a broad-band sound source operating in the 3.5 Hz to 10 kHz frequency range. This system is typically mounted on a sled and towed behind the vessel.
- Medium penetration SBPs (Sparkers) to map deeper subsurface stratigraphy as needed. A sparker creates acoustic pulses from 50 Hz to 4 kHz omni-directionally from the source that can penetrate several hundred meters into the seafloor. These are typically towed behind the vessel with adjacent hydrophone arrays to receive the return signals.

- Parametric SBPs, also called sediment echosounders, for providing high density data in sub-bottom profiles that are typically required for cable routes, very shallow water, and archaeological surveys. These are typically mounted on the hull of the vessel or from a side pole.
- Ultra-short Baseline (USBL) Positioning and Global Acoustic Positioning System (GAPS) to provide high accuracy ranges to track the positions of other HRG equipment by measuring the time between the acoustic pulses transmitted by the vessel transceiver and the equipment transponder necessary to produce the acoustic profile. It is a two-component system with a hull or pole mounted transceiver and one to several transponders either on the seabed or on the equipment.
- Multibeam echosounder (MBES) to determine water depths and general bottom topography. MBES sonar systems project sonar pulses in several angled beams from a transducer mounted to a ship’s hull. The beams radiate out from the transducer in a fan-shaped pattern orthogonally to the ship’s direction.
- Seafloor imaging (sidescan sonar) for seabed sediment classification purposes, to identify natural and man-made acoustic targets resting on the bottom as well as any anomalous features. The sonar device emits conical or fan-shaped pulses down toward the seafloor in multiple beams at a wide angle, perpendicular to the path of the sensor through the water. The acoustic return of the pulses is recorded in a series of cross-track slices, which can be joined to form an image of the sea bottom within the swath of the beam. They are typically towed beside or behind the vessel or from an autonomous vehicle.

Table 2 identifies all the representative survey equipment that operate below 180 kilohertz (kHz) (*i.e.*, at frequencies that are audible and have the potential to disturb marine mammals) that may be used in support of planned geophysical survey activities, and are likely to be detected by marine mammals given the source level, frequency, and beamwidth of the equipment. The operational frequencies for MBES and Sidescan Sonar that would be used for these surveys are greater than 180 kHz, outside the general hearing range of marine mammals likely to occur in SFWF and SFEC. Parametric sub-bottom profilers operate at high frequencies with narrow beamwidths, resulting in Level A harassment and Level B harassment threshold isopleth distances less than 4 m. No harassment exposures can be reasonably expected from the operation of these sources; therefore, the Innomar parametric SBPs were not carried forward in the application analysis. USBLs are instruments that are used to locate the position(s) of other HRG equipment; the sources characteristics and functionality of USBLs are not expected to result in Level A harassment or Level B harassment. These equipment types are, therefore, not considered further in this notice. For discussion of acoustic terminology, please see the Potential Effects of Specified Activities on Marine Mammals and their Habitat and Estimated Take sections.

The make and model of the listed geophysical equipment may vary depending on availability and the final equipment choices will vary depending upon the final survey design, vessel availability, and survey contractor selection. Selection of equipment combinations is based on specific survey objectives.

TABLE 2—SUMMARY OF REPRESENTATIVE HRG SURVEY EQUIPMENT

HRG equipment category	Specific HRG equipment	Operating frequency range (kHz)	Source level (dB rms)	Source level (dB 0-peak)	Beamwidth (degrees)	Typical pulse duration (ms)	Pulse repetition rate
Shallow Sub-bottom Profilers.	ET 216 (2000DS or 3200 top unit).	2–16 2–8	195	–	24	20	6
	ET 424	4–24	176	–	71	3.4	2
	ET 512	0.7–12	179	–	80	9	8

TABLE 2—SUMMARY OF REPRESENTATIVE HRG SURVEY EQUIPMENT—Continued

HRG equipment category	Specific HRG equipment	Operating frequency range (kHz)	Source level (dB rms)	Source level (dB 0-peak)	Beamwidth (degrees)	Typical pulse duration (ms)	Pulse repetition rate
Medium Sub-bottom Profilers.	GeoPulse 5430A	2–17	196	–	55	50	10
	TB Chirp III—TTV 170	2–7	197	–	100	60	15
	AA, Dura-spark UHD (400 tips, 500 J) ¹ .	0.3–1.2	203	211	Omni	1.1	4
	AA, Dura-spark UHD (400+400) ¹ .	0.3–1.2	203	211	Omni	1.1	4
	GeoMarine, Geo-Source or similar dual 400 tip sparker (≤800 J) ¹ .	0.4–5	203	211	Omni	1.1	2
	GeoMarine Geo-Source 200 tip light weight sparker (400 J) ¹ .	0.3–1.2	203	211	Omni	1.1	4
	GeoMarine Geo-Source 200–400 tip freshwater sparker (400 J) ¹ .	0.3–1.2	203	211	Omni	1.1	4
	AA, triple plate S-Boom (700–1,000 J) ² .	0.1–5	205	211	80	0.6	4

– = not applicable; NR = not reported; AA = Applied Acoustics; dB = decibel; ET = EdgeTech; J = joule; Omni = omnidirectional source.

¹ The Dura-spark measurements and specifications provided in Crocker and Fratantonio (2016) were used for all sparker systems proposed for the survey. The data provided in Crocker and Fratantonio (2016) represent the most applicable data for similar sparker systems with comparable operating methods and settings when manufacturer or other reliable measurements are not available.

² Crocker and Fratantonio (2016) provide S-Boom measurements using two different power sources (CSP–D700 and CSP–N). The CSP–D700 power source was used in the 700 J measurements but not in the 1,000 J measurements. The CSP–N source was measured for both 700 J and 1,000 J operations but resulted in a lower SL; therefore, the single maximum SL value was used for both operational levels of the S-Boom.

Proposed mitigation, monitoring, and reporting measures are described in detail later in this document (please see Proposed Mitigation and Proposed Monitoring and Reporting).

Description of Marine Mammals in the Area of Specified Activities

Sections 3 and 4 of the IHA application summarize available information regarding status and trends, distribution and habitat preferences, and behavior and life history, of the potentially affected species. Additional information regarding population trends and threats may be found in NMFS’ Stock Assessment Reports (SARs; www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments) and more general information about these species (e.g., physical and behavioral descriptions) may be found on NMFS’ website (www.fisheries.noaa.gov/find-species).

There are 36 marine mammal species that could potentially occur in the proposed project area and that are included in Table 16 of the IHA application. However, the temporal and/or spatial occurrence of 20 of these species is such that take is not expected to occur, and they are therefore not discussed further beyond the explanation provided here. The following species are not expected to occur in the project area due to the location of preferred habitat outside the SFWF and SFEC, based on the best available information: The beluga whale

(*Delphinapterus leucas*), northern bottlenose whale (*Hyperoodon ampullatus*), killer whale (*Orcinus orca*), pygmy killer whale (*Feresa attenuata*), false killer whale (*Pseudorca crassidens*), melon-headed whale (*Peponocephala electra*), the pygmy sperm whale (*Kogia breviceps*), Cuvier’s beaked whale (*Ziphius cavirostris*), Mesplodont beaked whales (spp.), short-finned pilot whale (*Globicephala macrorhynchus*), pantropical spotted dolphin (*Stenella attenuata*), Fraser’s dolphin (*Lagenodelphis hosei*), white-beaked dolphin (*Lagenorhynchus albirostris*), rough-toothed dolphin (*Steno bredanensis*), Clymene dolphin (*Stenella clymene*), spinner dolphin (*Stenella longirostris*), and striped dolphin (*Stenella coeruleoalba*). The following species may occur in the project area, but at such low densities that take is not anticipated: Hooded seal (*Cystophora cristata*) and harp seal (*Pagophilus groenlandica*). There are two pilot whale species (long-finned and short-finned (*Globicephala macrorhynchus*)) with distributions that overlap in the latitudinal range of the SFWF (Hayes *et al.*, 2020; Roberts *et al.*, 2016). Because it is difficult to differentiate between the two species at sea, sightings, and thus the densities calculated from them, are generally reported together as *Globicephala* spp. (Hayes *et al.*, 2020; Roberts *et al.*, 2016). However, based on the best available information, short-finned pilot whales occur in habitat that is both further

offshore on the shelf break and further south than the project area (Hayes *et al.*, 2020). Therefore, NMFS assumes that any take of pilot whales would be of long-finned pilot whales.

In addition, the Florida manatee (*Trichechus manatus*) may be found in the coastal waters of the Survey Area. However, Florida manatees are managed by the U.S. Fish and Wildlife Service and are not considered further in this document.

Between October 2011 and June 2015 a total of 76 aerial surveys were conducted throughout the MA and RI/MA Wind Energy Areas (WEAs) (the SFWF is contained within the RI/MA WEA along with several other offshore renewable energy lease areas). Between November 2011 and March 2015, Marine Autonomous Recording Units (MARU; a type of static passive acoustic monitoring (PAM) recorder) were deployed at nine sites in the MA and RI/MA WEAs. The goal of the study was to collect visual and acoustic baseline data on distribution, abundance, and temporal occurrence patterns of marine mammals (Kraus *et al.*, 2016). The lack of detections of any of the species listed above reinforces the fact that these species are not expected to occur in the project area. As these species are not expected to occur in the project area during the proposed activities, NMFS does not propose to authorize take of these species and they are not discussed further in this document.

NMFS expects that the 16 species listed in Table 3 will potentially occur

in the project area and may be taken as a result of the proposed project. Table 3 summarizes information related to the population or stock, including regulatory status under the MMPA and Endangered Species Act (ESA) and potential biological removal (PBR), where known. For taxonomy, NMFS follows the Committee on Taxonomy (2020). PBR is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach

or maintain its optimum sustainable population (as described in NMFS' SARs). While no mortality is anticipated or authorized here, PBR is included here as a gross indicator of the status of the species and other threats.

Marine mammal abundance estimates presented in this document represent the total number of individuals that make up a given stock or the total number estimated within a particular study or survey area. NMFS' stock abundance estimates for most species represent the total estimate of

individuals within the geographic area, if known, that comprises that stock. For some species, this geographic area may extend beyond U.S. waters. All managed stocks in this region are assessed in NMFS' U.S. Atlantic SARs. All values presented in Table 3 are the most recent available at the time of publication and are available in the draft 2020 Atlantic SARs, available online at: <https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments>.

TABLE 3—MARINE MAMMALS KNOWN TO OCCUR IN THE PROJECT AREA THAT MAY BE AFFECTED BY SOUTH FORK WIND'S PROPOSED ACTIVITY

Common name (scientific name)	Stock	MMPA and ESA status; strategic (Y/N) ¹	Stock abundance (CV, N _{min} , most recent abundance survey) ²	PBR ³	Annual M/SI ³	Occurrence and seasonality in project area
Toothed whales (Odontoceti)						
Sperm whale (<i>Physeter macrocephalus</i>)	North Atlantic	E; Y	4,349 (0.28; 3,451; 2016) ...	3.9	0	Rare.
Long-finned pilot whale (<i>Globicephala melas</i>).	W North Atlantic	--; N	39,215 (0.3; 30,627; 2016)	306	21	Rare.
Atlantic spotted dolphin (<i>Stenella frontalis</i>)	W North Atlantic	--; N	39,921 (0.27; 32,032; 2016)	320	0	Rare.
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>).	W North Atlantic	--; N	93,233 (0.71; 54,443; 2016)	544	26	Common year round.
Bottlenose dolphin (<i>Tursiops truncatus</i>)	W North Atlantic, Off-shore.	--; N	62,851 (0.23; 51,914; 2019)	519	28	Common year round.
Common dolphin (<i>Delphinus delphis</i>)	W North Atlantic	--; N	172,974 (0.21; 145,216; 2016).	1,452	399	Common year round.
Risso's dolphin (<i>Grampus griseus</i>)	W North Atlantic	--; N	35,493 (0.19; 30,298; 2016)	303	54.3	Rare.
Harbor porpoise (<i>Phocoena phocoena</i>)	Gulf of Maine/Bay of Fundy.	--; N	95,543 (0.31; 74,034; 2019)	851	217	Common year round.
Baleen whales (Mysticeti)						
Blue whale (<i>Balaenoptera musculus</i>)	W North Atlantic	E; Y	ukn (unk; 402; 2008)	0.8	0	Rare.
North Atlantic right whale (<i>Eubalaena glacialis</i>).	W North Atlantic	E; Y	412 (0; 418; 2018)	0.8	18.6	Year round in continental shelf and slope waters, occur seasonally.
Humpback whale (<i>Megaptera novaeangliae</i>).	Gulf of Maine	--; N	1,393 (0.15; 1,375; 2016) ...	22	58	Common year round.
Fin whale (<i>Balaenoptera physalus</i>)	W North Atlantic	E; Y	6,802 (0.24; 5,573; 2016) ...	11	2.35	Year round in continental shelf and slope waters, occur seasonally.
Sei whale (<i>Balaenoptera borealis</i>)	Nova Scotia	E; Y	6,292 (1.02; 3,098 ; 2016) ..	6.2	1.2	Year round in continental shelf and slope waters, occur seasonally.
Minke whale (<i>Balaenoptera acutorostrata</i>)	Canadian East Coast	--; N	21,968 (0.31; 17,002; 2016)	170	10.6	Year round in continental shelf and slope waters, occur seasonally.
Earless seals (Phocidae)						
Gray seal ⁴ (<i>Halichoerus grypus</i>)	W North Atlantic	--; N	27,131 (0.19; 23,158; 2016)	1,389	4,729	Common year round.
Harbor seal (<i>Phoca vitulina</i>)	W North Atlantic	--; N	75,834 (0.15; 66,884; 2012)	2,006	350	Common year round.

¹ ESA status: Endangered (E), Threatened (T)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR (see footnote 3) or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

² Stock abundance as reported in NMFS marine mammal stock assessment reports (SAR) except where otherwise noted. SARs available online at: www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments. CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance. In some cases, CV is not applicable. For certain stocks, abundance estimates are actual counts of animals and there is no associated CV. The most recent abundance survey that is reflected in the abundance estimate is presented; there may be more recent surveys that have not yet been incorporated into the estimate. All values presented are from the draft 2020 Atlantic SARs.

³ Potential biological removal, defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population size (OSP). Annual Mortality/Serious Injury (M/SI), found in NMFS' SARs, represent annual levels of human-caused mortality plus serious injury from all sources combined (e.g., commercial fisheries, subsistence hunting, ship strike). Annual M/SI values often cannot be determined precisely and is, in some cases, presented as a minimum value. All M/SI values are as presented in the draft 2020 Atlantic SARs.

⁴ NMFS stock abundance and PBR estimates apply to U.S. population only, actual stock abundance is approximately 505,000.

Four marine mammal species that are listed under ESA may be present in the project area and may be taken incidental

to the proposed activity: The North Atlantic right whale, fin whale, sei whale, and sperm whale.

Below is a description of the species that are likely to occur in the project area and are thus expected to potentially

be taken by the proposed activities. For the majority of species potentially present in the specific geographic region, NMFS has designated only a single generic stock (e.g., “western North Atlantic”) for management purposes. This includes the “Canadian east coast” stock of minke whales, which includes all minke whales found in U.S. waters and is also a generic stock for management purposes. For humpback and sei whales, NMFS defines stocks on the basis of feeding locations, i.e., Gulf of Maine and Nova Scotia, respectively. However, references to humpback whales and sei whales in this document refer to any individuals of the species that are found in the specific geographic region. Any biologically important areas (BIAs) that overlap spatially with the project area are addressed in the species sections below.

North Atlantic Right Whale

The North Atlantic right whale ranges from calving grounds in the southeastern United States to feeding grounds in New England waters and into Canadian waters (Hayes *et al.*, 2020). Surveys have demonstrated the existence of seven areas where North Atlantic right whales congregate seasonally, including north and east of the proposed project area in Georges Bank, off Cape Cod, and in Massachusetts Bay (Hayes *et al.*, 2020). In the late fall months (e.g. October), North Atlantic right whales are generally thought to depart from the feeding grounds in the North Atlantic and move south along a migratory corridor to their calving grounds off Georgia and Florida. However, ongoing research indicates our understanding of their movement patterns remains incomplete (Davis *et al.*, 2017; Oleson *et al.*, 2020). A review of passive acoustic monitoring data from 2004 to 2014 throughout the western North Atlantic demonstrated nearly continuous year-round North Atlantic right whale presence across their entire habitat range (for at least some individuals), including in locations previously thought of as migratory corridors, suggesting that not all of the population undergoes a consistent annual migration (Davis *et al.*, 2017). Acoustic monitoring data from 2004 to 2014 indicated that the number of North Atlantic right whale vocalizations detected in the proposed project area were relatively constant throughout the year, with the exception of August through October when detected vocalizations showed an apparent decline (Davis *et al.*, 2017). Shifts in habitat use have also been observed. During visual surveys

conducted from 2012 to 2016, fewer North Atlantic right whales were detected in the Great South Channel (NMFS unpublished data) and the Bay of Fundy (Davies *et al.*, 2019), while the number of individuals using Cape Cod Bay in the spring increased (Mayo *et al.*, 2018). Cole *et al.* (2013) provided survey evidence that North Atlantic right whales were absent from the well-documented central Gulf of Maine winter habitat. Although present to some extent year round in the region south of Martha’s Vineyard and Nantucket Islands (Oleson *et al.*, 2020), North Atlantic right whales have recently been observed feeding in large numbers in this area in the winter (Leiter *et al.*, 2017), which is outside of the 2016 Northeastern U.S. Foraging Area Critical Habitat. In addition, North Atlantic right whale distribution has shifted northward into the Gulf of St. Lawrence (Simard *et al.*, 2019), where acoustic and visual survey effort indicate North Atlantic right whale presence in late spring through the early fall (Cole *et al.*, 2016; Khan *et al.*, 2016, 2018; Oleson *et al.* 2020). Observations of these transitions in North Atlantic right whale habitat use, variability in seasonal presence in identified core habitats, and utilization of habitat outside of previously focused survey effort prompted the formation of a NMFS’ Expert Working Group, which identified current data collection efforts, data gaps, and provided recommendations for future survey and research efforts (Oleson *et al.*, 2020).

The western North Atlantic population demonstrated overall growth of 2.8 percent per year between 1990 to 2010, despite a decline in 1993 and no growth between 1997 and 2000 (Pace *et al.*, 2017). However, since 2010 the population has been in decline, with a 100 percent probability of a decline from 2011 to 2018 of just over two percent per year (Pace *et al.*, 2017). Between 1990 and 2017, calving rates varied substantially, with low calving rates coinciding with all three periods of decline or no growth (Pace *et al.*, 2017). On average, North Atlantic right whale calving rates are estimated to be roughly one third that of southern right whales (*Eubalaena australis*) (Hayes *et al.*, 2020), which are increasing in abundance (NEFSC 2015). The current best estimate of population abundance for the North Atlantic right whale is 412 individuals (Hayes *et al.*, 2020).

In addition, elevated North Atlantic right whale mortalities have occurred since June 7, 2017 along the U.S. and Canadian coast. As of January 2021, a total of 32 confirmed dead stranded whales (21 in Canada; 11 in the United

States) and 14 serious injury (including entanglement and vessel strike) cases have been documented. Full necropsies have been conducted on 20 of the dead North Atlantic right whales and, in the 18 cases for which a preliminary cause of death could be determined, 8 and 10 were attributed to entanglement and vessel strike, respectively. This event has been declared an Unusual Mortality Event (UME); the leading cause of death for this UME is “human interaction”, specifically from entanglements or vessel strikes. More information is available online at: www.fisheries.noaa.gov/national/marine-life-distress/2017-2020-north-atlantic-right-whale-unusual-mortality-event.

During the aerial surveys conducted in the RI/MA and MA WEAs from 2011–2015, the highest number of North Atlantic right whale sightings occurred in March (n=21), with sightings also occurring in December (n=4), January (n=7), February (n=14), and April (n=14), and no sightings in any other months (Kraus *et al.*, 2016). There was not significant variability in sighting rate among years, indicating consistent annual seasonal use of the area by North Atlantic right whales. Despite the lack of visual detection, North Atlantic right whales were acoustically detected in 30 out of the 36 recorded months (Kraus *et al.*, 2016). While density data from Roberts *et al.* (2020) confirm that the highest density of North Atlantic right whales in the project area occurs in March, it is clear that North Atlantic right whales are present in or near the project area throughout the year, particularly south of Martha’s Vineyard and Nantucket Islands, and that habitat use is changing (Leiter *et al.*, 2017; Stone *et al.*, 2017; Oleson *et al.*, 2020). The proposed project area is part of an important migratory area for North Atlantic right whales; this migratory area is comprised of the waters of the continental shelf offshore the East Coast of the United States and extends from Florida through Massachusetts. Aerial surveys conducted in and near the project area from 2011–2015 documented a total of six instances of feeding behavior by North Atlantic right whales (Kraus *et al.*, 2016). Finally, the project area is located within the North Atlantic right whale migratory corridor Biologically Important Area (BIA), which is applicable November 1 through December 31, 2021 and March 1, 2022 through April 31, 2022 and extends from Florida to Massachusetts (LeBreque *et al.*, 2015).

NMFS’ regulations at 50 CFR 224.105 designated nearshore waters of the Mid-Atlantic Bight as Mid-Atlantic U.S.

Seasonal Management Areas (SMA) for North Atlantic right whales in 2008. SMAs were developed to reduce the threat of collisions between ships and North Atlantic right whales around their migratory route and calving grounds. The Block Island SMA, which is active from November 1 through April 30 each year, overlaps with the project area.

Humpback Whale

Humpback whales are found worldwide in all oceans. Humpback whales were listed as endangered under the Endangered Species Conservation Act (ESCA) in June 1970. In 1973, the ESA replaced the ESCA, and humpbacks continued to be listed as endangered. NMFS recently evaluated the status of the species, and on September 8, 2016, NMFS divided the species into 14 distinct population segments (DPS), removed the current species-level listing, and in its place listed four DPSs as endangered and one DPS as threatened (81 FR 62259; September 8, 2016). The remaining nine DPSs were not listed. The West Indies DPS, which is not listed under the ESA, is the only DPS of humpback whale that is expected to occur in the project area. The best estimate of population abundance for the West Indies DPS is 12,312 individuals, as described in the NMFS Status Review of the Humpback Whale under the Endangered Species Act (Bettridge *et al.*, 2015). In the western North Atlantic, humpback whales feed over a broad geographic range encompassing the eastern coast of the United States (including the Gulf of Maine), Scotian Shelf, Gulf of St. Lawrence, Newfoundland/Labrador, and Western Greenland (Katona and Beard 1990). Spatial and genetic mixing occurs when humpback whales from most of these feeding areas migrate to the West Indies in the winter to mate and calve. The Gulf of Maine feeding stock population abundance is estimated at 1,393 individuals, or approximately 11 percent of the West Indies DPS.

In New England waters, feeding is the principal activity of humpback whales, and their distribution in this region has been largely correlated to abundance of prey species, although behavior and bathymetry are factors influencing foraging strategy (Payne *et al.*, 1986, 1990). Humpback whales are frequently piscivorous when in New England waters, feeding on herring (*Clupea harengus*), sand lance (*Ammodytes* spp.), and other small fishes, as well as euphausiids in the northern Gulf of Maine (Paquet *et al.*, 1997). During winter, the majority of humpback whales from North Atlantic feeding areas (including the Gulf of Maine) mate

and calve in the West Indies, where spatial and genetic mixing among feeding groups occurs, though significant numbers of animals are found in mid- and high-latitude regions at this time and some individuals have been sighted repeatedly within the same winter season, indicating that not all humpback whales migrate south every winter (Hayes *et al.*, 2020).

Kraus *et al.* (2016) observed humpbacks in the RI/MA & MA Wind Energy Areas (WEAs) and surrounding areas during all seasons. Humpback whales were observed most often during 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.* study (2016). That study also observed one instance of courtship behavior. Although humpback whales were 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 the winter and spring (Kraus *et al.*, 2016). Other sightings of note include 46 sightings of humpback whales in the New York-New Jersey Harbor Estuary documented from 2011–2016 (Brown *et al.*, 2017). Since January 2016, elevated humpback whale mortalities have occurred along the Atlantic coast from Maine to Florida, leading to the declaration of an UME. Partial or full necropsy examinations have been conducted on approximately half of the 140 known cases. Of the whales examined, about 50 percent had evidence of human interaction, either ship strike or entanglement. While a portion of the whales have shown evidence of pre-mortem vessel strike, this finding is not consistent across all whales examined and more research is needed. NOAA is consulting with researchers that are conducting studies on the humpback whale populations, and these efforts may provide information on changes in whale distribution and habitat use that could provide additional insight into how these vessel interactions occurred. Three previous UMEs involving humpback whales have occurred since 2000, in 2003, 2005, and 2006. More information is available at: www.fisheries.noaa.gov/national/marine-life-distress/2016-2019-humpback-whale-unusual-mortality-event-along-atlantic-coast. A BIA for humpback whales for feeding has been designated northeast of the lease area and is applicable from March through December (LeBreque *et al.*, 2015).

Fin Whale

Fin whales are common in waters of the U.S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward (Hayes *et al.*, 2020). Fin whales are present north of 35-degree latitude in every season and are broadly distributed throughout the western North Atlantic for most of the year, though densities vary seasonally (Hayes *et al.*, 2020). In this region, fin whales are the dominant large cetacean species during all seasons, having the largest standing stock, the largest food requirements, and therefore the largest influence on ecosystem processes of any cetacean species (Hain *et al.*, 1992; Kenney *et al.*, 1997). It is likely that fin whales occurring in the U.S. Atlantic EEZ undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions (Edwards *et al.*, 2015).

New England waters represent a major feeding ground for fin whales; a feeding BIA for the species exists just west of the proposed project area, stretching from just south of the eastern tip of Long Island to south of the western tip of Martha's South Fork (LeBreque *et al.*, 2015). In aerial surveys conducted from 2011–2015 in the project area, sightings occurred in every season with the greatest numbers of sightings during the spring ($n=35$) and summer ($n=49$) months (Kraus *et al.*, 2016). Despite much lower sighting rates during the winter, confirmed acoustic detections of fin whales recorded on a hydrophone array in the project area from 2011–2015 occurred throughout the year; however, due to acoustic detection ranges in excess of 200 km, the detections do not confirm that fin whales were present in the project area during that time (Kraus *et al.*, 2016).

Sei Whale

The Nova Scotia stock of sei whales can be found in deeper waters of the continental shelf edge waters of the northeastern United States and northeastward to south of Newfoundland. The southern portion of the stock's range during spring and summer includes the Gulf of Maine and Georges Bank, a region now considered a portion of a feeding BIA for sei whales from May through November (LeBreque *et al.*, 2015). Spring is the period of greatest abundance in U.S. waters, with sightings concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (Hayes *et al.*, 2020). Sei whales often occur in shallower waters to feed. In aerial

surveys conducted from 2011–2015 in the project area sightings of sei whales occurred between March and June, with the greatest number of sightings in May ($n=8$) and June ($n=13$), and no sightings from July through January (Kraus *et al.*, 2016).

Minke Whale

Minke whales occur in temperate, tropical, and high-latitude waters. The Canadian East Coast stock can be found in the area from the western half of the Davis Strait (45° W) to the Gulf of Mexico (Hayes *et al.*, 2020). This species generally occupies waters less than 100 m deep on the continental shelf. There appears to be a strong seasonal component to minke whale distribution, in which spring to fall are times of relatively widespread and common occurrence, and when the whales are most abundant in New England waters, while during winter the species appears to be largely absent (Hayes *et al.*, 2020). In aerial surveys conducted from 2011–2015 in the project area, sightings of minke whales occurred between March and September, with the greatest number of sightings occurring in May ($n=38$) and no sightings from October through February (Kraus *et al.*, 2016). Although they do not overlap with the SFWF and SFEC, two minke whale feeding BIAs were defined for the southern Gulf of Maine and surrounding waters (<200 m), including the waters east of Cape Cod and Nantucket, applicable from March through November (LeBreque *et al.*, 2015).

Since January 2017, elevated minke whale mortalities have occurred along the Atlantic coast from Maine through South Carolina, with a total of 103 strandings recorded when this document was written. This event has been declared a UME. Full or partial necropsy examinations were conducted on more than 60 percent of the whales. Preliminary findings in several of the whales have shown evidence of human interactions or infectious disease, but these findings are not consistent across all of the whales examined, so more research is needed. More information is available at: www.fisheries.noaa.gov/national/marine-life-distress/2017-2019-minke-whale-unusual-mortality-event-along-atlantic-coast.

Sperm Whale

The distribution of the sperm whale in the U.S. EEZ occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Hayes *et al.*, 2020). The basic social unit of the sperm whale appears to be the mixed group of adult females with their calves and some juveniles of

both sexes, normally numbering 20–40 animals in all. There is evidence that some social bonds persist for many years (Christal *et al.*, 1998). In summer, the distribution of sperm whales includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100-m isobath) south of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level, and there remains a continental shelf edge occurrence in the mid-Atlantic bight. In winter, sperm whales are concentrated east and northeast of Cape Hatteras. Sperm whales are not expected to be common in the project area due to the relatively shallow depths in the project area. In aerial surveys conducted from 2011–2015 in the project area only four sightings of sperm whales occurred, three in summer and one in autumn (Kraus *et al.*, 2016).

Long-Finned Pilot Whale

Long-finned pilot whales are found from North Carolina and north to Iceland, Greenland and the Barents Sea (Hayes *et al.*, 2020). In U.S. Atlantic waters the species is distributed principally along the continental shelf edge off the northeastern U.S. coast in winter and early spring, and in late spring pilot whales move onto Georges Bank and into the Gulf of Maine and more northern waters and remain in these areas through late autumn (Waring *et al.*, 2016). In aerial surveys conducted from 2011–2015 in the project area the majority of pilot whale sightings were in spring ($n=11$); sightings were also documented in summer, with no sightings in autumn or winter (Kraus *et al.*, 2016).

Atlantic White-Sided Dolphin

White-sided dolphins are found in temperate and sub-polar waters of the North Atlantic, primarily in continental shelf waters to the 100-m depth contour from central West Greenland to North Carolina (Hayes *et al.*, 2020). The Gulf of Maine stock is most common in continental shelf waters from Hudson Canyon to Georges Bank, and in the Gulf of Maine and lower Bay of Fundy. Sighting data indicate seasonal shifts in distribution (Northridge *et al.*, 1997). During January to May, low numbers of white-sided dolphins are found from Georges Bank to Jeffreys Ledge (off New Hampshire), with even lower numbers south of Georges Bank, as documented by a few strandings collected on beaches of Virginia to South Carolina. From June through September, large numbers of white-sided dolphins are found from

Georges Bank to the lower Bay of Fundy. From October to December, white-sided dolphins occur at intermediate densities from southern Georges Bank to southern Gulf of Maine (Payne and Heinemann 1990). Sightings south of Georges Bank, particularly around Hudson Canyon, occur year round but at low densities. In aerial surveys conducted from 2011–2015 in the project area there were sightings of white-sided dolphins in every season except winter (Kraus *et al.*, 2016).

Atlantic Spotted Dolphin

Atlantic spotted dolphins are found in tropical and warm temperate waters ranging from southern New England south to Gulf of Mexico and the Caribbean to Venezuela (Waring *et al.*, 2014). This stock regularly occurs in continental shelf waters south of Cape Hatteras and in continental shelf edge and continental slope waters north of this region (Waring *et al.*, 2014). There are two forms of this species, with the larger ecotype inhabiting the continental shelf, usually found inside or near the 200 m isobath (Waring *et al.*, 2014).

Common Dolphin

The common dolphin is found worldwide in temperate to subtropical seas. In the North Atlantic, common dolphins are found over the continental shelf between the 100-m and 2,000-m isobaths and over prominent underwater topography and east to the mid-Atlantic Ridge (Hayes *et al.*, 2020), but may be found in shallower shelf waters as well. Common dolphins are expected to occur in the vicinity of the project area in relatively high numbers. Common dolphins were the most frequently observed dolphin species in aerial surveys conducted from 2011–2015 in the project area (Kraus *et al.*, 2016). Sightings peaked in the summer between June and August, though there were sightings recorded in nearly every month of the year (Kraus *et al.*, 2016).

Bottlenose Dolphin

There are two distinct bottlenose dolphin morphotypes in the western North Atlantic: The coastal and offshore forms (Hayes *et al.*, 2020). The two morphotypes are genetically distinct based upon both mitochondrial and nuclear markers (Hoelzel *et al.*, 1998; Rosel *et al.*, 2009). The offshore form is distributed primarily along the outer continental shelf and continental slope in the Northwest Atlantic Ocean from Georges Bank to the Florida Keys, and is the only type that may be present in the project area as the northern extent of the range of the Western North Atlantic Northern Migratory Coastal

Stock occurs south of the project area. Bottlenose dolphins are expected to occur in the project area in relatively high numbers. They were the second most frequently observed species of dolphin in aerial surveys conducted from 2011–2015 in the project area, and were observed in every month of the year except January and March (Kraus *et al.*, 2016).

Risso's Dolphin

Risso's dolphins are distributed worldwide in tropical and temperate seas, and in the Northwest Atlantic occur from Florida to eastern Newfoundland (Leatherwood *et al.* 1976; Baird and Stacey 1991). Off the northeastern U.S. coast, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and autumn (CETAP 1982; Payne *et al.* 1984), with the range extending outward into oceanic waters in the winter (Payne *et al.*, 1984). Risso's dolphins are not expected to be common in the project area due to the relatively shallow water depths. In aerial surveys conducted from 2011–2015 in the project there were only two confirmed sightings of Risso's dolphins, both of which occurred in the spring (Kraus *et al.*, 2016).

Harbor Porpoise

Harbor porpoises occur from the coastline to deep waters (>1800 m; Westgate *et al.* 1998), although the majority of the population is found over the continental shelf (Hayes *et al.*, 2020). In the project area, only the Gulf of Maine/Bay of Fundy stock of harbor porpoise may be present. This stock is found in U.S. and Canadian Atlantic waters and is concentrated in the northern Gulf of Maine and southern Bay of Fundy region, generally in waters less than 150 m deep (Waring *et al.*, 2016). In aerial surveys conducted from 2011–2015 in the project area, sightings of harbor porpoise occurred from November through May, with the highest number of detections occurring in April and almost none during June–September (Kraus *et al.*, 2016).

Harbor Seal

The harbor seal is found in all nearshore waters of the North Atlantic

and North Pacific Oceans and adjoining seas above about 30° N (Burns, 2009). In the western North Atlantic, harbor seals are distributed from the eastern Canadian Arctic and Greenland south to southern New England and New York, and occasionally to the Carolinas (Hayes *et al.*, 2020). Haulout and pupping sites are located off Manomet, MA and the Isles of Shoals, ME (Waring *et al.*, 2016). Based on harbor seal sightings reported at sea in shipboard surveys conducted by the NMFS Northeast Fisheries Science Center from 1995–2011, harbor seals would be expected to occur in the project area from September to May (Hayes *et al.*, 2020). Harbor seals are expected to be relatively common in the project area. Since July 2018, elevated numbers of harbor seal and gray seal mortalities have occurred across Maine, New Hampshire and Massachusetts. This event has been declared a UME. Additionally, stranded seals have shown clinical signs as far south as Virginia, although not in elevated numbers; therefore, the UME investigation now encompasses all seal strandings from Maine to Virginia. Full or partial necropsy examinations have been conducted on some of the seals and samples have been collected for testing. Based on tests conducted thus far, the main pathogen found in the seals is phocine distemper virus. NMFS is performing additional testing to identify any other factors that may be involved in this UME. Information on this UME is available online at: www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/2018-2019-pinniped-unusual-mortality-event-along.

Gray Seal

There are three major populations of gray seals found in the world: Eastern Canada (western North Atlantic stock), northwestern Europe, and the Baltic Sea. Gray seals in the project area belong to the western North Atlantic stock. The range for this stock is from New Jersey to Labrador. Current population trends show that gray seal abundance is likely increasing in the U.S. Atlantic EEZ (Hayes *et al.*, 2020). Although the rate of increase is unknown, surveys conducted since their arrival in the 1980s indicate a steady increase in abundance in both Maine

and Massachusetts (Hayes *et al.*, 2020). It is believed that recolonization by Canadian gray seals is the source of the U.S. population (Hayes *et al.*, 2020). Gray seals are expected to be relatively common in the project area. As described above, elevated seal mortalities, including gray seals, have occurred across Maine, New Hampshire and Massachusetts, and as far south as Virginia, since July 2018. This event has been declared a UME, with phocine distemper virus identified as the main pathogen found in the seals. NMFS is performing additional testing to identify any other factors that may be involved in this UME.

Marine Mammal Hearing

Hearing is the most important sensory modality for marine mammals underwater, and exposure to anthropogenic sound can have deleterious effects. To appropriately assess the potential effects of exposure to sound, it is necessary to understand the frequency ranges marine mammals are able to hear. Current data indicate that not all marine mammal species have equal hearing capabilities (*e.g.*, Richardson *et al.*, 1995; Wartzok and Ketten, 1999; Au and Hastings, 2008). To reflect this, Southall *et al.* (2007, 2019) recommended that marine mammals be divided into functional hearing groups based on directly measured or estimated hearing ranges on the basis of available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. Note that no direct measurements of hearing ability have been successfully completed for mysticetes (*i.e.*, low-frequency cetaceans). Subsequently, NMFS (2018) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 decibel (dB) threshold from the normalized composite audiograms, with the exception for lower limits for low-frequency cetaceans where the lower bound was deemed to be biologically implausible and the lower bound from Southall *et al.* (2007) retained. Marine mammal hearing groups and their associated hearing ranges are provided in Table 4.

TABLE 4—MARINE MAMMAL HEARING GROUPS [NMFS, 2018]

Hearing group	Generalized hearing range*
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz.

TABLE 4—MARINE MAMMAL HEARING GROUPS—Continued
[NMFS, 2018]

Hearing group	Generalized hearing range *
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz.
High-frequency (HF) cetaceans (true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>).	275 Hz to 160 kHz.
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz.
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz.

* Represents the generalized hearing range for the entire group as a composite (*i.e.*, all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall *et al.* 2007) and PW pinniped (approximation).

The pinniped functional hearing group was modified from Southall *et al.* (2007) on the basis of data indicating that phocid species have consistently demonstrated an extended frequency range of hearing compared to otariids, especially in the higher frequency range (Hemilä *et al.*, 2006; Kastelein *et al.*, 2009; Reichmuth and Holt, 2013).

For more details concerning these groups and associated frequency ranges, please see NMFS (2018) for a review of available information. Sixteen marine mammal species (14 cetacean and 2 pinniped (both phocid species)) have the reasonable potential to co-occur with the proposed activities (Table 3). Of the cetacean species that may be present, six are classified as low-frequency cetaceans (*i.e.*, all mysticete species), seven are classified as mid-frequency cetaceans (*i.e.*, all delphinid species and the sperm whale), and one is classified as a high-frequency cetacean (*i.e.*, harbor porpoise).

Potential Effects of Specified Activities on Marine Mammals and Their Habitat

This section includes a summary and discussion of the ways that components of the specified activity may impact marine mammals and their habitat. The Estimated Take section later in this document includes a quantitative analysis of the number of individuals that are expected to be taken by this activity. The Negligible Impact Analysis and Determination section considers the content of this section, the Estimated Take section, and the Proposed Mitigation section, to draw conclusions regarding the likely impacts of these activities on the reproductive success or survivorship of individuals and how those impacts on individuals are likely to impact marine mammal species or stocks.

Description of Sound Sources

This section contains a brief technical background on sound, on the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant

to the specified activity and to a discussion of the potential effects of the specified activity on marine mammals found later in this document. For general information on sound and its interaction with the marine environment, please see, *e.g.*, Au and Hastings (2008); Richardson *et al.* (1995); Urick (1983).

Sound travels in waves, the basic components of which are frequency, wavelength, velocity, and amplitude. Frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in Hz or cycles per second. Wavelength is the distance between two peaks or corresponding points of a sound wave (length of one cycle). Higher frequency sounds have shorter wavelengths than lower frequency sounds, and typically attenuate (decrease) more rapidly, except in certain cases in shallower water. Amplitude is the height of the sound pressure wave or the "loudness" of a sound and is typically described using the relative unit of the dB. A sound pressure level (SPL) in dB is described as the ratio between a measured pressure and a reference pressure (for underwater sound, this is 1 microPascal (μPa)), and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL) represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa), while the received level is the SPL at the listener's position (referenced to 1 μPa).

Root mean square (rms) is the quadratic mean sound pressure over the duration of an impulse. Root mean square is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). Root mean square accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation

of pressure levels (Hastings and Popper, 2005). This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units than by peak pressures.

Sound exposure level (SEL; represented as dB re 1 micropascal-squared second ($\mu\text{Pa}^2\text{-s}$)) represents the total energy in a stated frequency band over a stated time interval or event, and considers both intensity and duration of exposure. The per-pulse SEL is calculated over the time window containing the entire pulse (*i.e.*, 100 percent of the acoustic energy). SEL is a cumulative metric; it can be accumulated over a single pulse, or calculated over periods containing multiple pulses. Cumulative SEL represents the total energy accumulated by a receiver over a defined time window or during an event. Peak sound pressure (also referred to as zero-to-peak sound pressure or 0-pk) is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source, and is represented in the same units as the rms sound pressure.

When underwater objects vibrate or activity occurs, sound-pressure waves are created. These waves alternately compress and decompress the water as the sound wave travels. Underwater sound waves radiate in a manner similar to ripples on the surface of a pond and may be either directed in a beam or beams or may radiate in all directions (omnidirectional sources), as is the case for sound produced by the pile driving activity considered here. The compressions and decompressions associated with sound waves are detected as changes in pressure by aquatic life and man-made sound receptors such as hydrophones.

Even in the absence of sound from the specified activity, the underwater environment is typically loud due to ambient sound, which is defined as environmental background sound levels

lacking a single source or point (Richardson *et al.*, 1995). The sound level of a region is defined by the total acoustical energy being generated by known and unknown sources. These sources may include physical (*e.g.*, wind and waves, earthquakes, ice, atmospheric sound), biological (*e.g.*, sounds produced by marine mammals, fish, and invertebrates), and anthropogenic (*e.g.*, vessels, dredging, construction) sound. A number of sources contribute to ambient sound, including wind and waves, which are a main source of naturally occurring ambient sound for frequencies between 200 Hz and 50 kHz (ICES 1995). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Precipitation can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times. Marine mammals can contribute significantly to ambient sound levels, as can some fish and snapping shrimp. The frequency band for biological contributions is from approximately 12 Hz to over 100 kHz. Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, geophysical surveys, sonar, and explosions. Vessel noise typically dominates the total ambient sound for frequencies between 20 and 300 Hz. In general, the frequencies of anthropogenic sounds are below 1 kHz and, if higher frequency sound levels are created, they attenuate rapidly.

The sum of the various natural and anthropogenic sound sources that comprise ambient sound at any given location and time depends not only on the source levels (as determined by current weather conditions and levels of biological and human activity) but also on the ability of sound to propagate through the environment. In turn, sound propagation is dependent on the spatially and temporally varying properties of the water column and sea floor, and is frequency-dependent. As a result of the dependence on a large number of varying factors, ambient sound levels can be expected to vary widely over both coarse and fine spatial and temporal scales. Sound levels at a given frequency and location can vary by 10–20 dB from day to day (Richardson *et al.*, 1995). The result is that, depending on the source type and its intensity, sound from the specified activity may be a negligible addition to the local environment or could form a distinctive signal that may affect marine mammals. Underwater ambient sound

in the Atlantic Ocean southeast of Rhode Island is comprised of sounds produced by a number of natural and anthropogenic sources. Human-generated sound is a significant contributor to the ambient acoustic environment in the project location. Details of source types are described in the following text.

Sounds are often considered to fall into one of two general types: Impulsive and non-impulsive (defined in the following). The distinction between these two sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (*e.g.*, Ward, 1997 in Southall *et al.*, 2007). Please see Southall *et al.* (2007) for an in-depth discussion of these concepts. The distinction between these two sound types is not always obvious, as certain signals share properties of both impulsive and non-impulsive sounds. A signal near a source could be categorized as impulsive, but due to propagation effects as it moves farther from the source, the signal duration becomes longer (*e.g.*, Greene and Richardson, 1988).

Impulsive sound sources (*e.g.*, airguns, explosions, gunshots, sonic booms, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, atonal transients (ANSI, 1986, 2005; Harris, 1998; NIOSH, 1998; ISO, 2003) and occur either as isolated events or repeated in some succession. Impulsive sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or intermittent (ANSI, 1995; NIOSH, 1998). Some of these non-impulsive sounds can be transient signals of short duration but without the essential properties of pulses (*e.g.*, rapid rise time). Examples of non-impulsive sounds include those produced by vessels, aircraft, machinery operations such as drilling or dredging, vibratory pile driving, and active sonar systems. The duration of such sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

General background information on marine mammal hearing was provided previously (see Description of Marine

Mammals in the Area of the Specified Activities). Here, the potential effects of sound on marine mammals are discussed.

Potential Effects of Underwater Sound—Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on received levels, duration of exposure, behavioral context, and various other factors. The potential effects of underwater sound from active acoustic sources can potentially result in one or more of the following: Temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson *et al.*, 1995; Gordon *et al.*, 2003; Nowacek *et al.*, 2007; Southall *et al.*, 2007; Götz *et al.*, 2009). The degree of effect is intrinsically related to the signal characteristics, received level, distance from the source, and duration of the sound exposure. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within an animal's hearing range. We first describe specific manifestations of acoustic effects before providing discussion specific to pile driving.

Richardson *et al.* (1995) described zones of increasing intensity of effect that might be expected to occur, in relation to distance from a source and assuming that the signal is within an animal's hearing range. First is the area within which the acoustic signal would be audible (potentially perceived) to the animal but not strong enough to elicit any overt behavioral or physiological response. The next zone corresponds with the area where the signal is audible to the animal and of sufficient intensity to elicit behavioral or physiological responsiveness. Third is a zone within which, for signals of high intensity, the received level is sufficient to potentially cause discomfort or tissue damage to auditory or other systems. Overlaying these zones to a certain extent is the area within which masking (*i.e.*, when a sound interferes with or masks the ability of an animal to detect a signal of interest that is above the absolute hearing threshold) may occur; the masking zone may be highly variable in size.

We describe the more severe effects (*i.e.*, certain non-auditory physical or physiological effects) only briefly as we do not expect that there is a reasonable likelihood that pile driving may result

in such effects (see below for further discussion). Potential effects from impulsive sound sources can range in severity from effects such as behavioral disturbance or tactile perception to physical discomfort, slight injury of the internal organs and the auditory system, or mortality (Yelverton *et al.*, 1973). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to high level underwater sound or as a secondary effect of extreme behavioral reactions (*e.g.*, change in dive profile as a result of an avoidance reaction) caused by exposure to sound include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox *et al.*, 2006; Southall *et al.*, 2007; Zimmer and Tyack, 2007; Tal *et al.*, 2015). The construction activities considered here do not involve the use of devices such as explosives or mid-frequency tactical sonar that are associated with these types of effects.

Threshold Shift—Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience hearing threshold shift (TS), which NMFS defines as a change, usually an increase, in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level" (NMFS, 2018). TS can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall *et al.*, 2007). Repeated sound exposure that leads to TTS could cause PTS. In severe cases of PTS, there can be total or partial deafness, while in most cases the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985).

When PTS occurs, there is physical damage to the sound receptors in the ear (*i.e.*, tissue damage), whereas TTS represents primarily tissue fatigue and is reversible (Southall *et al.*, 2007). In addition, other investigators have suggested that TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury (*e.g.*, Ward, 1997). Therefore, NMFS does not consider TTS to constitute auditory injury.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, and there is no PTS data for cetaceans, but such relationships are assumed to be similar to those in humans and other terrestrial mammals. PTS typically occurs at exposure levels at least several decibels

above (a 40-dB threshold shift approximates PTS onset; *e.g.*, Kryter *et al.*, 1966; Miller, 1974) that inducing mild TTS (a 6-dB threshold shift approximates TTS onset; *e.g.*, Southall *et al.*, 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS thresholds for impulse sounds (such as impact pile driving pulses as received close to the source) are at least 6 dB higher than the TTS threshold on a peak-pressure basis and PTS cumulative sound exposure level thresholds are 15 to 20 dB higher than TTS cumulative sound exposure level thresholds (Southall *et al.*, 2007). Given the higher level of sound or longer exposure duration necessary to cause PTS as compared with TTS, it is considerably less likely that PTS could occur.

TTS is the mildest form of hearing impairment that can occur during exposure to sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises, and a sound must be at a higher level in order to be heard. In terrestrial and marine mammals, TTS can last from minutes or hours to days (in cases of strong TTS). In many cases, hearing sensitivity recovers rapidly after exposure to the sound ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals.

Marine mammal hearing plays a critical role in communication with conspecifics, and interpretation of environmental cues for purposes such as predator avoidance and prey capture. Depending on the degree (elevation of threshold in dB), duration (*i.e.*, recovery time), and frequency range of TTS, and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. For example, a marine mammal may be able to readily compensate for a brief, relatively small amount of TTS in a non-critical frequency range that occurs during a time where ambient noise is lower and there are not as many competing sounds present. Alternatively, a larger amount and longer duration of TTS sustained during time when communication is critical for successful mother/calf interactions could have more serious impacts.

Currently, TTS data only exist for four species of cetaceans (bottlenose dolphin, beluga whale (*Delphinapterus leucas*), harbor porpoise, and Yangtze finless porpoise (*Neophocoena asiakororientalis*)) and three species of pinnipeds (northern elephant seal (*Mirounga angustirostris*), harbor seal, and California sea lion (*Zalophus californianus*)) exposed to a limited number of sound sources (*i.e.*, mostly

tones and octave-band noise) in laboratory settings (Finneran, 2015). TTS was not observed in trained spotted (*Phoca largha*) and ringed (*Pusa hispida*) seals exposed to impulsive noise at levels matching previous predictions of TTS onset (Reichmuth *et al.*, 2016). In general, harbor seals and harbor porpoises have a lower TTS onset than other measured pinniped or cetacean species (Finneran, 2015). Additionally, the existing marine mammal TTS data come from a limited number of individuals within these species. There are no data available on noise-induced hearing loss for mysticetes. For summaries of data on TTS or PTS in marine mammals or for further discussion of TTS or PTS onset thresholds, please see Southall *et al.* (2007), Finneran and Jenkins (2012), Finneran (2015), and NMFS (2018).

Behavioral Effects—Behavioral disturbance may include a variety of effects, including subtle changes in behavior (*e.g.*, minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. Behavioral responses to sound are highly variable and context-specific and any reactions depend on numerous intrinsic and extrinsic factors (*e.g.*, species, state of maturity, experience, current activity, reproductive state, auditory sensitivity, time of day), as well as the interplay between factors (*e.g.*, Richardson *et al.*, 1995; Wartzok *et al.*, 2003; Southall *et al.*, 2007; Weilgart, 2007; Archer *et al.*, 2010). Behavioral reactions can vary not only among individuals but also within an individual, depending on previous experience with a sound source, context, and numerous other factors (Ellison *et al.*, 2012), and can vary depending on characteristics associated with the sound source (*e.g.*, whether it is moving or stationary, number of sources, distance from the source). Please see Appendices B–C of Southall *et al.* (2007) for a review of studies involving marine mammal behavioral responses to sound.

Habituation can occur when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok *et al.*, 2003). Animals are most likely to habituate to sounds that are predictable and unvarying. It is important to note that habituation is appropriately considered as a "progressive reduction in response to stimuli that are perceived as neither aversive nor beneficial," rather than as,

more generally, moderation in response to human disturbance (Bejder *et al.*, 2009). The opposite process is sensitization, when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at a lower level of exposure. As noted, behavioral state may affect the type of response. For example, animals that are resting may show greater behavioral change in response to disturbing sound levels than animals that are highly motivated to remain in an area for feeding (Richardson *et al.*, 1995; NRC, 2003; Wartzok *et al.*, 2003). Controlled experiments with captive marine mammals have showed pronounced behavioral reactions, including avoidance of loud sound sources (Ridgway *et al.*, 1997; Finneran *et al.*, 2003). Observed responses of wild marine mammals to loud impulsive sound sources (typically airguns or acoustic harassment devices) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (Morton and Symonds, 2002; see also Richardson *et al.*, 1995; Nowacek *et al.*, 2007). However, many delphinids approach low-frequency airgun source vessels with no apparent discomfort or obvious behavioral change (*e.g.*, Barkaszi *et al.*, 2012), indicating the importance of frequency output in relation to the species' hearing sensitivity.

Available studies show wide variation in response to underwater sound; therefore, it is difficult to predict specifically how any given sound in a particular instance might affect marine mammals perceiving the signal. If a marine mammal does react briefly 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. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (*e.g.*, Lusseau and Bejder, 2007; Weilgart, 2007; NRC, 2005). However, there are broad categories of potential response, which we describe in greater detail here, that include alteration of dive behavior, alteration of foraging behavior, effects to breathing, interference with or alteration of vocalization, avoidance, and flight.

Changes in dive behavior can vary widely and may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive (*e.g.*, Frankel and Clark, 2000; Costa *et al.*, 2003; Ng and Leung, 2003; Nowacek *et al.*, 2004; Goldbogen *et al.*, 2013a,b).

Variations in dive behavior may reflect interruptions in biologically significant activities (*e.g.*, foraging) or they may be of little biological significance. The impact of an alteration to dive behavior resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (*e.g.*, bubble nets or sediment plumes), or changes in dive behavior. As for other types of behavioral response, the frequency, duration, and temporal pattern of signal presentation, as well as differences in species sensitivity, are likely contributing factors to differences in response in any given circumstance (*e.g.*, Croll *et al.*, 2001; Nowacek *et al.*, 2004; Madsen *et al.*, 2006; Yazvenko *et al.*, 2007). An understanding of the energetic requirements of the affected individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal can facilitate the assessment of whether foraging disruptions are likely to incur fitness consequences.

Variations in respiration naturally vary with different behaviors and alterations to breathing rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Various studies have shown that respiration rates may either be unaffected or could increase, depending on the species and signal characteristics, again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure (*e.g.*, Kastelein *et al.*, 2001, 2005, 2006; Gailey *et al.*, 2007; Gailey *et al.*, 2016).

Marine mammals vocalize for different purposes and across multiple modes, such as whistling, echolocation click production, calling, and singing. Changes in vocalization behavior in response to anthropogenic noise can occur for any of these modes and may result from a need to compete with an increase in background noise or may reflect increased vigilance or a startle response. For example, in the presence of potentially masking signals, humpback whales and killer whales have been observed to increase the

length of their songs (Miller *et al.*, 2000; Fristrup *et al.*, 2003; Foote *et al.*, 2004), while North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks *et al.*, 2007). In some cases, animals may cease sound production during production of aversive signals (Bowles *et al.*, 1994).

Avoidance is the displacement of an individual from an area or migration path as a result of the presence of a sound or other stressors, and is one of the most obvious manifestations of disturbance in marine mammals (Richardson *et al.*, 1995). For example, gray whales are known to change direction—deflecting from customary migratory paths—in order to avoid noise from airgun surveys (Malme *et al.*, 1984). Avoidance may be short-term, with animals returning to the area once the noise has ceased (*e.g.*, Bowles *et al.*, 1994; Goold, 1996; Stone *et al.*, 2000; Morton and Symonds, 2002; Gailey *et al.*, 2007). Longer-term displacement is possible, however, which may lead to changes in abundance or distribution patterns of the affected species in the affected region if habituation to the presence of the sound does not occur (*e.g.*, Blackwell *et al.*, 2004; Bejder *et al.*, 2006; Teilmann *et al.*, 2006).

A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. The flight response differs from other avoidance responses in the intensity of the response (*e.g.*, directed movement, rate of travel). Relatively little information on flight responses of marine mammals to anthropogenic signals exist, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus, 1996). The result of a flight response could range from brief, temporary exertion and displacement from the area where the signal provokes flight to, in extreme cases, marine mammal strandings (Evans and England, 2001). However, it should be noted that response to a perceived predator does not necessarily invoke flight (Ford and Reeves, 2008), and whether individuals are solitary or in groups may influence the response.

Behavioral disturbance can also impact marine mammals in more subtle ways. Increased vigilance may result in costs related to diversion of focus and attention (*i.e.*, when a response consists of increased vigilance, it may come at the cost of decreased attention to other critical behaviors such as foraging or resting). These effects have generally not

been demonstrated for marine mammals, but studies involving fish and terrestrial animals have shown that increased vigilance may substantially reduce feeding rates (e.g., Beauchamp and Livoreil, 1997; Fritz *et al.*, 2002; Purser and Radford, 2011). In addition, chronic disturbance can cause population declines through reduction of fitness (e.g., decline in body condition) and subsequent reduction in reproductive success, survival, or both (e.g., Harrington and Veitch, 1992; Daan *et al.*, 1996; Bradshaw *et al.*, 1998). However, Ridgway *et al.* (2006) reported that increased vigilance in bottlenose dolphins exposed to sound over a five-day period did not cause any sleep deprivation or stress effects.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (24-hour cycle). Disruption of such functions resulting from reactions to stressors such as sound exposure are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall *et al.*, 2007). Consequently, a behavioral response lasting less than one day and not recurring on subsequent days is not considered particularly severe unless it could directly affect reproduction or survival (Southall *et al.*, 2007). Note that there is a difference between multi-day substantive behavioral reactions and multi-day anthropogenic activities. For example, just because an activity lasts for multiple days does not necessarily mean that individual animals are either exposed to activity-related stressors for multiple days or, further, exposed in a manner resulting in sustained multi-day substantive behavioral responses.

Stress Responses—An animal's perception of a threat may be sufficient to trigger stress responses consisting of some combination of behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses (e.g., Seyle, 1950; Moberg, 2000). In many cases, an animal's first and sometimes most economical (in terms of energetic costs) response is behavioral avoidance of the potential stressor. Autonomic nervous system responses to stress typically involve changes in heart rate, blood pressure, and gastrointestinal activity. These responses have a relatively short duration and may or may not have a significant long-term effect on an animal's fitness.

Neuroendocrine stress responses often involve the hypothalamus-pituitary-adrenal system. Virtually all neuroendocrine functions that are affected by stress—including immune competence, reproduction, metabolism,

and behavior—are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction, altered metabolism, reduced immune competence, and behavioral disturbance (e.g., Moberg, 1987; Blecha, 2000). Increases in the circulation of glucocorticoids are also equated with stress (Romano *et al.*, 2004).

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and "distress" is the cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose serious fitness consequences. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other functions. This state of distress will last until the animal replenishes its energetic reserves sufficient to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses are well studied through controlled experiments and for both laboratory and free-ranging animals (e.g., Holberton *et al.*, 1996; Hood *et al.*, 1998; Jessop *et al.*, 2003; Krausman *et al.*, 2004; Lankford *et al.*, 2005). Stress responses due to exposure to anthropogenic sounds or other stressors and their effects on marine mammals have also been reviewed (Fair and Becker, 2000; Romano *et al.*, 2002b) and, more rarely, studied in wild populations (e.g., Romano *et al.*, 2002a). For example, Rolland *et al.* (2012) found that noise reduction from reduced ship traffic in the Bay of Fundy was associated with decreased stress in North Atlantic right whales. These and other studies lead to a reasonable expectation that some marine mammals will experience physiological stress responses upon exposure to acoustic stressors and that it is possible that some of these would be classified as "distress." In addition, any animal experiencing TTS would likely also experience stress responses (NRC, 2003).

Auditory Masking—Sound can disrupt behavior through masking, or interfering with, an animal's ability to detect, recognize, or discriminate between acoustic signals of interest (e.g., those used for intraspecific communication and social interactions, prey detection, predator avoidance, navigation) (Richardson *et al.*, 1995; Erbe *et al.*, 2016). Masking occurs when

the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may occur whether the sound is natural (e.g., snapping shrimp, wind, waves, precipitation) or anthropogenic (e.g., shipping, sonar, seismic exploration) in origin. The ability of a noise source to mask biologically important sounds depends on the characteristics of both the noise source and the signal of interest (e.g., signal-to-noise ratio, temporal variability, direction), in relation to each other and to an animal's hearing abilities (e.g., sensitivity, frequency range, critical ratios, frequency discrimination, directional discrimination, age or TTS hearing loss), and existing ambient noise and propagation conditions.

Under certain circumstances, marine mammals experiencing significant masking could also be impaired from maximizing their performance fitness in survival and reproduction. Therefore, when the coincident (masking) sound is man-made, it may be considered harassment if disrupting behavioral patterns. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without resulting in TTS) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

The frequency range of the potentially masking sound is important in determining any potential behavioral impacts. For example, low-frequency signals may have less effect on high-frequency echolocation sounds produced by odontocetes but are more likely to affect detection of mysticete communication calls and other potentially important natural sounds such as those produced by surf and some prey species. The masking of communication signals by anthropogenic noise may be considered as a reduction in the communication space of animals (e.g., Clark *et al.*, 2009) and may result in energetic or other costs as animals change their vocalization behavior (e.g., Miller *et al.*, 2000; Foote *et al.*, 2004; Parks *et al.*, 2007; Di Iorio and Clark, 2009; Holt *et al.*, 2009). Masking can be reduced in situations where the signal and noise come from different directions (Richardson *et al.*, 1995), through amplitude modulation of the signal, or through other compensatory behaviors (Houser and Moore, 2014). Masking can be tested directly in captive species (e.g., Erbe, 2008), but in wild populations it must be either modeled

or inferred from evidence of masking compensation. There are few studies addressing real-world masking sounds likely to be experienced by marine mammals in the wild (e.g., Branstetter *et al.*, 2013).

Masking affects both senders and receivers of acoustic signals and can potentially have long-term chronic effects on marine mammals at the population level as well as at the individual level. Low-frequency ambient sound levels have increased by as much as 20 dB (more than three times in terms of SPL) in the world's ocean from pre-industrial periods, with most of the increase from distant commercial shipping (Hildebrand, 2009). All anthropogenic sound sources, but especially chronic and lower-frequency signals (e.g., from vessel traffic), contribute to elevated ambient sound levels, thus intensifying masking.

Potential Acoustic Effects of Proposed Activities

Acoustic effects on marine mammals during the specified activity can occur from impact pile driving, vibratory pile driving/removal, and HRG surveys. The effects of underwater noise from construction of the SFWF and SFEC have the potential to result in PTS (Level A harassment) or disruption of behavioral patterns (Level B harassment) of marine mammals in the action area.

The effects of pile driving on marine mammals are dependent on several factors, including the size, type, and depth of the animal; the type (impact or vibratory), depth, intensity, and duration of the pile driving sound; the depth of the water column; the substrate of the habitat; the distance between the pile and the animal; and the sound propagation properties of the environment.

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 by biological receivers such as marine mammals through the water, as the result of reflected paths from the surface, or re-radiated into the water from the seabed (See Figure 3 Appendix J1 of the SFWF COP for a schematic diagram illustrating sound propagation paths associated with pile driving).

Noise generated by impact pile driving consists of regular, impulsive sounds of short duration. These impulsive sounds are typically high energy with fast rise times. Exposure to these sounds may result in harassment depending on proximity to the sound source and a variety of environmental

and biological conditions (Dahl *et al.* 2015; Nedwell *et al.*, 2007). Illingworth & Rodkin (2007) measured an unattenuated sound pressure within 10 m (33 ft) at a peak of 220 dB re 1 μ Pa for a 2.4 m (96 in) steel pile driven by an impact hammer, and Brandt *et al.* (2011) found that for a pile driven in a Danish wind farm in the North Sea, the peak pressure at 720 m (0.4 nm) from the source was 196 dB re 1 μ Pa. Studies of underwater sound from pile driving finds that most of the acoustic energy is below one to two kHz, with broadband sound energy near the source (40 Hz to >40 kHz) and only low-frequency energy (<400 Hz) at longer ranges (Bailey *et al.*, 2010; Erbe, 2009; Illingworth & Rodkin, 2007). There is typically a decrease in sound pressure and an increase in pulse duration the greater the distance from the noise source (Bailey *et al.*, 2010). Maximum noise levels from pile driving usually occur during the last stage of driving each pile where the highest hammer energy levels are used (Betke, 2008).

Available information on impacts to marine mammals from pile driving associated with offshore wind is limited to information on harbor porpoises and seals, as the vast majority of this research has occurred at European offshore wind projects where large whales are uncommon. Harbor porpoises, one of the most behaviorally sensitive cetaceans, have received particular attention in European waters due to their protection under the European Union Habitats Directive (EU 1992, Annex IV) and the threats they face as a result of fisheries bycatch. Brandt *et al.* (2016) summarized the effects of the construction of eight offshore wind projects within the German North Sea between 2009 and 2013 on harbor porpoises, combining PAM data from 2010–2013 and aerial surveys from 2009–2013 with data on noise levels associated with pile driving. Baseline analyses were conducted initially to identify the seasonal distribution of porpoises in different geographic subareas. Results of the analysis revealed significant declines in porpoise detections during pile driving when compared to 25–48 hours before pile driving began, with the magnitude of decline during pile driving clearly decreasing with increasing distances to the construction site. During the majority of projects, significant declines in detections (by at least 20 percent) were found within at least 5–10 km of the pile driving site, with declines at up to 20–30 km of the pile driving site documented in some cases. However, there were no

indications for a population decline of harbor porpoises over the five year study period based on analyses of daily PAM data and aerial survey data at a larger scale (Brandt *et al.*, 2016). Despite extensive construction activities over the study period and an increase in these activities over time, there was no long-term negative trend in acoustic porpoise detections or densities within any of the subareas studied. In some areas, PAM data even detected a positive trend from 2010 to 2013. Even though clear negative short-term effects (1–2 days in duration) of offshore wind farm construction were found (based on acoustic porpoise detections), the authors found no indication that harbor porpoises within the German Bight were negatively affected by wind farm construction at the population level (Brandt *et al.*, 2016).

Monitoring of harbor porpoises before and after construction at the Egmond aan Zee offshore wind project in the Dutch North Sea showed that more porpoises were found in the wind project area compared to two reference areas post-construction, leading the authors to conclude that this effect was linked to the presence of the wind project, likely due to increased food availability as well as the exclusion of fisheries and reduced vessel traffic in the wind project (Lindeboom *et al.*, 2011). The available literature indicates harbor porpoise avoidance of pile driving at offshore wind projects has occurred during the construction phase. Where long term monitoring has been conducted, harbor porpoises have re-populated the wind farm areas after construction ceased, with the time it takes to re-populate the area varying somewhat, suggesting that while there are short-term impacts to porpoises during construction, population-level or long-term impacts are unlikely.

Harbor seals are also a particularly behaviorally sensitive species. A harbor seal telemetry study off the East coast of England found that seal abundance was significantly reduced up to 25 km from WTG pile driving during construction, but found no significant displacement resulted from construction overall as the seals' distribution was consistent with the non-piling scenario within 2 hours of cessation of pile driving (Russell *et al.*, 2016). Based on 2 years of monitoring at the Egmond aan Zee offshore wind project in the Dutch North Sea, satellite telemetry, while inconclusive, seemed to show that harbor seals avoided an area up to 40 km from the construction site during pile driving, though the seals were documented inside the wind farm after construction ended, indicating any

avoidance was temporary (Lindeboom *et al.*, 2011).

Overall, the available literature suggests harbor seals and harbor porpoises have shown avoidance of pile driving at offshore wind projects during the construction phase in some instances, with the duration of avoidance varying greatly, and with re-population of the area generally occurring post-construction. The literature suggests that marine mammal responses to pile driving in the offshore environment are not predictable and may be context-dependent. It should also be noted that the only studies available on marine mammal responses to offshore wind-related pile driving have focused on species which are known to be more behaviorally sensitive to auditory stimuli than the other species that occur in the project area. Therefore, the documented behavioral responses of harbor porpoises and harbor seals to pile driving in Europe should be considered as a worst case scenario in terms of the potential responses among all marine mammals to offshore pile driving, and these responses cannot reliably predict the responses that will occur in other marine mammal species. Harwood *et al.* (2014) discuss a theoretical framework to predict the population level consequences of disturbance from offshore renewable energy development in the UK on bottlenose dolphins and minke whales (among other species), providing illustrative examples of the extent to which each species might be exposed to behavioral disturbance or experience PTS on a given construction day, as well as probabilities of different levels of population decline at the end of the modeled construction period. For bottlenose dolphins, most of the simulated populations had declined in abundance by less than 5 percent by the time construction of the offshore wind project ended; of the simulated minke whale populations, the mean decline in abundance was approximately 3 percent. The results, which relied heavily on assumptions and expert opinion, highlight the need for empirical data to support more robust predictive capabilities for assessment of population level impacts of offshore wind development on affected species (Harwood *et al.*, 2014).

Noise generated from vibratory pile driving is mostly concentrated at lower frequencies. Rise time is slower, and sound energy is distributed over a great amount of time, reducing the probability and severity of injury (Nedwell and Edwards, 2002; Carlson *et al.* 2005). Vibratory hammers produce peak SPLs that may be 180 dB or greater, but are

generally 10 to 20 dB lower than SPLs generated during impact pile driving of the same-sized pile (Oestman *et al.*, 2009). Measurements from vibratory pile driving of sheet piles during construction activities for bridges and piers indicate that root mean square sound pressure level SPL_{rms} produced by this activity can range from 130 to 170 dB referenced to 1 micropascal squared seconds ($dB re 1 \mu Pa^2 s$; $re 1 \mu Pa$) depending on the measured distance from the source and physical properties of the location (Buehler *et al.*, 2015; Illingworth and Rodkin, Inc., 2017).

Masking, which occurs when the receipt of a sound is interfered with by a coincident sound at similar frequencies and similar or higher levels, may occur during the short periods of vibratory pile driving; however, this is unlikely to become biologically significant. It is possible that vibratory pile driving resulting from construction and removal of the temporary cofferdam may mask acoustic signals important to low frequency marine mammals, but the short-term duration (approximately 36 hours over 3 non-consecutive days, 18 hours each for installation and removal) would result in limited impacts from masking. In this case, vibratory pile driving durations are relatively short and no significant seal rookeries or haulouts, or cetacean foraging habitats are located near the inshore proposed cofferdam locations.

While thresholds for auditory impairment consider exposure time, the metrics used for the behavioral harassment threshold do not consider the duration of the animal's exposure to a sound level. Therefore, the traditional assessment for behavioral exposures is dependent solely on the presence or absence of a species within the area ensonified above the threshold. Also, animals are less likely to respond to sounds from more distance sources, even when equivalent sound levels elicit responses at closer ranges; both proximity and received levels are important factors in aversion responses (Dunlop *et al.*, 2017).

HRG surveys may temporarily impact marine mammals in the area due to elevated in-water sound levels. Animals exposed to active acoustic sources during the HRG survey are unlikely to incur TTS hearing impairment due to the characteristics of the sound sources, which include relatively narrow beamwidths (*e.g.*, shallow sub-bottom profilers) and generally very short pulses and duration of the sound. Even for high-frequency cetacean species (*e.g.*, harbor porpoises), which may have increased sensitivity to TTS (Lucke *et*

al., 2009; Kastelein *et al.*, 2012), individuals would have to make a very close approach and also remain very close to vessels operating these sources in order to receive the multiple exposures at relatively high levels that would be necessary to cause TTS. Intermittent exposures—as would occur due to the brief, transient signals produced by these sources—require a higher cumulative SEL to induce TTS than would continuous exposures of the same duration (*i.e.*, intermittent exposure results in lower levels of TTS) (Mooney *et al.*, 2009; Finneran *et al.*, 2010). Moreover, most marine mammals would more likely avoid a loud sound source rather than swim in such close proximity as to result in TTS. Kremser *et al.* (2005) noted that the probability of a cetacean swimming through the area of exposure when a sub-bottom profiler emits a pulse is small—because if the animal was in the area, it would have to pass the transducer at close range in order to be subjected to sound levels that could cause TTS and would likely exhibit avoidance behavior to the area near the transducer rather than swim through at such a close range. Further, the restricted beam shape of the majority of the geophysical survey equipment planned for use (Table 2) makes it unlikely that an animal would be exposed more than briefly during the passage of the vessel.

The onset of behavioral disturbance from anthropogenic sound depends on both external factors (characteristics of sound sources and their paths) and the specific characteristics of the receiving animals (hearing, motivation, experience, demography) and is difficult to predict (Southall *et al.*, 2007, Ellison *et al.*, 2012). It is possible that pile driving could result in temporary, short-term changes in an animal's typical behavioral patterns and/or temporary avoidance of the affected area. These behavioral changes may include (Richardson *et al.*, 1995): Changing durations of surfacing and dives, number of blows per surfacing, or moving direction and/or speed; reduced/increased vocal activities; changing/cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where sound sources are located; and/or flight responses. The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification could be expected to be

biologically significant if the change affects growth, survival, or reproduction. Significant behavioral modifications that could lead to effects on growth, survival, or reproduction, such as drastic changes in diving/surfacing patterns or significant habitat abandonment are considered extremely unlikely in the case of the proposed project, as it is expected that mitigation measures, including clearance zones and soft start (described in detail below, see Proposed Mitigation) will minimize the potential for marine mammals to be exposed to sound levels that would result in more extreme behavioral responses. In addition, marine mammals in the project area are expected to avoid any area that would be ensounded at sound levels high enough for the potential to result in more severe acute behavioral responses, as the offshore environment would allow marine mammals the ability to freely move to other areas without restriction.

In the case of impact pile driving, sound sources would be active for relatively short durations (2 to 3 hours per pile), and only one pile would be driven per day. The acoustic frequencies produced during pile driving activity are lower than those used by most species for communication or foraging expected to be present in the project area. Given the short duration and the frequency spectra produced by pile driving, NMFS expects minimal masking impacts from these activities. Further, any masking events that might qualify as Level B harassment under the MMPA would be expected to occur concurrently within the zones of behavioral harassment already estimated for pile driving, and have, therefore, already been taken into account in the exposure analysis. The zones of behavioral harassment estimated for vibratory pile driving are large (see Estimated Take), but the short duration of this activity coupled with the ephemeral use by LF cetaceans (the group most susceptible to potential masking from these activities) of the nearshore habitat will limit masking impacts. Finally, masking effects from HRG survey activities are not anticipated due to the characteristics of the acoustic sources (intermittent and higher frequency signals), the small isopleths generated by those signals, and the influence of the proposed mitigation.

Anticipated Effects on Marine Mammal Habitat

The proposed activities would result in the placement of 16 permanent structures (*i.e.*, the monopiles and associated scour protection supporting

the WTGs and OSS) and a temporary cofferdam in the marine environment. HRG surveys would not impact marine mammal habitat beyond the noise transmission discussed above, and are, therefore, not discussed further in this section. Based on the best available information, the long-term presence of the WTGs and OSS is not expected to have negative impacts on habitats used by marine mammals, and may ultimately have beneficial impacts on those habitats as a result of increased presence of prey species in the project area due to the WTGs and OSS acting as artificial reefs (Russell *et al.*, 2014). Although studies assessing the impacts of offshore wind development on marine mammals are limited, the repopulation of wind energy areas by harbor porpoises (Brandt *et al.*, 2016; Lindeboom *et al.*, 2011) and harbor seals (Lindeboom *et al.*, 2011; Russell *et al.*, 2016) following the installation of wind turbines are promising. SFWF would be located within the migratory corridor BIA for North Atlantic right whales; however, the 13,000 acre (62.5 km²) lease area occupies a fraction of the available habitat for North Atlantic right whales migrating through the region. Additionally, SFWF would operate a relatively small number of WTGs (15) compared to the number of foundations in offshore wind farms assessed in *e.g.*, Brandt *et al.* (2016) (range: 30–81; mean: 62), making the footprint comparatively small once installation is complete. There are no known foraging hotspots, or other ocean bottom structures of significant biological importance to marine mammals present in the project area. The proposed activities may have potential short-term impacts to food sources such as forage fish and could also affect acoustic habitat (see *Auditory Masking* discussion above), but meaningful impacts are unlikely. Therefore, the main impact issue associated with the proposed activity would be temporarily elevated sound levels and the associated direct effects on marine mammals, as discussed previously. The most likely impact to marine mammal habitat occurs from impact and vibratory pile driving effects on marine mammal prey (*e.g.*, fish). Impacts to the immediate substrate during installation of piles are anticipated, but these would be limited to minor, temporary suspension of sediments, which could impact water quality and visibility for a short amount of time, but which would not be expected to have any effects on individual marine mammals. Impacts to substrate are therefore not discussed further.

Effects to Prey—Sound may affect marine mammals through impacts on the abundance, behavior, or distribution of prey species (*e.g.*, crustaceans, cephalopods, fish, zooplankton). Marine mammal prey varies by species, season, and location and, for some, is not well documented. Here, we describe studies regarding the effects of noise on known marine mammal prey.

Fish utilize the soundscape and components of sound in their environment to perform important functions such as foraging, predator avoidance, mating, and spawning (*e.g.*, Zelick *et al.*, 1999; Fay, 2009). Depending on their hearing anatomy and peripheral sensory structures, which vary among species, fishes hear sounds using pressure and particle motion sensitivity capabilities and detect the motion of surrounding water (Fay *et al.*, 2008). The potential effects of noise on fishes depends on the overlapping frequency range, distance from the sound source, water depth of exposure, and species-specific hearing sensitivity, anatomy, and physiology. Key impacts to fishes may include behavioral responses, hearing damage, barotrauma (pressure-related injuries), and mortality.

Fish react to sounds which are especially strong and/or intermittent low-frequency sounds, and behavioral responses such as flight or avoidance are the most likely effects. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. The reaction of fish to noise depends on the physiological state of the fish, past exposures, motivation (*e.g.*, feeding, spawning, migration), and other environmental factors. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of pile driving on fish, although several are based on studies in support of large, multiyear bridge construction projects (*e.g.*, Scholik and Yan, 2001, 2002; Popper and Hastings, 2009). Several studies have demonstrated that impulse sounds might affect the distribution and behavior of some fishes, potentially impacting foraging opportunities or increasing energetic costs (*e.g.*, Fewtrell and McCauley, 2012; Pearson *et al.*, 1992; Skalski *et al.*, 1992; Santulli *et al.*, 1999; Paxton *et al.*, 2017). However, some studies have shown no or slight reaction to impulse sounds (*e.g.*, Pena *et al.*, 2013; Wardle *et al.*, 2001; Jorgenson and Gyselman, 2009; Cott *et al.*, 2012). More commonly, though, the impacts of noise on fish are temporary.

SPLs of sufficient strength have been known to cause injury to fish and fish mortality. However, in most fish species, hair cells in the ear continuously regenerate and loss of auditory function likely is restored when damaged cells are replaced with new cells. Halvorsen *et al.* (2012a) showed that a TTS of 4–6 dB was recoverable within 24 hours for one species. Impacts would be most severe when the individual fish is close to the source and when the duration of exposure is long. Injury caused by barotrauma can range from slight to severe and can cause death, and is most likely for fish with swim bladders. Barotrauma injuries have been documented during controlled exposure to impact pile driving (Halvorsen *et al.*, 2012b; Casper *et al.*, 2013). As described in the Proposed Mitigation section below, South Fork Wind would utilize a sound attenuation device which would reduce potential for injury to marine mammal prey.

The most likely impact to fish from impact and vibratory pile driving activities at the project areas would be temporary behavioral avoidance of the area. The duration of fish avoidance of an area after pile driving stops is unknown, but a rapid return to normal recruitment, distribution and behavior is anticipated. In general, impacts to marine mammal prey species are expected to be minor and temporary due to the expected short daily duration of individual pile driving events and the relatively small areas being affected.

Any behavioral avoidance by fish of the disturbed area would still leave significantly large areas of fish and marine mammal foraging habitat in the nearby vicinity. Based on the information discussed herein, NMFS concludes that impacts of South Fork Wind's activities are not likely to have more than short-term adverse effects on any prey habitat or populations of prey species. Further, any impacts to marine mammal habitat are not expected to result in significant or long-term consequences for individual marine mammals, or to contribute to adverse impacts on their populations.

Estimated Take

This section provides an estimate of the number of incidental takes proposed for authorization through this IHA, which will inform both NMFS'

consideration of "small numbers" and the negligible impact determination.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of the MMPA defines "harassment" as any act of pursuit, torment, or annoyance, which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Authorized takes would primarily be by Level B harassment, as noise from pile driving and HRG surveys has the potential to result in disruption of behavioral patterns for individual marine mammals. There is also some potential for auditory injury (Level A harassment) to result from impact pile driving. The proposed mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable (see Proposed Mitigation).

As described previously, no mortality is anticipated or proposed to be authorized for these activities. The approach by which take is estimated is described below.

Generally speaking, NMFS estimates take by considering: (1) Acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; (2) the area or volume of water that will be ensonified above these levels in a day; (3) the density or occurrence of marine mammals within these ensonified areas; and, (4) and the number of days of activities. NMFS notes that while these basic factors can contribute to a basic calculation to provide an initial prediction of takes, additional information that can qualitatively inform take estimates is also sometimes available (*e.g.*, previous monitoring results or average group size). Below, NMFS describes the factors considered here in more detail and present the proposed take estimate.

Acoustic Thresholds

NMFS recommends the use of acoustic thresholds that identify the received level of underwater sound

above which exposed marine mammals would be reasonably expected to be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment—Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.*, frequency, predictability, duty cycle), the environment (*e.g.*, bathymetry), and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Southall *et al.*, 2007, Ellison *et al.*, 2012). Based on what the available science indicates and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner we consider Level B harassment when exposed to underwater anthropogenic noise above received levels of 160 dB re 1 μ Pa (rms) for impulsive and/or intermittent sources. South Fork Wind's proposed activity includes the use of impulsive and intermittent sources (*e.g.*, impact pile driving, HRG acoustic sources), and thus the 160 dB threshold applies.

Level A harassment—NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) (Technical Guidance, 2018) identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive). The components of South Fork Wind's proposed activity that may result in take of marine mammals include the use of impulsive and non-impulsive sources.

These thresholds are provided in Table 5. The references, analysis, and methodology used in the development of the thresholds are described in NMFS 2018 Technical Guidance, which may be accessed at: www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance.

TABLE 5—THRESHOLDS IDENTIFYING THE ONSET OF PERMANENT THRESHOLD SHIFT

Hearing group	PTS onset acoustic thresholds* (received level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	Cell 1: $L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB	Cell 2: $L_{E,LF,24h}$: 199 dB.
Mid-Frequency (MF) Cetaceans	Cell 3: $L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB	Cell 4: $L_{E,MF,24h}$: 198 dB.
High-Frequency (HF) Cetaceans	Cell 5: $L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB	Cell 6: $L_{E,HF,24h}$: 173 dB.
Phocid Pinnipeds (PW) (Underwater)	Cell 7: $L_{pk,flat}$: 218 dB; $L_{E,PW,24h}$: 185 dB	Cell 8: $L_{E,PW,24h}$: 201 dB.
Otariid Pinnipeds (OW) (Underwater)	Cell 9: $L_{pk,flat}$: 232 dB; $L_{E,OW,24h}$: 203 dB	Cell 10 : $L_{E,OW,24h}$: 219 dB.

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (L_{pk}) has a reference value of 1 μ Pa, and cumulative sound exposure level (L_E) has a reference value of 1 μ Pa²s. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript “flat” is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (*i.e.*, varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Acoustic Modeling

Here, NMFS describes operational and environmental parameters of the activity that will feed into identifying the area ensounded above the acoustic thresholds, which include source levels and transmission loss coefficient.

Impact Pile Driving: Acoustic Range

As described above, South Fork Wind is proposing to install up to 15 WTGs and one OSS in the SFWF (*i.e.*, a maximum of 16 foundations). Two piling scenarios may be encountered in the construction of the project and were therefore considered in the acoustic

modeling study conducted to estimate the potential number of marine mammal exposures above relevant harassment thresholds: (1) Maximum design, including one difficult to drive pile, and (2) standard design with no difficult to drive pile included.

In recognition of the need to ensure that the range of potential impacts to marine mammals from the various potential scenarios are accounted for, piling scenarios were modeled separately in order to conservatively assess the impacts of each. The two monopile installation scenarios modeled are:

(1) The “maximum design” consisting of fifteen piles requiring ~4,500 strikes per pile (per 24 hrs), and one difficult to drive pile requiring ~8,000 strikes (per 24 hrs).

(2) The “standard design” consisting of sixteen piles requiring ~4,500 strike per pile (per 24 hrs).

Representative hammering schedules of increasing hammer energy with increasing penetration depth were modeled, resulting in, generally, higher intensity sound fields as the hammer energy and penetration increases (Table 6).

TABLE 6—HAMMER ENERGY SCHEDULE FOR MONOPILE INSTALLATION

Energy level (kilojoule[kJ])	Standard pile strike count (4,500 total)	Difficult pile strike count (8,000 total)	Pile penetration (m)
1,000	500	800	0–6
1,500	1,000	1,200	6–23.5
2,500	1,500	3,000	23.5–41
4,000	1,500	3,000	41–45

Monopiles were assumed to be vertical and driven to a penetration depth of 45 m. While pile penetrations across the site would vary, this value was chosen as a reasonable penetration depth. All acoustic modeling was performed assuming that only one pile is driven at a time.

Additional modeling assumptions for the monopiles were as follows:

- One pile installed per day.
- 10.97 m steel cylindrical piling with wall thickness of 10 cm.
- *Impact pile driver:* IHC S-4000 (4000 kilojoules (kJ) rated energy; 1977 kilonewtons (kN) ram weight).
- *Helmet weight:* 3234 kN.

Sound fields produced during impact pile driving were modeled by first characterizing the sound signal produced during pile driving using the industry-standard GRLWEAP (wave equation analysis of pile driving) model and JASCO Applied Sciences’ (JASCO) Pile Driving Source Model (PDSM). The full JASCO modeling report can be found at <https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act> and we provide a summary of the modelling effort below.

Underwater sound propagation (*i.e.*, transmission loss) as a function of range

from each source was modeled using JASCO’s Marine Operations Noise Model (MONM) for multiple propagation radials centered at the source to yield 3D transmission loss fields in the surrounding area. The MONM computes received per-pulse SEL for directional sources at specified depths. MONM uses two separate models to estimate transmission loss.

At frequencies less than 2 kHz, MONM computes acoustic propagation via a wide-angle parabolic equation (PE) solution to the acoustic wave equation based on a version of the U.S. Naval Research Laboratory’s Range-dependent Acoustic Model (RAM) modified to

account for an elastic seabed. MONM–RAM incorporates bathymetry, underwater sound speed as a function of depth, and a geoacoustic profile based on seafloor composition, and accounts for source horizontal directivity. The PE method has been extensively benchmarked and is widely employed in the underwater acoustics community, and MONM–RAM’s predictions have been validated against experimental data in several underwater acoustic measurement programs conducted by JASCO. At frequencies greater than 2 kHz, MONM accounts for increased sound attenuation due to volume absorption at higher frequencies with the widely used BELLHOP Gaussian beam ray-trace propagation model. This component incorporates bathymetry and underwater sound speed as a function of depth with a simplified representation of the sea bottom, as subbottom layers have a negligible influence on the propagation of acoustic waves with frequencies above 1 kHz. MONM–BELLHOP accounts for horizontal directivity of the source and vertical variation of the source beam pattern. Both propagation models account for full exposure from a direct acoustic wave, as well as exposure from acoustic wave reflections and refractions (*i.e.*, multi-path arrivals at the receiver).

The sound field radiating from the pile was simulated using a vertical array of point sources. Because sound itself is an oscillation (vibration) of water particles, acoustic modeling of sound in the water column is inherently an evaluation of vibration. For this study, synthetic pressure waveforms were computed using the full-wave range-dependent acoustic model (FWRAM), which is JASCO’s acoustic propagation model capable of producing time-domain waveforms.

Models are more efficient at estimating SEL than SPL_{rms} . Therefore, conversions may be necessary to derive the corresponding SPL_{rms} . Propagation was modeled for a subset of sites using the FWRAM, from which broadband SEL to SPL conversion factors were calculated. The FWRAM required intensive calculation for each site, thus a representative subset of modeling sites were used to develop azimuth-, range-, and depth-dependent conversion factors. These conversion factors were used to calculate the broadband SPL_{rms} from the broadband SEL prediction.

Two locations within the SFWF were selected to provide representative propagation and sound fields for the project area (see Figure 1 in SFWF COP, Appendix J1). The two locations were selected to span the region from shallow to deeper water and varying distances to

dominant bathymetric features (*i.e.*, slope and shelf break). Water depth and environmental characteristics (*e.g.*, bottom-type) are similar throughout the SFWF, and therefore minimal differences were found in sound propagation results for the two sites (Denes *et al.*, 2018). The model also incorporated two different sound velocity profiles (related to in situ measurements of temperature, salinity, and pressure within the water column) to account for variations in the acoustic propagation conditions between summer and winter. Estimated pile driving schedules (Table 6) were used to calculate the SEL sound fields at different points in time during pile driving.

The sound propagation modeling incorporated site-specific environmental data that describes the bathymetry, sound speed in the water column, and seabed geoacoustics in the construction area. Sound level estimates are calculated from three-dimensional sound fields and then at each horizontal sampling range, the maximum received level that occurs within the water column is used as the received level at that range. These maximum-over-depth (R_{max}) values are then compared to predetermined threshold levels to determine acoustic ranges to Level A harassment and Level B harassment zone isopleths. However, the ranges to a threshold typically differ among radii from a source, and might not be continuous because sound levels may drop below threshold at some ranges and then exceed threshold at farther ranges. To minimize the influence of these inconsistencies, 5 percent of the farthest such footprints were excluded from the model data. The resulting range, $R_{95percent}$, is used because, regardless of the shape of the maximum-over-depth footprint, the predicted range encompasses at least 95 percent of the horizontal area that would be exposed to sound at or above the specified threshold. The difference between R_{max} and $R_{95percent}$ depends on the source directivity and the heterogeneity of the acoustic environment. $R_{95percent}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonified zone (see Figure 12; SFWF COP Appendix J1).

The modeled source spectrum is provided in Figure 7 of the SFWF COP (Appendix J1). The dominant energy for both pile driving scenarios (“maximum” and “standard”) is below 100 Hz. Please see Appendix J1 of the SFWF COP for further details on the modeling methodology (Denes *et al.*, 2020a).

South Fork Wind will employ a noise mitigation system during all impact pile driving of monopiles. Noise mitigation systems, such as bubble curtains, are sometimes used to decrease the sound levels radiated from 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 bubble curtain systems, confined or unconfined bubbles, and some with encapsulated bubbles or panels. Attenuation levels also vary by type of system, frequency band, and location. Small bubble curtains have been measured to reduce sound levels but effective attenuation is highly dependent on depth of water, current, and configuration and operation of the curtain (Austin, Denes, MacDonnell, & Warner, 2016; Koschinski & Lüdemann, 2013). Bubble curtains vary in terms of the sizes of the bubbles and those with larger bubbles tend to perform a bit better and more reliably, particularly when deployed with two separate rings (Bellmann, 2014; Koschinski & Lüdemann, 2013; Nehls, Rose, Diederichs, Bellmann, & Pehlke, 2016).

Encapsulated bubble systems (*e.g.*, Hydro Sound Dampers (HSDs)), can be effective within their targeted frequency ranges, *e.g.*, 100–800 Hz, and when used in conjunction with a bubble curtain appear to create the greatest attenuation. The literature presents a wide array of observed attenuation results for bubble curtains. The variability in attenuation levels is the result of variation in design, as well as differences in site conditions and difficulty in properly installing and operating in-water attenuation devices. A California Department of Transportation (CalTrans) study tested several systems and found that the best attenuation systems resulted in 10–15 dB of attenuation (Buehler *et al.*, 2015). Similarly, Dähne *et al.* (2017) found that single bubble curtains that reduced sound levels by 7 to 10 dB reduced the overall sound level by ~12 dB when combined as a double bubble curtain for 6 m steel monopiles in the North Sea. Bellmann *et al.* (2020) provide a review of the efficacy of using bubble curtains (both single and double) as noise abatement systems in the German EEZ of the North and Baltic Seas. For 8 m diameter monopiles, single bubble curtains achieved an average of 11 dB broadband noise reduction (Bellmann *et al.*, 2020). In modeling the sound fields for South Fork Wind’s proposed activities, hypothetical broadband attenuation levels of 0 dB, 6 dB, 10 dB,

12 dB, and 15 dB were modeled to gauge the effects on the ranges to thresholds given these levels of attenuation. Although five attenuation levels (and associated ranges) are provided, South Fork Wind anticipates that the use of a noise mitigation system will produce field measurements of the isopleth distances to the Level A harassment and Level B harassment thresholds that accord with those modeled assuming 10 dB of attenuation (see Estimated Take, Proposed Mitigation, and Proposed Monitoring and Reporting sections).

The updated acoustic thresholds for impulsive sounds (such as impact pile driving) contained in the Technical Guidance (NMFS, 2018) were presented as dual metric acoustic thresholds using

both SEL_{cum} and peak sound pressure level metrics (Table 5). As dual metrics, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the two metrics is exceeded (*i.e.*, metric resulting in the largest isopleth). The SEL_{cum} metric considers both level and duration of exposure, as well as auditory weighting functions by marine mammal hearing group.

Tables 7 and 8 shows the modeled acoustic ranges to the Level A harassment thresholds, with 0, 6, 10, 12 and 15 dB sound attenuation incorporated. For the peak level, the greatest distances expected within a given hearing group are shown, typically occurring at the highest hammer energies (Table 7). The SEL_{cum}

Level A harassment threshold is the only metric that is affected by the number of strikes within a 24 hr period; therefore, it is only this acoustic threshold that is associated with differences in range estimates between the standard scenario and the difficult-to drive pile scenario (Table 8). The maximum distances for the other two metrics (peak sound pressure level (SPL_{pk}) and SPL_{rms}) are equal for both scenarios because these metrics are used to define characteristics of a single impulse and do not vary based on the number of strikes (Denes *et al.*, 2020a). The radial distances shown in Tables 7 and 8 are the mean distances from the piles, averaged between the two modeled locations and between summer and winter sound velocity profiles.

TABLE 7—MEAN ACOUSTIC RANGE (R_{95%}) TO LEVEL A PEAK SOUND PRESSURE LEVEL (SPL_{pk}) ACOUSTIC HARASSMENT THRESHOLDS FOR MARINE MAMMALS DUE TO IMPACT PILE DRIVING

Marine mammal hearing group	Threshold SPL _{pk} (dB re 1 μPa)	Mean distance (m) to threshold				
		0 dB attenuation	6 dB attenuation	10 dB attenuation	12 dB attenuation	15 dB attenuation
Low-frequency cetaceans	219	87	22	9	7	2
Mid-frequency cetaceans	230	8	2	1	1	1
High-frequency cetaceans	202	1,545	541	243	183	108
Phocid pinnipeds	218	101	26	12	8	2

dB re 1 μPa = decibel referenced to 1 micropascal.

TABLE 8—MEAN ACOUSTIC RANGE (R_{95%}) TO LEVEL A SOUND EXPOSURE LEVEL (SEL_{cum}) ACOUSTIC HARASSMENT THRESHOLDS FOR MARINE MAMMALS DUE TO IMPACT PILE DRIVING OF A STANDARD PILE (S; 4,500 STRIKES*) AND A DIFFICULT TO DRIVE PILE (D; 8,000 STRIKES*)

Marine mammal hearing group	Threshold SEL _{cum} (dB re 1 μPa ² s)	Mean distance (m) to threshold									
		0 dB attenuation		6 dB attenuation		10 dB attenuation		12 dB attenuation		15 dB attenuation	
		S	D	S	D	S	D	S	D	S	D
Low-frequency cetaceans	183	16,416	21,941	8,888	11,702	6,085	7,846	5,015	6,520	3,676	4,870
Mid-frequency cetaceans	185	107	183	43	59	27	32	27	26	26	26
High-frequency cetaceans	155	9,290	13,374	4,012	6,064	2,174	3,314	2,006	2,315	814	1,388
Phocid pinnipeds	185	3,224	4,523	1,375	2,084	673	1,080	437	769	230	415

dB re 1 μPa² s = decibel referenced to 1 micropascal squared second;

* Approximation.

Table 9 shows the acoustic ranges to the Level B harassment threshold with no attenuation, 6, 10, 12, and 15 dB sound attenuation incorporated. Acoustic propagation was modeled at two representative sites in the SFWF as

described above. The radial distances shown in Table 8 are the mean distance to the Level B harassment threshold from the piles, derived by averaging the R_{95percent} to the Level B harassment thresholds for summer and winter (see

Appendix P2 of the SFWF COP for more details). The range estimated assuming 10 dB attenuation (4,684 m) was used to determine the extent of the Level B harassment zone for impact pile driving.

TABLE 9—MEAN ACOUSTIC RANGE (R_{95%}) TO LEVEL B HARASSMENT ACOUSTIC THRESHOLD (SPL_{rms}) DUE TO IMPACT PILE DRIVING

Threshold SPL _{rms} (dB re 1 μPa)	Mean distance (m) to threshold				
	0 dB attenuation	6 dB attenuation	10 dB attenuation	12 dB attenuation	15 dB attenuation
160	11,382	6,884	4,684	4,164	3,272

dB re 1 μPa = decibel referenced to 1 micropascal.

Impact Pile Driving: Exposure-Based Ranges

Modeled acoustic ranges to threshold levels may overestimate the actual distances at which animals receive exposures meeting the Level A (SEL_{cum}) harassment threshold criterion. In addition, modeled acoustic ranges to thresholds assume that receivers (*i.e.*, animals) are stationary. Therefore, such ranges are not realistic, particularly for accumulating metrics like SEL_{cum}. Applying animal movement and behavior (Denes *et al.* 2020c) within the propagated noise fields provides the exposure range, which results in a more

realistic indication of the distances at which acoustic thresholds are met. For modeled animals that have received enough acoustic energy to exceed a given threshold, the exposure range for each animal is defined as the closest point of approach (CPA) to the source made by that animal while it moved throughout the modeled sound field, accumulating received acoustic energy. The resulting exposure range for each species is the 95th percentile of the CPA distances for all animals that exceeded threshold levels for that species (termed the 95 percent exposure range [ER_{95percent}]). Notably, the ER_{95percent} are species-specific rather than categorized

only by hearing group which affords more biologically-relevant data (*e.g.*, dive durations, swim speeds, etc.) to be considered when assessing impact ranges. The ER_{95percent} for SEL_{cum} are provided in Table 10 and are smaller than the acoustic ranges calculated using propagation modeling alone (Table 7 and 8). Please see the Estimated Take section below and Appendix P1 of the SFWF COP for further detail on the acoustic modeling methodology. The ER_{95percent} ranges assuming 10 dB attenuation for a difficult-to-drive pile were used to determine the Level A harassment zones for impact pile driving.

TABLE 10—EXPOSURE-BASED RANGES (ER_{95%}) TO LEVEL A SOUND EXPOSURE LEVEL (SEL_{cum}) HARASSMENT ACOUSTIC THRESHOLDS DUE TO IMPACT PILE DRIVING OF A STANDARD PILE (S; 4,500 STRIKES*) AND A DIFFICULT TO DRIVE PILE (D; 8,000 STRIKES*)

Species	ER _{95%} to SEL _{cum} thresholds (m)									
	0 dB attenuation		6 dB attenuation		10 dB attenuation		12 dB attenuation		15 dB attenuation	
	S	D	S	D	S	D	S	D	S	D
Low-Frequency Cetaceans										
Fin whale	5,386	6,741	2,655	2,982	1,451	1,769	959	1,381	552	621
Minke whale	5,196	6,033	2,845	2,882	1,488	1,571	887	964	524	628
Sei whale	5,287	6,488	2,648	3,144	1,346	1,756	1,023	1,518	396	591
Humpback whale	9,333	11,287	5,195	5,947	3,034	3,642	2,450	2,693	1,593	1,813
North Atlantic right whale	4,931	5,857	2,514	3,295	1,481	1,621	918	1,070	427	725
Blue whale ¹	5,386	6,741	2,655	2,982	1,451	1,769	959	1,381	552	621
Mid-Frequency Cetaceans										
Sperm whale	0	0	0	0	0	0	0	0	0	0
Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0
Atlantic white-sided dolphin	20	6	20	6	0	0	0	0	0	0
Common dolphin	0	0	0	0	0	0	0	0	0	0
Risso's dolphin	24	13	24	0	0	0	0	0	0	0
Bottlenose dolphin	13	13	0	0	0	0	0	0	0	0
Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0
High-Frequency Cetaceans										
Harbor porpoise	2,845	3,934	683	996	79	365	26	39	21	26
Pinnipeds in Water										
Gray seal	1,559	1,986	276	552	46	117	0	21	0	21
Harbor seal	1,421	2,284	362	513	22	85	22	0	21	0

dB re 1 μPa² s = decibel referenced to 1 micropascal squared second.

* Approximation.

¹ There were no Level A SEL_{cum} exposures as a result of animal movement modeling for the blue whale which resulted in a "0" exposure range; however, an expected exposure range for mitigation purposes must be applied to each species. Therefore, the fin whale exposure range was used as a proxy for the blue whale given similarity of species and activity.

Cofferdam Installation and Removal

For vibratory pile driving (non-impulsive sounds), sound source characteristics were generated by JASCO using GRLWEAP 2010 wave equation model (Pile Dynamics, Inc., 2010). Installation and removal of the cofferdam were modeled from a single location. The radiated sound waves were modeled as discrete point sources over the full length of the pile in the water and sediment (9.1 m [30 ft] water depth, 9.1 m [30 ft] penetration) with a

vertical separation of 0.1 m (0.32 ft). Removal of the cofferdam using a vibratory extractor is expected to be acoustically comparable to installation activities. No noise mitigation system will be used during vibratory piling. Summaries of the maximum ranges to Level A harassment thresholds and Level B harassment thresholds resulting from propagation modeling of vibratory pile driving are provided in Table 11. Peak thresholds were not reached for any marine mammal hearing group.

The large Level B harassment isopleths resulting from vibratory piling installation and removal are a reflection of the threshold set for behavioral disturbance from a continuous noise (*i.e.*, 120 dB_{rms}). Level B harassment thresholds are highly contextual for species and the isopleth distance does not represent a definitive impact zone or a suggested mitigation zone; rather, the information serves as the basis for assessing potential impacts within the context of the project and potentially exposed species.

TABLE 11—DISTANCES TO LEVEL A CUMULATIVE SOUND EXPOSURE LEVEL (SEL_{cum}) HARASSMENT ACOUSTIC THRESHOLDS AND LEVEL B ROOT-MEAN-SQUARE SOUND PRESSURE LEVEL (SPL_{rms}) ACOUSTIC THRESHOLD DUE TO 18 HOURS OF VIBRATORY PILE DRIVING

Marine mammal hearing group	Level A threshold SEL _{cum} (dB re 1 μPa ² s)	Maximum distance (m) to Level A threshold	Level B threshold SPL _{rms} (dB re 1 μPa)	Maximum distance (m) to Level B threshold
Low-frequency cetaceans	199	1,470	120	36,766
Mid-frequency cetaceans	198	0	120	36,766
High-frequency cetaceans	173	63	120	36,766
Phocid pinnipeds	201	103	120	36,766

dB re 1 μPa = decibel referenced to 1 micropascal; μPa² s = decibel referenced to 1 micropascal squared second.

HRG Surveys

Isopleth distances to Level A harassment thresholds for all types of HRG equipment and all marine mammal functional hearing groups were modeled using the NMFS User Spreadsheet and NMFS Technical Guidance (2018), which provides a conservative approach to exposure estimation.

NMFS has developed a user-friendly methodology for determining the rms sound pressure level (SPL_{rms}) at the 160-dB isopleth for the purposes of estimating the extent of Level B harassment isopleths associated with HRG survey equipment (NMFS, 2020). This methodology incorporates frequency-dependent absorption and some directionality to refine estimated ensounded zones. South Fork Wind used NMFS’s methodology with additional modifications to incorporate a seawater absorption formula and account for energy emitted outside of the primary beam of the source. For sources that

operate with different beam widths, the maximum beam width was used (see Table 2). The lowest frequency of the source was used when calculating the absorption coefficient (Table 2).

NMFS considers the data provided by Crocker and Fratantonio (2016) to represent the best available information on source levels associated with HRG equipment and, therefore, recommends that source levels provided by Crocker and Fratantonio (2016) be incorporated in the method described above to estimate isopleth distances to the Level A harassment and Level B harassment thresholds. In cases when the source level for a specific type of HRG equipment is not provided in Crocker and Fratantonio (2016), NMFS recommends that either the source levels provided by the manufacturer be used, or, in instances where source levels provided by the manufacturer are unavailable or unreliable, a proxy from Crocker and Fratantonio (2016) be used

instead. Table 2 shows the HRG equipment types that may be used during the proposed surveys and the sound levels associated with those HRG equipment types.

Results of modeling using the methodology described above indicated that, of the HRG survey equipment planned for use by South Fork Wind that has the potential to result in Level B harassment of marine mammals, sound produced by the Applied Acoustics Dura-Spark UHD sparkers and GeoMarine Geo-Source sparker would propagate furthest to the Level B harassment threshold (141 m; Table 12). For the purposes of the exposure analysis, it was conservatively assumed that sparkers would be the dominant acoustic source for all survey days. Thus, the distances to the isopleths corresponding to the threshold for Level B harassment for sparkers (141 m) was used as the basis of the take calculation for all marine mammals.

TABLE 12—DISTANCE TO WEIGHTED LEVEL A HARASSMENT AND LEVEL B HARASSMENT THRESHOLDS FOR EACH HRG SOUND SOURCE OR COMPARABLE SOUND SOURCE CATEGORY FOR MARINE MAMMAL HEARING GROUPS

Source	Distance to Level A threshold (m)					Distance to Level B (m)
	LF (SEL _{cum} threshold)	MF (SEL _{cum} threshold)	HF (SEL _{cum} threshold)	HF (SPL _{0-pk} threshold)	PW (SEL _{cum} threshold)	All species (160 dB SPL _{rms} threshold)
Shallow SBPs						
ET 216 CHIRP	<1	<1	2.9	—	0	12
ET 424 CHIRP	0	0	0	—	0	4
ET 512i CHIRP	0	0	<1	—	0	6
GeoPulse 5430	<1	<1	36.5	—	<1	29
TB CHIRP III	1.5	<1	16.9	—	<1	54
Medium SBPs						
AA Triple plate S-Boom (700/1,000 J)	<1	0	0	4.7	<1	76
AA, Dura-spark UHD (500 J/400 tip)	<1	0	0	2.8	<1	141
AA, Dura-spark UHD 400+400	<1	0	0	2.8	<1	141
GeoMarine, Geo-Source dual 400 tip sparker	<1	0	0	2.8	<1	141

— = not applicable; μPa = micropascal; AA = Applied Acoustics; CHIRP = Compressed High-Intensity Radiated Pulse; dB = decibels; ET = EdgeTech; HF = high-frequency; J = joules; LF = low-frequency; MF = mid-frequency; PW = Phocids in water; re = referenced to; SBP = sub-bottom profiler; SEL_{cum} = cumulative sound exposure level in dB re 1 μPa² s; SPL_{0-pk} = zero to peak sound pressure level in dB re 1 μPa; TB = teledyne benthos; UHD = ultra-high definition; USBL = ultra-short baseline.

Marine Mammal Occurrence

This section provides information about the presence, density, or group dynamics of marine mammals that will inform the take calculations. The best available information regarding marine mammal densities in the project area is provided by habitat-based density models produced by the Duke University Marine Geospatial Ecology Laboratory (Roberts *et al.*, 2016, 2017, 2018, 2020). Density models were originally developed for all cetacean taxa in the U.S. Atlantic (Roberts *et al.*, 2016); more information, including the model results and supplementary information for each of those models, is available at seamap.env.duke.edu/models/Duke-EC-GOM-2015/. In subsequent years, certain models have been updated on the basis of additional data as well as certain methodological improvements. Although these updated models (and a newly developed seal density model) are not currently publicly available, our evaluation of the changes leads to a conclusion that these represent the best scientific evidence available. Marine mammal density estimates in the SFWF (animals/km²) were obtained using these model results (Roberts *et al.*, 2016, 2017, 2018, 2020). As noted, the updated models incorporate additional sighting data, including sightings from the NOAA Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys from 2010–2016 which included some aerial surveys over the RI/MA & MA WEAs (NEFSC & SEFSC, 2011a, 2011b,

2012, 2014a, 2014b, 2015, 2016). Roberts *et al.* (2020) further updated model results for North Atlantic right whales by incorporating additional sighting data and implementing three major changes: Increasing spatial resolution, generating monthly estimates on three time periods of survey data, and dividing the study area into five discrete regions.

Densities of marine mammals and their subsequent exposure risk are different for the wind farm area (where impact pile driving will occur), the near shore export cable area (where vibratory pile driving will occur), and the HRG survey area. Therefore, density blocks (Roberts *et al.*, 2016; Roberts, 2018) specific to each construction area were selected for evaluating the potential takes of the 16 assessed species. The Denes *et al.* (2020c) model analysis utilized North Atlantic right whale densities from the most recent survey time period, 2010–2018, as suggested by Roberts *et al.* (2020).

Monopile Installation

Mean monthly densities for all animals were calculated using a 60 km (37.3 mi) square centered on SFWF and overlaying it on the density maps from Roberts *et al.* (2016, 2017, 2018, 2020). The relatively large area selected for density estimation encompasses and extends beyond the estimated distances to the isopleth corresponding to the Level B harassment (with no attenuation, as well as with 6, 10, 12 and 15 dB sound attenuation) for all

hearing groups using the unweighted threshold of 160 dB re 1 μPa (rms) (Table 9). Please see Figure 3 in the SFWF COP (Appendix P2) for an example of a density map showing Roberts *et al.* (2016, 2017, 2018, 2020) density grid cells overlaid on a map of the SFWF.

The mean density for each month was determined by calculating the unweighted mean of all 10 x 10 km (6.2 x 6.2 mi) grid cells partially or fully within the buffer zone polygon. Mean values from the density maps were converted from units of abundance (animals/100 km² [38.6 miles²]) to units of density (animals/km²). Densities were computed for the months of May to December to coincide with planned pile driving activities (as described above, no pile driving would occur from January through April). In cases where monthly densities were unavailable, annual mean densities (*e.g.*, pilot whales) and seasonal mean densities (*e.g.*, all seals) were used instead. Table 13 shows the monthly marine mammal density estimates for each species incorporated in the exposure modeling analysis. To obtain conservative exposure estimates, South Fork Wind used the maximum of the mean monthly (May to December) densities for each species to estimate the number of individuals of each species exposed above Level A harassment and Level B harassment thresholds. The maximum densities applied are denoted by an asterisk.

TABLE 13—ESTIMATED DENSITIES (ANIMALS/KM²) USED FOR MODELING MARINE MAMMAL EXPOSURES WITHIN SOUTH FORK WIND FARM

Common name	Monthly density (animals km ⁻²)							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fin whale	0.00201	0.00219	*0.00264	0.00251	0.00217	0.00145	0.00102	0.00105
Minke whale	*0.00163	0.00143	0.00047	0.00026	0.00027	0.00049	0.00022	0.00032
Sei whale	*0.00019	0.00013	0.00003	0.00002	0.00003	0.00000	0.00001	0.00001
Humpback whale	0.00133	0.00148	0.00069	0.00094	*0.00317	0.00156	0.00042	0.00061
North Atlantic right whale	*0.00154	0.00011	0.00002	0.00001	0.00001	0.00005	0.00029	0.00151
Blue whale	*0.00001							
Sperm whale	0.00002	0.00008	*0.00031	0.00024	0.00010	0.00007	0.00007	0.00001
Atlantic white-sided dolphin	*0.03900	0.03600	0.02500	0.01300	0.01500	0.02200	0.02100	0.02800
Atlantic spotted dolphin	0.00012	0.00016	0.00034	0.00041	0.00051	*0.00058	0.00037	0.00007
Common bottlenose dolphin	0.00496	0.01800	0.03700	0.03800	*0.04000	0.02000	0.00962	0.00846
Pilot whales ¹	*0.00596							
Risso's dolphin	0.00005	0.00005	0.00018	*0.00026	0.00015	0.00005	0.00009	0.00019
Common dolphin	0.04400	0.04600	0.04300	0.06200	0.10200	0.12800	0.09800	*0.20400
Harbor porpoise	*0.03800	0.00236	0.00160	0.00172	0.00161	0.00399	0.02400	0.02300
Gray seal	*0.03900	0.02600	0.00874	0.00357	0.00529	0.00955	0.00630	0.03400
Harbor seal	*0.03900	0.02600	0.00874	0.00357	0.00529	0.00955	0.00630	0.03400

* Denotes the highest monthly density estimated.

¹ Long- and short-finned pilot whales are grouped together to estimate the total density of both species.

Cofferdam Installation and Removal

Marine mammal densities in the near shore export cable area were estimated from the 10 × 10 km habitat density blocks that contained the anticipated location of the cofferdam. Monthly marine mammal densities for the potential construction locations of the cofferdam are provided in Table 14. The

maximum densities (denoted by an asterisk) were incorporated in the exposure modeling to obtain the most conservative estimates of potential take by Level A harassment or Level B harassment.

The species listed in each respective density table represent animals that could be reasonably expected within the propagated Level B harassment

threshold distances at each location, in the months during which the cofferdam may be installed and extracted (e.g., October through April). Several of the outer continental shelf and deeper water species that appear in the SFWF area are not included in the cofferdam species list because the densities were zero for those species.

TABLE 14—ESTIMATED DENSITIES (ANIMALS/KM²) USED FOR MODELING MARINE MAMMAL EXPOSURES WITHIN THE AFFECTED AREA AND CONSTRUCTION SCHEDULE OF THE COFFERDAM INSTALLATION

Species ¹	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Fin whale	0.0001	0.0001	0.0002	*0.0005	0.0002	0.0002	0.0001	0.0001
Minke whale	0.0005	*0.0008	0.0008	0.0000	0.0000	0.0000	0.0005	0.0005
Sei whale	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Humpback whale	*0.0002	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
North Atlantic right whale	*0.0014	0.0014	0.0013	0.0008	0.0003	0.0000	0.0002	0.0008
Atlantic white-sided dolphin	0.0001	0.0000	0.0001	0.0002	*0.0003	0.0003	0.0003	0.0002
Common dolphin	0.0003	0.0001	0.0001	0.0003	0.0007	0.0007	*0.0010	0.0008
Common bottlenose dolphin	0.0694	0.0296	0.0157	0.0474	0.3625	*0.4822	0.2614	0.0809
Harbor porpoise	0.0007	0.0005	0.0005	0.0011	0.0007	*0.0026	0.0003	0.0006
Gray seal	*0.3136	0.3136	0.3136	0.3136	0.3136	0.3136	0.3136	0.3136
Harbor seal	*0.3136	0.3136	0.3136	0.3136	0.3136	0.3136	0.3136	0.3136

* Denotes density used for take estimates.
¹ Only species with potential exposures are listed.

HRG Surveys

Densities for HRG surveys were combined for the wind farm area (inter-array cables) and the export cable route using density blocks that encompassed

those areas. The densities used for HRG surveys are provided in Table 15. Average annual, rather than maximum monthly, densities were estimated to account for spatial variability in the

distribution of marine mammals throughout the SFWF and SFEC and temporal variability in distribution over the 12-month timeframe during which HRG surveys would occur.

TABLE 15—ESTIMATED DENSITIES (ANIMALS/KM²) OF MARINE MAMMALS WITHIN THE HIGH RESOLUTION GEOPHYSICAL SURVEY AREA
 [Export cable route and inter-array cables]

Species	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual average*
Fin whale	0.0020	0.0015	0.0016	0.0027	0.0022	0.0022	0.0025	0.0024	0.0018	0.0018	0.0016	0.0022	0.0020
Minke whale	0.0006	0.0007	0.0006	0.0004	0.0005	0.0006	0.0006	0.0004	0.0002	0.0001	0.0006	0.0006	0.0005
Sei whale	0.0001	0.0001	0.0001	0.0002	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Humpback whale	0.0008	0.0007	0.0008	0.0006	0.0009	0.0013	0.0008	0.0010	0.0013	0.0013	0.0013	0.0007	0.0010
North Atlantic right whale	0.0038	0.0053	0.0060	0.0054	0.0016	0.0001	0.0000	0.0000	0.0000	0.0000	0.0003	0.0017	0.0020
Sperm whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Atlantic white-sided dolphin	0.0227	0.0103	0.0078	0.0172	0.0326	0.0276	0.0178	0.0126	0.0202	0.0267	0.0298	0.0352	0.0217
Atlantic spotted dolphin	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Common dolphin	0.0218	0.0100	0.0085	0.0182	0.0568	0.0645	0.0417	0.0456	0.0468	0.0538	0.0600	0.0506	0.0399
Common bottlenose dolphin	0.0081	0.0033	0.0014	0.0035	0.0241	0.0324	0.0544	0.0405	0.0393	0.0392	0.0271	0.0108	0.0237
Risso's dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Long-finned pilot whale	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
Harbor porpoise	0.0871	0.0584	0.0475	0.0964	0.0547	0.0182	0.0037	0.0014	0.0024	0.0150	0.0046	0.0482	0.0365
Gray seal	0.0151	0.0151	0.0151	0.0151	0.0151	0.0030	0.0030	0.0030	0.0151	0.0151	0.0151	0.0151	0.0121
Harbor seal	0.0151	0.0151	0.0151	0.0151	0.0151	0.0030	0.0030	0.0030	0.0151	0.0151	0.0151	0.0151	0.0121

* Annual average density used for take estimates.

Take Calculation and Estimation

Below is a description of how the information provided above is brought together to produce a quantitative take estimate. The following steps were performed to estimate the potential numbers of marine mammal exposures above Level A harassment and Level B harassment thresholds as a result of the proposed activities.

Monopile Installation

JASCO's Animal Simulation Model Including Noise Exposure (JASMINE) animal movement model was used to predict the probability of marine mammal exposure to impact pile driving sound. Sound exposure models like JASMINE use simulated animals (also known as "animats") to forecast behaviors of animals in new situations and locations based on previously documented behaviors of those animals. The predicted 3D sound fields (i.e., the

output of the acoustic modeling process described earlier) are sampled by animats using movement rules derived from animal observations. The output of the simulation is the exposure history for each animat within the simulation.

The precise location of animats (and their pathways) are not known prior to a project, therefore a repeated random sampling technique (Monte Carlo) is used to estimate exposure probability with many animats and randomized starting positions. The probability of an

animat starting out in or transitioning into a given behavioral state can be defined in terms of the animat's current behavioral state, depth, and the time of day. In addition, each travel parameter and behavioral state has a termination function that governs how long the parameter value or overall behavioral state persists in the simulation.

The output of the simulation is the exposure history for each animat within the simulation, and the combined history of all animats gives a probability density function of exposure during the project. Scaling the probability density function by the real-world density of animals (Table 13) results in the mean number of animats expected to be exposed over the duration of the project. Due to the probabilistic nature of the process, fractions of animats may be predicted to exceed threshold. If, for example, 0.1 animats are predicted to exceed threshold in the model, that is interpreted as a 10% chance that one animat will exceed a relevant threshold during the project, or equivalently, if the simulation were re-run ten times, one of the ten simulations would result in an animat exceeding the threshold. Similarly, a mean number prediction of 33.11 animats can be interpreted as re-running the simulation where the number of animats exceeding the threshold may differ in each simulation but the mean number of animats over all of the simulations is 33.11. A portion of an individual marine mammal cannot be taken during a project, so it is common practice to round mean number animat exposure values to integers using standard rounding methods. However, for low-probability events it is more precise to provide the actual values.

Sound fields were input into the JASMINE model and animats were programmed based on the best available information to "behave" in ways that reflect the behaviors of the 16 marine mammal species expected to occur in the project area during the proposed activity. The various parameters for forecasting realistic marine mammal behaviors (e.g., diving, foraging, surface times, etc.) are determined based on the available literature (e.g., tagging studies); when literature on these behaviors was not available for a

particular species, it was extrapolated from a similar species for which behaviors would be expected to be similar to the species of interest. Please refer to the footnotes on Tables 16 and 17, and Appendix P2 of SFWF COP for a more detailed description of the species that were used as proxies when data on a particular species was not available. The parameters used in JASMINE describe animat movement in both the vertical and horizontal planes (e.g., direction, travel rate, ascent and descent rates, depth, bottom following, reversals, inter-dive surface interval). More information regarding modeling parameters can be found in Denes *et al.* (2020c).

The mean number of animats that may be exposed to noise exceeding acoustic thresholds were calculated for two construction schedules; one representing the most likely schedule, and one representing a more aggressive, or maximum schedule (Denes *et al.*, 2019). The most likely schedule assumes that three foundations are installed per week with an average of one pile installed every other day. The maximum schedule assumes six monopile foundations are installed per week with one pile installation per day. Within each of the construction schedules, a single difficult-to-drive pile was included in the model assumptions to account for the potential for additional strikes (Denes *et al.*, 2019). Animats were modeled to move throughout the three-dimensional sound fields produced by each construction schedule for the entire construction period. For PTS exposures, both SPLpk and SELcum were calculated for each species based on the corresponding acoustic criteria. Once an animat is taken within a 24-hrs period, the model does not allow it to be taken a second time in that same period but rather resets the 24-hrs period on a sliding scale across 7 days of exposure. An individual animat's exposure levels are summed over that 24-hrs period to determine its total received energy, and then compared to the threshold criteria. Potential behavioral exposures are estimated when an animat is within the area ensounded by sound levels exceeding the corresponding thresholds.

It should be noted that the estimated numbers of individuals exceeding any of the thresholds is conservative because the 24-hrs evaluation window allows individuals to be counted on multiple days or can be interpreted as different individuals each 24-hrs period when in the real world it may in fact be the same individual experiencing repeated exposures (Denes *et al.*, 2019). Also note that animal aversion was not incorporated into the JASMINE model runs that were the basis for the take estimate for any species. See Appendix P2 of the SFWF COP for more details on the JASMINE modeling methodology, including the literature sources used for the parameters that were input in JASMINE to describe animal movement for each species that is expected to occur in the project area.

In summary, exposures were estimated in the following way:

- (1) The characteristics of the sound output from the proposed pile-driving activities were modeled using the GRLWEAP (wave equation analysis of pile driving) model and JASCO's PDSM;

- (2) Acoustic propagation modeling was performed within the exposure model framework using JASCO's MONM and FWRAM that combined the outputs of the source model with the spatial and temporal environmental context (e.g., location, oceanographic conditions, seabed type) to estimate sound fields;

- (3) Animal movement modeling integrated the estimated sound fields with species-typical behavioral parameters in the JASMINE model to estimate received sound levels for the animals that may occur in the operational area; and

- (4) The number of potential exposures above Level A and Level B harassment thresholds was calculated for each potential piling scenario (standard, maximum).

All scenarios were modeled with no sound attenuation and 6, 10, 12, and 15 dB sound attenuation. The results of marine mammal exposure modeling for the potentially more impactful maximum piling scenarios are shown in Tables 16 and 17, as these form the basis for the take authorization proposed in this document.

TABLE 16—MODELED POTENTIAL LEVEL A HARASSMENT EXPOSURES ¹ DUE TO IMPACT PILE DRIVING USING THE MAXIMUM DESIGN SCENARIO WITH THE INCLUSION OF 1 DIFFICULT PILE AND 0, 6, 10, 12, AND 15 dB BROADBAND ATTENUATION

Species	0 dB attenuation		6 dB attenuation		10 dB attenuation		12 dB attenuation		15 dB attenuation	
	SEL _{cum}	SPL _{pk}	SEL_{cum}	SPL_{pk}	SEL_{cum}	SPL_{pk}	SEL_{cum}	SPL_{pk}	SEL_{cum}	SPL_{pk}
Low-Frequency Cetaceans										
Fin whale	7	<1	3	<1	1	<1	1	<1	<1	<1
Minke whale ²	7	<1	3	<1	1	<1	1	<1	<1	<1
Sei whale ³	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Humpback whale ²	21	<1	9	<1	4	<1	3	<1	3	<1
North Atlantic right whale ²	4	<1	1	<1	<1	<1	<1	<1	<1	<1
Blue whale	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mid-Frequency Cetaceans										
Sperm whale	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Atlantic spotted dolphin ⁴	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Atlantic white sided dolphin ⁴	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bottlenose dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Common dolphin ⁴	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Risso's dolphin ⁴	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pilot whale ⁵	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
High-Frequency Cetaceans										
Harbor porpoise	33	23	4	7	7	3	1	3	<1	1
Pinnipeds in Water										
Gray seal ⁶	6	<1	1	<1	<1	<1	<1	<1	<1	<1
Harbor seal	8	1	2	<1	<1	<1	<1	<1	<1	<1

dB = decibel; SEL_{cum} = sound exposure level in units of dB referenced to 1 micropascal squared second; SPL_{pk} = peak sound pressure level in units of dB referenced to 1 micropascal.

¹ The maximum density available for any month was used for each species to estimate the maximum potential exposures (i.e., exposure estimates for all species are not for the same month).

² Subset of fin whale behaviors used to approximate model parameters.

³ Fin whale used as proxy species for exposure modeling.

⁴ Subset of sperm whale and Atlantic spotted dolphin behaviors used to approximate model parameters.

⁵ Subset of sperm whale behaviors used to approximate model parameters.

⁶ Harbor seal used as proxy species for exposure modeling.

⁷ Calculated exposures with 10 dB for harbor porpoises were <1 but >0.5; therefore they were rounded up to the nearest whole number.

Again, only the estimated Level B design pile driving schedule are harassment exposures for the maximum presented here (Table 17).

TABLE 17—MODELED POTENTIAL LEVEL B HARASSMENT EXPOSURES ¹ DUE TO IMPACT PILE DRIVING USING THE MAXIMUM DESIGN SCENARIO WITH 1 DIFFICULT PILE AND 0, 6, 10, 12, AND 15 dB BROADBAND ATTENUATION

Species	Level B exposures by noise attenuation level				
	0 dB attenuation	6 dB attenuation	10 dB attenuation	12 dB attenuation	15 dB attenuation
Low-Frequency Cetaceans:					
Fin whale	21	10	6	5	4
Minke whale ²	27	15	10	8	6
Sei whale ³	<1	<1	<1	<1	<1
Humpback whale ²	26	13	8	7	6
North Atlantic right whale ²	16	7	4	3	3
Blue whale	<1	<1	<1	<1	<1
Mid-Frequency Cetaceans:					
Sperm whale	<1	<1	<1	<1	<1
Atlantic spotted dolphin ⁴	6	3	2	1	<1
Atlantic white sided dolphin ⁴	322	152	107	85	48
Bottlenose dolphin	1,261	459	197	148	73
Common dolphin ⁴	2	1	<1	<1	<1
Risso's dolphin ⁴	212	85	43	34	14
Pilot whale ⁵	<1	<1	<1	<1	<1
High-Frequency Cetaceans:					
Harbor porpoise	272	129	78	67	40
Pinnipeds in Water:					
Gray seal ⁶	307	116	60	52	28
Harbor seal	319	119	54	45	28

dB = decibel.

- ¹ The maximum density available for any month was used for each species to estimate the maximum potential exposures (*i.e.*, exposure estimates for all species are not for the same).
- ² Subset of fin whale behaviors used to approximate model parameters.
- ³ Fin whale used as proxy species for exposure modeling.
- ⁴ Subset of sperm whale and Atlantic spotted dolphin behaviors used to approximate model parameters.
- ⁵ Subset of sperm whale behaviors used to approximate model parameters.
- ⁶ Harbor seal used as proxy species for exposure modeling.

Although exposures are presented according to a range of attenuation levels, proposed take numbers are based on an assumption of 10 dB attenuation and are shown below in Table 18. South Fork Wind considers an attenuation level of 10 dB achievable using a single big bubble curtain (BBC), which is the most likely noise mitigation system that will be used during construction of SFWF. Recently reported in situ measurements during installation of large monopiles (~8 m) for more than 150 WTGs in comparable water depths (>25 m) and conditions in Europe indicate that attenuation levels of 10 dB are readily achieved (Bellmann, 2019; Bellmann *et al.*, 2020) using single BBCs

as a noise mitigation system. Designed to gather additional data regarding the efficacy of BBCs, the Coastal Virginia Offshore Wind (CVOW) pilot project systematically measured noise resulting from the impact driven installation of two 7.8 m monopiles, one with a noise mitigation system (double bubble curtain (dBBC)) and one without (CVOW, unpublished data). Although many factors contributed to variability in received levels throughout the installation of the piles (*e.g.*, hammer energy, technical challenges during operation of the dBBC), reduction in broadband SEL using the dBBC (comparing measurements derived from the mitigated and the unmitigated

monopiles) ranged from approximately 9 to 15 dB. The effectiveness of the dBBC as a noise mitigation measure was found to be frequency dependent, reaching a maximum around 1 kHz; this finding is consistent with other studies (*e.g.*, Bellman, 2014; Bellman *et al.*, 2020). The noise measurements were incorporated into a dampened cylindrical transmission loss model to estimate distances to Level A and Level B harassment thresholds. The distances to Level A harassment and Level B harassment thresholds estimated for the monopile with the dBBC were more than 90 percent and 74 percent smaller than those estimated for the unmitigated pile, respectively (CVOW).

TABLE 18—PROPOSED LEVEL A HARASSMENT AND LEVEL B HARASSMENT TAKES OF MARINE MAMMALS RESULTING FROM IMPACT PILE DRIVING OF UP TO 15, 11-m MONOPILES WITHIN INCLUSION OF A SINGLE DIFFICULT PILE AT SOUTH FORK WIND FARM USING 10 dB BROADBAND NOISE ATTENUATION

Species/stock	Abundance estimate	Proposed takes ¹	
		Level A	Level B
Fin whale	6,802	1	6
Minke whale	21,968	1	10
Sei whale	6,292	1(0)	1
Humpback whale	1,393	4	8
North Atlantic right whale	412	0	4
Blue whale	402	0	1(0)
Sperm whale	4,349	0	3(0)
Long-finned pilot whale	39,921	0	2
Atlantic spotted dolphin	39,921	0	2
Atlantic white-sided dolphin	93,233	0	107
Common dolphin	172,974	0	197
Risso's dolphin	35,493	0	30(1)
Common bottlenose dolphin	62,851	0	43
Harbor porpoise	95,543	0	78
Gray seal	505,000	0	60
Harbor seal	75,834	0	54

¹ Parentheses denote animal exposure model estimates. For species with no modeled exposures for Level A harassment or Level B harassment, proposed takes for impact pile driving are based on mean group sizes (*e.g.*, sei whale, blue whale, long-finned pilot whale: Kenney and Vigness-Raposa, 2010; sperm whale, Risso's dolphin: Barkaszi and Kelly, 2018).

South Fork Wind conservatively based their exposure modeling on the maximum piling scenario, including one difficult-to-drive monopile (out of 16) and a compressed buildout schedule (16 piles installed over 20 days).

In addition, the acoustic modeling scenario represents only that which produced the largest harassment zones and does not reflect all the mitigation measures that will be employed during piling operations that will serve to reduce the Zone of Influence (ZOI) or increase mitigation actions, which may reduce take (see the Proposed Mitigation

section for details on the measures proposed for implementation).

Variability in monthly species densities is not considered in South Fork Wind's take estimates for monopile driving, which are based on the highest mean density value for any month for each species. Given that less than 30 days of pile driving will occur, it is unlikely that maximum monthly densities would be encountered for all species.

Finally, start delays and shutdowns of pile hammering are not considered in the exposure modeling parameters for

monopile driving. However, South Fork Wind will delay pile driving if a North Atlantic right whale is observed within the Level B harassment zone prior to initiating pile driving to avoid take and if a marine mammal is observed entering or within the respective exclusion zones after pile driving has commenced, an immediate shutdown of pile driving will be implemented unless South Fork Wind and/or its contractor determines shutdown is not practicable due to an imminent risk of injury or loss of life to an individual; or risk of damage to a vessel that creates risk of

injury or loss of life for individuals. There are two scenarios, approaching pile refusal and pile instability, where this imminent risk could be a factor. These scenarios are considered unlikely and it is expected that shutdowns will predominately be practicable during operations. See the Proposed Mitigation section for shutdown procedural details.

Although the exposure modeling indicated that Level A harassment takes are only expected for a three species of baleen whales (fin whale, minke whale, and humpback whale), South Fork Wind requested authorization of take by Level A harassment of one sei whale based on the occurrence of sei whales in the project area documented during prior and ongoing HRG surveys of the SFWF.

South Fork Wind requested authorization of take equal to the mean group size for Level B harassment, based on the best available data (seals, Herr *et al.*, 2009; blue whale, long-finned pilot whale, Kenney and Vigness-Raposa, 2010; sperm whale, and Risso's dolphin, Barkaszi and Kelly, 2018). NMFS agrees

that this approach is appropriate in cases where instantaneous exposure is expected to result in harassment, *e.g.*, Level B harassment and calculated take estimates are either zero or less than the group size.

Cofferdam Installation and Removal

Animal movement and exposure modeling was not used to determine potential exposures from vibratory pile driving. Rather, the modeled acoustic range distances to isopleths corresponding to the Level A harassment and Level B harassment threshold values were used to calculate the area around the cofferdam predicted to be ensonified daily to levels that exceed the thresholds, or the ZOI. ZOI is calculated as the following:

$$ZOI = \pi r^2,$$

where r is the linear acoustic range distance from the source to the isopleth for Level A harassment or Level B harassment thresholds. This area was adjusted to account for the portion of the ZOI truncated by the coastline of Long Island, NY.

The daily area was then multiplied by the maximum monthly density of a given marine mammal species. Roberts *et al.* (2018) produced density models for all seals but did not differentiate by seal species. Because the seasonality and habitat use by gray seals roughly overlaps with that of harbor seals in the survey areas, it was assumed that the mean annual density of seals could refer to either of the respective species and was, therefore, divided equally between the two species.

Finally, the resulting value was multiplied by the number of proposed activity days which is, for cofferdam installation and removal, conservatively estimated as two days. Modeling of the Level A harassment exposures resulting from two 18-hrs periods of vibratory pile driving and removal resulted in less than one exposure for all species for each month between October 1 and May 31. Modeled potential Level B harassment exposures resulting from installation and extraction of the cofferdam are shown in Table 19.

TABLE 19—MODELED LEVEL B HARASSMENT EXPOSURES RESULTING FROM VIBRATORY PILE DRIVING AND REMOVAL OF THE COFFERDAM

Species	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Fin whale	0	0	1	2	1	1	0	0
Minke whale	2	3	3	0	0	0	2	2
Sei whale	0	0	0	0	0	0	0	0
Humpback whale	1	1	1	0	0	0	0	1
North Atlantic right whale	6	6	5	3	1	0	1	3
Atlantic white-sided dolphin	0	0	0	1	1	1	1	1
Common dolphin	1	0	0	1	3	3	4	3
Common bottlenose dolphin	289	123	65	197	1,509	2,007	1,088	337
Harbor porpoise	3	2	2	5	3	11	1	2
Gray seal	1,305	1,305	1,305	1,305	1,305	1,305	1,305	1,305
Harbor seal	1,305	1,305	1,305	1,305	1,305	1,305	1,305	1,305

Maximum 18-hour periods of vibratory pile driving or removal will be separated by at least 24 hours of no vibratory sound source operating at the cofferdam.

Modeled vibratory pile driving activities for the SFEC (SFWF COP Appendix J1 [Denes *et al.*, 2018]) resulted in mean acoustic ranges to the PTS threshold for low frequency cetaceans, ranging from 742 m for 6 hrs of piling to 1,470 m for 18 hrs of piling (Denes *et al.*, 2018). Maximum acoustic ranges to PTS thresholds for other marine mammal hearing groups are all under 103 m. Level A harassment exposures are not expected due to low population densities of LFC species in the project area, animal movement and required accumulation periods (Denes *et al.*, 2019), the short duration of vibratory pile driving, and proposed mitigation measures (see Proposed Mitigation section).

Vibratory pile driving during cofferdam installation and removal for

the SFEC does have the potential to elicit behavioral responses in marine mammals. However, predicting Level B harassment exposure estimates resulting from vibratory pile driving is complicated by the nearshore location, short duration of cofferdam installation and removal, and static species density data that are not indicative of animals transiting the nearshore environment. Marine mammal densities at the near shore export cable area were estimated from the 10 x 10 km habitat density block from Roberts *et al.* (2016) and Roberts *et al.* (2018) that contained the anticipated location of the temporary cofferdam. However, the density estimates are not provided for the area adjacent to the shoreline, although some density blocks do intersect the shore. Due to this structure, densities are

artificially weighted to the nearest 100 km² offshore and do not adequately represent the low numbers expected for some groups like large whales. In addition, the species densities represented in the Roberts *et al.* (2016) and Robert *et al.* (2018) are provided as monthly estimates and are, therefore, not indicative of a single-day distribution of animals within the potential ensonified zone. The modeled behavioral harassment threshold acoustic ranges extend beyond 36 km from the source (Table 11); despite this extensive Level B harassment zone, only bottlenose dolphin, harbor seal, and gray seal exposure estimates are relatively large. However, the low densities of most species nearshore, the seasonality of occurrence, and the transitory nature of marine mammals

within the small time period of vibratory pile driving significantly reduces the risk of behavioral harassment exposures. In addition, marine mammal species in this region are not expected to remain in proximity to the cofferdam location for an extended amount of time. Although the modeled Level B harassment exposure estimates for harbor and gray seals were large (1,305), seals are only expected to be seasonally present in the region, and there are no known rookeries documented near the cofferdam location. Seals typically haul-out for some portion of their daily activities, often in large groups (Hayes *et al.*, 2020); however, the in-water median group size is estimated to be 1–3

animals depending on the distance to shore (Herr *et al.*, 2009) with larger groups typically being associated with direct proximity to a haul-out site. There are a few documented haul-out sites around Long Island, New York; the nearest site is in Montauk Point, approximately 20 km northeast of the cofferdam location, where seals are primarily observed in winter (CRESLI, 2019). Long Island, NY represents the northernmost portion of the range for the Western North Atlantic Migratory Coast Stock of bottlenose dolphins. Bottlenose dolphin occurrence is also seasonal along the coast of Long Island, peaking in late summer/early fall (Hayes *et al.*, 2020). Potential exposures of bottlenose dolphins varied substantially

across the proposed construction months, with a minimum number of potential Level B harassment exposures in March (65) and a maximum in October (2007). The impact of vibratory pile driving on this species (and both seal species) will be largely dependent on the timing of the installation and extraction of the cofferdam.

Given the possibility that vibratory pile driving could occur anytime between October and May, the maximum modeled exposure for each species (across months) was used to conservatively predict take numbers and assess impacts resulting from vibratory pile driving (Table 20).

TABLE 20—PROPOSED LEVEL B HARASSMENT TAKE RESULTING FROM VIBRATORY PILE DRIVING

Species/stock	Population estimate	Proposed level B takes
Fin whale	6,802	2
Minke whale	21,968	3
Sei whale	6,292	0
Humpback whale	1,393	1
North Atlantic right whale	412	6
Atlantic white sided dolphin	93,233	1
Common dolphin	172,974	4
Bottlenose dolphin	62,851	2,007
Harbor porpoise	95,543	11
Gray seal	505,000	1,305
Harbor seal	75,834	1,305

HRG Surveys

Potential exposures of marine mammals to acoustic impacts from HRG survey activities were estimated using an approach similar to that described for installation and removal of a cofferdam. For HRG surveys, however, the ZOI was calculated as follows:

$$ZOI = 2rd + \pi r^2$$

where r is the linear acoustic range from the source to the largest estimated Level A harassment (36.5 m) and Level B harassment (141 m) isopleths, and d is the survey trackline distance per day (70 km).

The daily area was then multiplied by the mean annual density of a given marine mammal species. Finally, the resulting value was multiplied by the number of proposed survey days (60).

Modeled distances to isopleths corresponding to the Level A harassment threshold are very small

(<1 m) for three of the four marine mammal functional hearing groups that may be impacted by the proposed activities (*i.e.*, low frequency and mid frequency cetaceans, and phocid pinnipeds; see Table 12). Based on the extremely small Level A harassment zones for these functional hearing groups, the potential for species within these functional hearing groups to be taken by Level A harassment is considered so low as to be discountable. These three functional hearing groups encompass all but one of the marine mammal species listed in Table 3 that may be impacted by the proposed activities. There is one species (harbor porpoise) within the high frequency functional hearing group that may be impacted by the proposed activities. However, the largest modeled distance to the Level A harassment threshold for the high frequency functional hearing group was only 36.5 m (Table 12). More

importantly, Level A harassment would also be more likely to occur at close approach to the sound source or as a result of longer duration exposure to the sound source, and the narrow beam width and directional nature of the sources, as well as the mitigation measures (including a 100 m exclusion zone for harbor porpoises), minimize the potential for exposure to HRG sources that would result in Level A harassment. In addition, harbor porpoises are a notoriously shy species which is known to avoid vessels and would also be expected to avoid a sound source prior to that source reaching a level that would result in injury (Level A harassment). Therefore, NMFS has determined that the potential for take by Level A harassment of harbor porpoises is so low as to be discountable. The modeled Level B harassment exposures of marine mammals resulting from HRG survey activities are shown in Table 21.

TABLE 21—MODELED LEVEL B HARASSMENT EXPOSURES SPECIES RESULTING FROM HIGH RESOLUTION GEOPHYSICAL SURVEYS OF THE SFWF AND SFEC

Species	Population estimate	Estimated level B exposures
Fin whale	6,802	3
Minke whale	21,968	1
Sei whale	6,292	<1
Humpback whale	1,393	1
North Atlantic right whale	412	3
Sperm whale	4,349	<1
Atlantic spotted dolphin	39,921	<1
Atlantic white-sided dolphin	93,233	26
Common dolphin	172,974	47
Bottlenose dolphin	62,851	28
Risso's dolphin	35,493	<1
Long-finned pilot whale	39,215	4
Harbor porpoise	95,543	43
Gray Seal	505,000	14
Harbor seal	75,834	14

The proposed number of takes by Level B harassment resulting from HRG survey activities are shown in Table 22. Again, as NMFS has determined that the likelihood of take of any marine mammals in the form of Level A harassment occurring as a result of the proposed surveys is so low as to be discountable and South Fork Wind did not request any take by Level A harassment associated with HRG surveys, NMFS does not propose to authorize take by Level A harassment of any marine mammals.

The seasonal mean number of minke whales sighted during HRG surveys

conducted by South Fork Wind in 2017 and 2018 was 19; therefore, South Fork increased the number of takes requested for minke whales from 1 to 19.

Preliminary Protected Species Observer (PSO) reports from SFWF during 2019 and 2020 HRG surveys show a high number of common dolphin detections within the estimated Level B harassment zones. Using a mean group size of 25, South Fork Wind multiplied the mean group size by the number of Level B harassment exposures modeled (47) to produce the number of takes they requested by Level B harassment (1,175). There were no exposures

estimated for several species; however, as a precautionary measure, South Fork Wind requested Level B harassment takes for those species based on published values of mean group sizes (sei whale, Kenney and Vigness-Raposa, 2010; sperm whale, Barkaszi and Kelly, 2018; Atlantic spotted dolphin, Barkaszi and Kelly, 2018; Risso's dolphin, Barkaszi and Kelly, 2018). The number of minke whale Level B harassment takes requested by South Fork Wind is based on the seasonal mean number of minke whales sighted during HRG surveys of SFWF in 2017 and 2018.

TABLE 22—PROPOSED AMOUNT OF LEVEL B HARASSMENT TAKE RESULTING FROM HIGH RESOLUTION GEOPHYSICAL SURVEYS OF THE SFWF AND SFEC

Species/stock	Population estimate	Proposed level B takes ¹
Fin whale	6,802	3
Minke whale	21,968	19(1)
Sei whale	6,292	1(0)
Humpback whale	1,393	1
North Atlantic right whale	412	3
Sperm whale	4,349	3(0)
Long-finned pilot whale	39,215	4
Atlantic spotted dolphin	39,921	13(0)
Atlantic white sided dolphin	93,233	26
Common dolphin	172,974	1,175(47)
Risso's dolphin	35,493	30(0)
Common bottlenose dolphin	62,851	28
Harbor porpoise	95,543	43
Gray seal	505,000	14
Harbor seal	75,834	14

¹ The modeled number of takes is shown in parenthesis.

Combined Activity Proposed Takes

Level A harassment and Level B harassment proposed takes for the combined activities of impact pile driving using a noise attenuation device, vibratory pile driving, and HRG surveys

are provided in Table 23. NMFS also presents the percentage of each stock taken based on the total amount of take. The mitigation and monitoring measures provided in the Proposed Mitigation and Proposed Monitoring

and Reporting sections are activity-specific and are designed to minimize acoustic exposures to marine mammal species.

The take numbers NMFS proposes for authorization (Table 23) are considered

conservative for the following key reasons:

- Proposed take numbers for impact pile driving assume a maximum piling schedule (16 monopiles installed in 20 days);
- Proposed take numbers for vibratory pile driving assume that a sheet pile temporary cofferdam will be installed (versus the alternative

installation of a gravity cell cofferdam, for which no take is anticipated);

- Proposed take numbers for pile driving are conservatively based on maximum densities across the proposed construction months;
- Proposed Level A harassment take numbers do not fully account for the likelihood that marine mammals will avoid a stimulus when possible before the individual accumulates enough

acoustic energy to potentially cause auditory injury;

- Proposed take numbers do not fully account for the effectiveness of proposed mitigation and monitoring measures in reducing the number of takes to effect the least practicable adverse impact (with the exception of the seasonal restriction on impact pile driving, which is accounted for in the proposed take numbers).

TABLE 23—PROPOSED TAKES BY LEVEL A HARASSMENT AND LEVEL B HARASSMENT FOR ALL ACTIVITIES¹ CONDUCTED DURING SFWF CONSTRUCTION

Species/stock	Population estimate	Proposed take authorization combined for all construction activities		Total proposed takes (level A + level B)	* Percentage of population or stock (%)
		Proposed level A takes	Proposed level B takes		
Fin whale	6,802	1	11	12	0.18
Minke whale	21,968	1	32	33	0.15
Sei whale	6,292	1	2	3	0.05
Humpback whale	1,393	4	10	14	1.01
North Atlantic right whale	412	0	13	13	3.16
Blue whale	402	0	1	1	0.20
Sperm whale	4,349	0	6	6	0.14
Pilot whales (long-finned)	39,215	0	16	16	0.04
Atlantic spotted dolphin	39,921	0	15	15	0.04
Atlantic white sided dolphin	93,233	0	133	133	0.14
Common dolphin	172,974	0	1,372	1,372	0.79
Risso's dolphin	35,493	0	60	60	0.17
Common Bottlenose dolphin	62,851	0	2,078	2,078	3.31
Harbor porpoise	95,543	0	132	132	0.14
Gray seal	505,000	0	1,379	1,379	0.27
Harbor seal	75,834	0	1,379	1,379	1.81

¹ Activities include impact pile driving using a noise mitigation system (NMS) from May through October, vibratory pile driving (October through May), and HRG surveys (year-round).

* Calculations of percentage of stock taken are based on the best available abundance estimate as shown in Table 3. The best available abundance estimates are derived from the draft 2020 NMFS Stock Assessment Reports (Hayes *et al.*, 2020). NMFS stock abundance estimate for gray seals applies to U.S. population only, actual stock abundance is approximately 505,000.

Proposed Mitigation

In order to issue an IHA under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses (latter not applicable for this action). NMFS regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)).

In evaluating how mitigation may or may not be appropriate to ensure the

least practicable adverse impact on species or stocks and their habitat, as well as subsistence uses where applicable, NMFS carefully considers two primary factors:

(1) The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned), and;

(2) The practicability of the measures for applicant implementation, which may consider such things as cost and impact on operations.

The mitigation strategies described below are consistent with those required

and successfully implemented under previous incidental take authorizations issued in association with in-water construction activities. Additional measures have also been incorporated to account for the fact that the proposed construction activities would occur offshore. Modeling was performed to estimate harassment zones, which were used to inform mitigation measures for pile driving activities to minimize Level A harassment and Level B harassment to the extent practicable.

In addition to the specific measures described later in this section, South Fork Wind would conduct briefings for construction supervisors and crews, the marine mammal and acoustic monitoring teams, and South Fork Wind staff prior to the start of all pile driving and HRG survey activity, and when new personnel join the work, in order to explain responsibilities, communication procedures, the marine mammal monitoring protocol, and operational procedures.

Monopile Installation

Seasonal Restriction on Impact Pile Driving

No impact pile driving activities would occur January 1 through April 30. This seasonal restriction would minimize the potential for North Atlantic right whales to be exposed to pile driving noise. Based on the best available information (Kraus *et al.*, 2016; Roberts *et al.*, 2020), the highest densities of North Atlantic right whales in the project area are expected during the months of January through April. This restriction is expected to greatly reduce the potential for North Atlantic right whale exposure to pile driving noise associated with the proposed project.

Clearance and Exclusion Zones

South Fork Wind would use PSOs to establish clearance zones around the pile driving equipment to ensure these zones are clear of marine mammals prior to the start of pile driving. The purpose of “clearance” of a particular zone is to prevent potential instances of auditory injury and potential instances of more severe behavioral disturbance as a result of exposure to pile driving noise (serious injury or death are unlikely outcomes even in the absence of mitigation measures) by delaying the activity before it begins if marine mammals are detected within certain pre-defined distances of the pile driving equipment. The primary goal in this case is to prevent auditory injury (Level A harassment), and the proposed clearance zones are larger than the modeled distances to the isopleths (assuming an effective 10 dB attenuation of pile driving noise) corresponding to Level A harassment for all marine

mammal species (excluding humpback whales). These zones vary depending on species and are shown in Table 24. All distances to the perimeter of clearance zones are the radius from the center of the pile. The pre-start clearance zones for large whales, harbor porpoises, and seals are based upon the maximum distance to the Level A harassment isopleth for each group (excluding humpback whales) plus a 20 percent buffer, rounded up for PSO clarity. The North Atlantic right whale Level A harassment zone is conservatively based on the Level B harassment zone, and the distance to the perimeter of the clearance zone is rounded up from 4,684 m to 5,000 m. Although the Level A harassment zones are small, mid-frequency cetacean (except sperm whales) zones were established using a precautionary distance of 100 m and will extend to that distance or just beyond the placement of the noise mitigation system, whichever is further.

The exclusion zones for large whales, North Atlantic right whale, porpoise, and seals are based upon the maximum Level A harassment zone for each group (excluding humpback whales), increased by a 10 percent buffer and rounded up for PSO clarity. Similar to clearance zones, mid-frequency cetacean (except sperm whale) exclusion zones will extend to the larger of two distances: 50 m or just outside the noise mitigation system.

The Level A harassment zone is larger for humpback whales than other low frequency baleen whales because animal movement modeling used to estimate the associated isopleth relies on behavior-based exposures with no aversion (based on the best available data that inform the animal models); specific movement parameters help

drive the larger zone size for humpbacks, including a modeled preference for slightly deeper water than the depths in the SFWF. This modeled preference resulted in fewer exposures, but each exposure was farther from the impact piling location, producing the larger Level A harassment zone. While the clearance zone (2,200 m) for humpback whales is smaller than the Level A harassment zone (3,642 m), visual monitoring would be conducted from both the construction vessel and a secondary, smaller vessel (on which dedicated PSOs would be deployed) surveying the circumference of the construction vessel at a radius approximate to the pre-start clearance zone for large whales (2,200 m). NMFS expects that this additional visual monitoring would facilitate detection of humpback whales within the Level A harassment zone.

South Fork Wind would establish a clearance zone for North Atlantic right whales slightly larger than the Level B harassment zone to minimize all take. If a North Atlantic right whale is detected nearing the exclusion zone, shutdown would be triggered. NMFS agrees that, under typical conditions, South Fork Wind would be capable of monitoring this zone using a combination of visual monitoring from both the construction vessel and secondary monitoring vessel (described above), and real-time PAM, which would occur before, during, and after driving using a combination of acoustic detection systems (*e.g.*, moored buoys, free-floating arrays). Communication of marine mammal detections, either visual or acoustic, among PSOs on both vessels and PAM operators would facilitate both clearance of the zone and initiation of shutdown, if required.

TABLE 24—PROPOSED CLEARANCE AND EXCLUSION ZONES¹ DURING SOUTH FORK WIND IMPACT PILE DRIVING WITH A NOISE MITIGATION SYSTEM

Species	Level A harassment zone (m) (SEL)	Level A harassment zone (m) (PK)	Level B harassment zone (m)	Pre-start clearance zone (m)	Exclusion zone (m)	Vessel separation distance (m)
Low-frequency Cetaceans:						
Fin whale	1,756	≤10	4,684	2,200	2,000	100
Minke whale	1,571	≤10	4,684	2,200	2,000	100
Sei whale	1,769	≤10	4,684	2,200	2,000	100
Humpback whale	3,642	≤10	4,684	2,200	2,000	100
North Atlantic right whale	1,621	≤10	4,684	5,000	2,000	500
Blue whale ²	1,756	≤10	4,684	2,200	2,000	100
Mid-frequency Cetaceans:						
Sperm whale		≤10	4,684	2,200	2,000	100
Atlantic spotted dolphin		≤10	4,684	100	50	50
Atlantic white-sided dolphin		≤10	4,684	100	50	50
Common dolphin		≤10	4,684	100	50	50
Risso's dolphin		≤10	4,684	100	50	50
Bottlenose dolphin		≤10	4,684	100	50	50
Long-finned pilot whale		≤10	4,684	100	50	50
High-frequency Cetaceans:						

TABLE 24—PROPOSED CLEARANCE AND EXCLUSION ZONES¹ DURING SOUTH FORK WIND IMPACT PILE DRIVING WITH A NOISE MITIGATION SYSTEM—Continued

Species	Level A harassment zone (m) (SEL)	Level A harassment zone (m) (PK)	Level B harassment zone (m)	Pre-start clearance zone (m)	Exclusion zone (m)	Vessel separation distance (m)
Harbor porpoise	365	301	4,684	450	450	50
Phocid Pinnipeds in Water:						
Gray seal	120	≤10	4,684	150	150	50
Harbor seal	85	≤10	4,684	150	150	50

dB = decibel; SEL = cumulative sound exposure level PK = peak sound pressure level.

¹ Zones are based upon the following modeling assumptions: 11-m monopile installation with inclusion of a difficult to install pile that requires approximately 8,000 hammer strikes and mitigated with 10 dB broadband noise attenuation from a noise mitigation system. Only 1 pile out of the 16 total monopiles is expected to be a difficult pile.

² No Level A exposures were calculated for blue whales resulting in no expected Level A exposure range; therefore, the exposure range for fin whales was used as a proxy due to similarities in species.

If a marine mammal is observed approaching or entering the relevant clearance zones prior to the start of pile driving, pile driving activity will be delayed until either the marine mammal has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, 30 minutes have elapsed without re-detection of the animal in the case of mysticetes, sperm whales, Risso’s dolphins and pilot whales, or 15 minutes have elapsed without re-detection of the animal in the case of all other marine mammals.

Prior to the start of pile driving activity, the clearance zones will be monitored for 60 minutes using a combined effort of passive acoustic monitoring and visual observation to ensure that they are clear of the relevant species of marine mammals. Pile driving would only commence once PSOs have declared the respective clearance zones clear of marine mammals. Marine mammals observed within a clearance zone will be allowed to remain in the clearance zone (*i.e.*, must leave of their own volition), and their behavior will be monitored and documented. The clearance zones may only be declared clear, and pile driving started, when the entire clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 60 minutes immediately prior to commencing pile driving. For North Atlantic right whales, the clearance zone may be declared clear if no visual or acoustic detections have occurred during the 60 minute monitoring period. If a species for which authorization has not been granted, or, a species for which authorization has been granted but the authorized number of takes have been met, approaches or is observed within the exclusion zone, shutdown would be required.

Soft Start of Impact Pile Driving

The use of a soft start procedure is believed to provide additional protection to marine mammals by warning marine mammals or providing them with a chance to leave the area prior to the hammer operating at full capacity, and typically involves a requirement to initiate sound from the hammer at reduced energy followed by a waiting period. South Fork Wind will utilize soft start techniques for impact pile driving including by performing 4–6 strikes per minute at 10 to 20 percent of the maximum hammer energy, for a minimum of 20 minutes. NMFS notes that it is difficult to specify the reduction in energy for any given hammer because of variation across drivers and, for impact hammers, the actual number of strikes at reduced energy will vary because operating the hammer at less than full power results in “bouncing” of the hammer as it strikes the pile, resulting in multiple “strikes”; however, as mentioned previously, South Fork Wind has proposed that they will target less than 20 percent of total hammer energy for the initial hammer strikes during soft start. Soft start would be required at the beginning of each day’s impact pile driving work and at any time following a cessation of impact pile driving of thirty minutes or longer.

Shutdown of Impact Pile Driving Equipment

The purpose of a shutdown is to prevent some undesirable outcome, such as auditory injury or severe behavioral disturbance of sensitive species, by halting the activity. If a marine mammal is observed entering or within the respective exclusion zone (Table 24) after pile driving has begun, the PSO will request a temporary cessation of pile driving.

In situations when shutdown is called for but South Fork Wind determines

shutdown is not practicable due to imminent risk of injury or loss of life to an individual, or risk of damage to a vessel that created risk of injury or loss of life for individuals, reduced hammer energy would be implemented when practicable. After shutdown, pile driving may be initiated once all clearance zones are clear of marine mammals for the minimum species-specific time periods, or, if required to maintain installation feasibility. Installation feasibility refers to ensuring that the pile installation results in a usable foundation for the WTG (*e.g.*, installed to the target penetration depth without refusal and with a horizontal foundation/tower interface flange).

Visibility Requirements

Pile driving would not be initiated at night, or, when the full extent of all relevant clearance zones cannot be confirmed to be clear of marine mammals, as determined by the lead PSO on duty. The clearance zones may only be declared clear, and pile driving started, when the full extent of all clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 60 minutes prior to pile driving. Pile driving may continue after dark only when the driving of the same pile began no less than 90 minutes prior to civil sunset, when clearance zones were fully visible, and must proceed for human safety or installation feasibility reasons. PSOs would utilize night vision devices (NVDs) (Infrared (IR) and/or thermal cameras) to monitor clearance zones if pile driving continues past civil sunset.

Sound Attenuation Devices

South Fork Wind would implement sound attenuation technology designed to result in an average of 10 dB attenuation of impact pile driving noise (see *Acoustic Monitoring for Sound Source and Harassment Isopleth*

Verification section below). The attenuation system would likely be a single bubble curtain, but may include one of the following or some combination of the following: A double BBC, Hydro-sound Damper, and/or Noise Abatement System. South Fork would also have a second back-up attenuation device (e.g., additional bubble curtain or similar) available, if needed, to achieve the targeted reduction in noise levels that would result in the measured Level A harassment and Level B harassment isopleths corresponding to those modeled assuming 10 dB attenuation, pending results of sound field verification testing.

If South Fork Wind uses a bubble curtain, the bubble curtain must distribute air bubbles around 100 percent of the piling perimeter for the full depth of the water column. The

lowest bubble ring shall be in contact with the mudline for the full circumference of the ring, and the weights attached to the bottom ring shall ensure 100 percent mudline contact. No parts of the ring or other objects shall prevent full mudline contact. South Fork Wind would require that construction contractors train personnel in the proper balancing of airflow to the bubblers, and would require that construction contractors submit an inspection/performance report for approval by South Fork Wind within 72 hours following the performance test. Corrections to the attenuation device to meet the performance standards would occur prior to impact driving. If South Fork Wind uses a noise attenuation device other than a BBC, similar quality control measures would be required.

Cofferdam Installation and Removal Clearance and Exclusion Zones

South Fork Wind would implement visual monitoring of the clearance zones for 30 minutes prior to the initiation of ramp-up of vibratory piling equipment (Table 25). During this period, the clearance zone will be monitored by the PSOs, using the appropriate visual technology. Ramp-up may not be initiated if any marine mammal(s) is detected within its respective exclusion zone. If a marine mammal is observed within a clearance zone during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting its respective clearance zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and seals, and 30 minutes for all other species).

TABLE 25—PROPOSED CLEARANCE AND EXCLUSION ZONES DURING INSTALLATION AND REMOVAL OF A TEMPORARY COFFERDAM

Species	Level A harassment zone (m) (SEL)	Level B harassment zone (m) (SPL)	Pre-start clearance zone (m)	Exclusion zone (m)	Vessel separation distance (m)
Low-Frequency Cetaceans:					
Fin whale	1,470	36,766	1,500	1,500	100
Minke whale	1,470	36,766	1,500	1,500	100
Sei whale	1,470	36,766	1,500	1,500	100
Humpback whale	1,470	36,766	1,500	1,500	100
North Atlantic right whale	1,470	36,766	1,500	1,500	500
Blue whale	1,470	36,766	1,500	1,500	100
Mid-Frequency Cetaceans:					
Sperm whale		36,766	1,500	1,500	100
Atlantic spotted dolphin		36,766	100	50	50
Atlantic white-sided dolphin		36,766	100	50	50
Common dolphin		36,766	100	50	50
Risso's dolphin		36,766	100	50	50
Bottlenose dolphin		36,766	100	50	50
Long-finned pilot whale		36,766	100	50	50
High-Frequency Cetaceans:					
Harbor porpoise	63	36,766	100	100	50
Phocid Pinnipeds in Water:					
Gray seal	103	36,766	150	125	50
Harbor seal	103	36,766	150	125	50

SEL = cumulative sound exposure level in units of decibels referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.

Shutdown of Vibratory Pile Driving

An immediate shutdown of vibratory pile driving equipment must be implemented if a marine mammal is sighted entering or within its respective exclusion zone after cofferdam installation has commenced.

Resumption of vibratory pile driving can begin if the animal has been observed exiting its respective exclusion zone or an additional time period has elapsed without a resighting (i.e., 15 minutes for small odontocetes and seals and 30 minutes for all other species). If

a species for which authorization has not been granted, or, a species for which authorization has been granted but the authorized number of takes have been met, approaches or is observed within the exclusion zone, shutdown would be required.

HRG Surveys

Clearance and Exclusion Zones

South Fork Wind would implement a 30-minute pre-clearance period of the clearance zones prior to the initiation of ramp-up of HRG equipment (Table 26).

During this period, the clearance zone will be monitored by the PSOs, using the appropriate visual technology. Ramp-up may not be initiated if any marine mammal(s) is within its respective clearance zone. If a marine mammal is observed within a clearance zone during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting its respective clearance zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and seals, and 30 minutes for all other species).

TABLE 26—PROPOSED MONITORING, CLEARANCE, AND EXCLUSION ZONES DURING HRG SURVEYS OPERATING CHIRP SUB-BOTTOM PROFILERS, BOOMERS, AND SPARKERS

Species	Level A harassment zone (SEL)	Level A harassment zone (PK)	Maximum extent of zone in meters (m) from all potential HRG sound sources				Vessel separation distance (m)
			Level B zones		Pre-start clearance zone	Exclusion zone	
			CHIRPS	Boomers and sparkers			
Low-Frequency Cetaceans:							
Fin whale	<1	<1	50	141	100	100	100
Minke whale	<1	<1	50	141	100	100	100
Sei whale	<1	<1	50	141	100	100	100
Humpback whale ..	<1	<1	50	141	100	100	100
N.A. right whale	<1	<1	50	141	500	500	500
Blue whale	<1	<1	50	141	100	100	100
Mid-Frequency Cetaceans:							
Sperm whale	<1	<1	50	141	100	100	100
Atlantic spotted dolphin	<1	<1	50	141	100	.....	50
Atlantic white-sided dolphin	<1	<1	50	141	100	.....	50
Common dolphin ...	<1	<1	50	141	100	.....	50
Risso's dolphin	<1	<1	50	141	100	.....	50
Bottlenose dolphin	<1	<1	50	141	100	.....	50
Long-finned pilot whale	<1	<1	50	141	100	.....	50
High-Frequency Cetaceans:							
Harbor porpoise	37	5	50	141	100	100	50
Phocid Pinnipeds in Water:							
Gray seal	<1	<1	50	141	100	.....	50
Harbor seal	<1	<1	50	141	100	.....	50

Ramp-Up of HRG Survey Equipment

When practicable, a ramp-up procedure would be used for HRG survey equipment capable of adjusting energy levels at the start or restart of survey activities. The ramp-up procedure would be used at the beginning of HRG survey activities in order to provide additional protection to marine mammals near the Survey Area by allowing them to vacate the area prior to the commencement of survey equipment operation at full power.

A ramp-up would begin with the powering up of the smallest acoustic HRG equipment at its lowest practical power output appropriate for the survey. When practicable, the power would then be gradually turned up and other acoustic sources would be added.

Ramp-up activities will be delayed if a marine mammal(s) enters its respective exclusion zone. Ramp-up will continue if the animal has been observed exiting its respective exclusion zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and seals and 30 minutes for all other species).

Shutdown of HRG Survey Equipment

An immediate shutdown of the impulsive HRG survey equipment would be required if a marine mammal is sighted entering or within its respective exclusion zone. No shutdown is required for surveys operating only non-impulsive acoustic sources. The vessel operator must comply immediately with any call for shutdown by the Lead PSO. Any disagreement between the Lead PSO and vessel operator should be discussed only after shutdown has occurred. Subsequent restart of the survey equipment can be initiated if the animal has been observed exiting its respective exclusion zone or until an additional time period has elapsed (i.e., 15 minutes for small odontocetes and seals and 30 minutes for all other species).

If a species for which authorization has not been granted, or, a species for which authorization has been granted but the authorized number of takes have been met, approaches or is observed within the Level B harassment zone, shutdown would occur.

If the acoustic source is shut down for reasons other than mitigation (e.g., mechanical difficulty) for less than 30 minutes, it may be activated again

without ramp-up if PSOs have maintained constant observation and no detections of any marine mammal have occurred within the respective exclusion zones. If the acoustic source is shut down for a period longer than 30 minutes and PSOs have maintained constant observation, then pre-clearance and ramp-up procedures will be initiated as described in the previous section.

The shutdown requirement would be waived for small delphinids of the following genera: *Delphinus*, *Lagenorhynchus*, *Stenella*, and *Tursiops*. Specifically, if a delphinid from the specified genera is visually detected approaching the vessel (i.e., to bow ride) or towed equipment, shutdown is not required. Furthermore, if there is uncertainty regarding identification of a marine mammal species (i.e., whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived), PSOs must use best professional judgement in making the decision to call for a shutdown. Additionally, shutdown is required if a delphinid is detected in the exclusion zone and belongs to a genus other than those specified.

Vessel Strike Avoidance

Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (*i.e.*, PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal. Vessel strike avoidance measures will include, but are not limited to, the following, except under circumstances when complying with these measures would put the safety of the vessel or crew at risk:

- All vessels greater than or equal to 65 ft (19.8 m) in overall length must comply with the 10 knot speed restriction in any Seasonal Management Area (SMA) per the NOAA ship strike reduction rule (73 FR 60173; October 10, 2008).

- Vessels of all sizes will operate port to port at 10 knots or less between November 1 and April 30, except for vessels transiting inside Narragansett Bay or Long Island Sound.

- A trained, dedicated visual observer and alternative visual detection system (*e.g.*, thermal cameras) will be stationed on all transiting vessels that intend to operate at greater than 10 knots from November 1 through April 30. The primary role of the visual observer is to alert the vessel navigation crew to the presence of marine mammals and to report transit activities and marine mammal sightings to the designated South Fork Wind information system.

- Vessels of all sizes will operate at 10 knots or less in any North Atlantic right whale Dynamic Management Area (DMA).

- Outside of DMAs, SMAs, and the November 1 through April 30 time period, localized detections of North Atlantic right whales, using passive acoustics, would trigger a slow-down to 10 knots or less in the area of detection (zone) for the following 12 hours (hrs). Each subsequent detection would trigger a 12-hr reset. A slow-down in that zone expires when there has been no further visual or acoustic detection in the past 12-hr within the triggered zone.

- For all vessels greater than or equal to 65 ft (19.8 m) in overall length, vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

- All vessels must maintain a minimum separation distance of 500 m from North Atlantic right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

- All vessels must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

- All vessels must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those that approach the vessel.

- When marine mammals are sighted while a vessel is underway, the vessel must 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 within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

- These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

- When not on active watch duty, members of the monitoring team must consult NMFS' North Atlantic right whale reporting systems for the presence of North Atlantic right whales in the project area.

- Project-specific training must be conducted for all vessel crew prior to the start of in-water construction activities. Confirmation of the training and understanding of the requirements must be documented on a training course log sheet.

NMFS has carefully evaluated South Fork Wind's proposed mitigation measures and considered a range of other measures in the context of ensuring that NMFS prescribed the means of effecting the least practicable adverse impact on the affected marine mammal species and stocks and their habitat. Based on NMFS' evaluation of

these measures, NMFS has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable adverse impact on marine mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for subsistence uses.

Proposed Monitoring and Reporting

In order to issue an IHA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth requirements pertaining to the monitoring and reporting of such taking. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for authorizations must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area. Effective reporting is critical both to compliance as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (*e.g.*, presence, abundance, distribution, density).

- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: (1) Action or environment (*e.g.*, source characterization, propagation, ambient noise); (2) affected species (*e.g.*, life history, dive patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (*e.g.*, age, calving or feeding areas).

- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.

- How anticipated responses to stressors impact either: (1) Long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.

- Effects on marine mammal habitat (*e.g.*, marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat).

- Mitigation and monitoring effectiveness.

Monitoring would be conducted before, during, and after impact pile driving, vibratory pile driving and during HRG surveys. In addition, observers will record all incidents of marine mammal occurrence at any distance from the piling location or active HRG acoustic source, and monitors will document any behavioral reactions in concert with distance from an acoustic source. Observations made outside the clearance zones will not result in delay of project activities.

A pile segment or HRG survey trackline may be completed without cessation, unless the marine mammal approaches or enters the clearance zone, at which point pile driving or survey activities would be halted when practicable, as described above.

The following additional measures apply to visual monitoring:

(1) Monitoring will be conducted by qualified, trained PSOs, who will be placed on the installation (monopile and cofferdam installation), secondary observation (monopile installation only), or HRG survey vessels, which represents the best vantage point to monitor for marine mammals and implement shutdown procedures when applicable;

(2) PSOs may not exceed 4 consecutive watch hours; must have a minimum 2 hour break between watches; and may not exceed a combined watch schedule of more than 12 hours in a 24-hour period;

(3) PSOs will have no other construction-related tasks while conducting monitoring;

(4) PSOs should have the following minimum qualifications:

- Visual acuity in both eyes (correction is permissible) sufficient for discernment of moving targets at the water's surface with ability to estimate target size and distance; use of binoculars may be necessary to correctly identify the target;

- Ability to conduct field observations and collect data according to assigned protocols;

- Sufficient training, orientation, or experience with the construction operation to provide for personal safety during observations;

- Writing skills sufficient to document observations including, but not limited to: The number and species of marine mammals observed; dates and times when in-water construction activities were conducted; dates and times when in-water construction activities were suspended to avoid potential incidental injury of marine mammals from construction noise

within a defined shutdown zone; and marine mammal behavior; and

- Ability to communicate orally, by radio or in person, with project personnel to provide real-time information on marine mammals observed in the area as necessary.

Observer teams employed by South Fork Wind in satisfaction of the mitigation and monitoring requirements described herein must meet the following additional requirements:

- Independent observers (*i.e.*, not construction personnel) are required;

- At least one observer must have prior experience working as an observer;

- Other observers may substitute education (degree in biological science or related field) or training for experience;

- One observer will be designated as lead observer or monitoring coordinator. The lead observer must have prior experience working as an observer; and

- NMFS will require submission and approval of observer curriculum vitae.

Visual Marine Mammal Observations

Monopile Installation

South Fork Wind will collect sighting data and behavioral responses to pile driving for marine mammal species observed in the region of activity during the period of activity. All observers will be trained in marine mammal identification and behaviors and are required to have no other construction-related tasks while conducting monitoring. PSOs would monitor all clearance zones at all times. PSOs would also monitor Level B harassment zones and would document any marine mammals observed within these zones, to the extent practicable (noting that some distances to these zones are too large to fully observe). South Fork Wind would conduct monitoring before, during, and after pile driving, with observers located at the best practicable vantage points on the pile driving vessel.

South Fork Wind would implement the following procedures for pile driving:

- A minimum of two PSOs on the impact pile driving vessel will maintain watch at all times when pile driving is underway.

- A minimum of two PSOs on a secondary PSO vessel located at the outer edge of the 2,200 m clearance zone will maintain watch at all times when pile driving is underway.

- PSOs would be located at the best vantage point(s) on the impact pile driving and secondary vessels to ensure that they are able to observe the entire clearance zones and as much of the Level B harassment zone as possible.

- During all observation periods, PSOs will use binoculars and the naked eye to search continuously for marine mammals.

- PSOs will be provided reticle binoculars, NVDs, and a thermal/IR camera system.

- If the clearance zones are obscured by fog or poor lighting conditions, pile driving will not be initiated until clearance zones are fully visible. Should such conditions arise while impact driving is underway, the activity would be halted when practicable, as described above.

- The clearance zones will be monitored for the presence of marine mammals for 60 mins before, throughout the installation of the pile, and for 30 mins after all pile driving activity.

When monitoring is required during vessel transit (as described above), the PSO(s) will be stationed on vessels at the best vantage points to ensure maintenance of standoff distances between marine mammals and vessels (as described above). South Fork Wind would implement the following measures during vessel transit when there is an observation of a marine mammal:

- PSOs or dedicated observers will record the vessel's position and speed, water depth, sea state, and visibility at the beginning and end of each observation period, and whenever there is a change in any of those variables that materially affects sighting conditions.

Individuals implementing the monitoring protocol will assess its effectiveness using an adaptive approach. PSOs will use their best professional judgment throughout implementation and seek improvements to these methods when deemed appropriate. Any modifications to the protocol will be coordinated between NMFS and South Fork Wind.

Cofferdam Installation and Removal

The visual monitoring requirements for installation of the cofferdam would be consistent with those described for monopile installation, differing as follows:

- A minimum of two PSOs on the vibratory pile driving platform or construction vessel will maintain watch at all times when vibratory pile driving is underway.

- During daytime (*i.e.*, 30 minutes prior to sunrise through 30 minutes following sunset) observations, one PSO will monitor the exclusion zone using naked eye/reticle binoculars; a second PSO will also periodically scan outside the exclusion zone, using mounted big eye binoculars.

- During daytime low visibility conditions, one PSO will monitor the exclusion zone with a mounted IR camera, while the second PSO maintains visual watch using naked eye/reticle binoculars.

- If nighttime observations are required, two PSOs will monitor the exclusion zone using a mounted IR camera and hand-held/wearable NVDs.

HRG Surveys

The visual monitoring requirements for HRG surveys would be consistent with those described for monopile installation, differing as follows:

- At least one PSO must be on duty during daylight operations on each survey vessel, conducting visual observations at all times on all active survey vessels during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).

- A minimum of two PSOs must be on watch during nighttime operations.

- PSO(s) would ensure 360° visual coverage around the vessel from the most appropriate observation posts and would conduct visual observations using binoculars and/or NVDs and the naked eye.

- In cases where multiple vessels are surveying concurrently, any observations of marine mammals would be communicated to PSOs on all nearby survey vessels.

Data Collection

Among other pieces of information, South Fork Wind will record detailed information about any implementation of delays or shutdowns, including the distance of animals to the pile and a description of specific actions that ensued and resulting behavior of the animal, if any. NMFS requires that, at a minimum, the following information be collected on the sighting forms:

- Date and time that monitored activity begins or ends;

- Construction activities occurring during each observation period;

- Weather parameters (*e.g.*, wind speed, percent cloud cover, visibility);

- Water conditions (*e.g.*, sea state, tide state);

- Species, numbers, and, if possible, sex and age class of marine mammals;

- Description of any observable marine mammal behavioral patterns, including:

- Bearing and direction of travel and distance from pile driving activity,

- changes in behavioral patterns, noting when/if they correspond to change in activity (*e.g.*, turning source on or off), and

- amount of time spent within Level A and Level B harassment zones

- Distance from pile driving activities to marine mammals and distance from the marine mammals to the observation point;

- Type of construction activity (*e.g.*, vibratory or impact pile driving, HRG survey) and specific phase of activity (*e.g.*, ramp-up for HRG survey, HRG acoustic source on/off, soft start for pile driving, active pile driving, etc.) when marine mammals are observed.

- Description of implementation of mitigation measures (*e.g.*, delay or shutdown).

- Locations of all marine mammal observations; and

- Other human activity in the area.

Marine Mammal Passive Acoustic Monitoring

South Fork Wind would utilize a PAM system to supplement visual monitoring during all pre-clearance, WTG and OSS impact piling operations, and post visual monitoring periods. The PAM system would be monitored by a minimum of one acoustic PSO beginning at least 60 minutes prior to soft start of pile driving and at all times during pile driving. Acoustic PSOs would immediately communicate all detections of marine mammals to visual PSOs, including any determination regarding species identification, distance, and bearing and the degree of confidence in the determination. PAM would be used to inform visual monitoring during construction. The PAM system would not be located on the pile installation vessel.

Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least two hours between watches, and for a maximum of twelve hours per day. Acoustic PSOs would be required to complete specialized training for operating PAM systems. PSOs can act as acoustic or visual observers (but not simultaneously) as long as they demonstrate that their training and experience are sufficient to perform each task.

Acoustic Monitoring for Sound Source and Harassment Isopleth Verification

During the first monopile installation, South Fork Wind would be required to empirically determine the distances to the isopleths corresponding to Level B harassment thresholds either by extrapolating from in situ measurements conducted at distances approximately 100 m (or less, depending on the position of the noise mitigation system), 750 m, 1500 m, 3000 m, and 6000 m from the pile being driven, or by direct measurements to locate the distance where the received levels reach the

relevant thresholds or below.

Additionally, measurements conducted at multiple distances from the pile will be used to estimate propagation loss. Isopleths corresponding to the Level B harassment threshold would be verified for comparison with the acoustic propagation range and $R_{95\text{percent}}$ modeled isopleths used to estimate proposed authorized take.

If initial acoustic field measurements indicate distances to the isopleths corresponding to Level B harassment thresholds are greater than the distances predicted by modeling (as presented in the IHA application), South Fork Wind must implement additional sound attenuation measures prior to conducting additional pile driving. Initial additional measures may include improving the efficacy of the implemented noise attenuation technology and/or modifying the piling schedule to reduce the sound source. If implementation of these corrective actions does not result in distances to the Level B harassment isopleths that are similar to or less than those used to calculate take, South Fork Wind would install a second noise mitigation system to achieve the modelled ranges. Each sequential modification would be evaluated empirically by acoustic field measurements.

If acoustic measurements indicate that distances to isopleths corresponding to the Level B harassment threshold are less than the distances predicted by modeling (as presented in the IHA application), South Fork Wind may request a modification to the clearance and exclusion zones for impact pile driving. If modifications are approved by NMFS, each sequential modification to decrease zone sizes would also be evaluated empirically by acoustic field measurements.

Reporting

A draft report would be submitted to NMFS within 90 days of the completion of monitoring for each installation's in-water work window. The report would include marine mammal observations pre-activity, during-activity, and post-activity during pile driving days, and would also provide descriptions of any changes in marine mammal behavioral patterns resulting from construction activities. The report would detail the monitoring protocol, summarize the data recorded during monitoring including an estimate of the number of marine mammals that may have been harassed during the period of the report, and describe any mitigation actions taken (*i.e.*, delays or shutdowns due to detections of marine mammals, and documentation of when shutdowns

were called for but not implemented and why). The report would also include results from acoustic monitoring including dates and times of all detections, types and nature of sounds heard, whether detections were linked with visual sightings, water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, a record of the PAM operator's review of any acoustic detections, and any other notable information. A final report must be submitted within 30 days following resolution of comments on the draft report.

South Fork Wind would be required to submit a preliminary acoustic monitoring report to NMFS within 24 hrs of completing sound source verification (SSV) on the first monopile. In addition to in situ measured distances to the Level A harassment and Level B harassment thresholds, the acoustic monitoring report would include: SPLpk, SPLrms that contains 90 percent of the acoustic energy, single strike sound exposure level, integration time for SPLrms, SELss spectrum ($\frac{1}{3}$ octave band or power density spectra). All these levels would be reported in the form of median, mean, max, and minimum. The sound levels reported would be in median and linear average (*i.e.*, taking averages of sound intensity before converting to dB). The acoustic monitoring report would also include a description of the hydrophones used, hydrophone and water depth, distance to the pile driven, and sediment type at the recording location.

Negligible Impact Analysis and Determination

NMFS has defined negligible impact as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.*, population-level effects). An estimate of the number of takes alone is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS considers other factors, such as the likely nature of any responses (*e.g.*, intensity, duration), the context of any responses (*e.g.*, critical reproductive time or location, migration), as well as effects

on habitat, and the likely effectiveness of the mitigation. NMFS also assesses the number, intensity, and context of estimated takes by evaluating this information relative to population status. Consistent with the 1989 preamble for NMFS's implementing regulations (54 FR 40338; September 29, 1989), the impacts from other past and ongoing anthropogenic activities are incorporated into this analysis via their impacts on the environmental baseline (*e.g.*, as reflected in the regulatory status of the species, population size and growth rate where known, ongoing sources of human-caused mortality, or ambient noise levels).

Pile driving and HRG survey activities associated with the proposed project, as described previously, have the potential to disturb or temporarily displace marine mammals. Specifically, the specified activities may result in take, in the form of Level A harassment (potential injury; from impact pile driving only) or Level B harassment (potential behavioral disturbance) from underwater sounds generated from pile driving (impact and vibratory) and certain HRG active acoustic sources. Potential takes could occur if individual marine mammals are present in the ensonified zone when pile driving or HRG survey activities are occurring.

To avoid repetition, the majority of our analyses apply to all the species listed in Table 3, given that many of the anticipated effects of the proposed project on different marine mammal stocks are expected to be relatively similar in nature. Where there are meaningful differences between species or stocks—as is the case of the North Atlantic right whale—they are included as separate subsections below.

North Atlantic Right Whales

North Atlantic right whales are currently threatened by low population abundance, higher than normal mortality rates and lower than normal reproductive rates. As described above, the project area represents part of an important migratory area for North Atlantic right whales, which make annual migrations up and down the Atlantic coast. Due to the current status of North Atlantic right whales, and the spatial overlap of the proposed project with an area of biological significance for North Atlantic right whales, the potential impacts of the proposed project on North Atlantic right whales warrant particular attention.

As described above, North Atlantic right whale presence in the project area is largely seasonal. As a result of several years of aerial surveys and PAM deployments in the area, NMFS has

confidence that North Atlantic right whales are expected in the project area predominately during certain times of year while at other times of year North Atlantic right whales are expected to occur less frequently in the project area. During aerial surveys conducted from 2011–2015 in the project area, North Atlantic right whale sightings occurred only December through April, with no sightings from May through November (Kraus *et al.*, 2016). There was not significant variability in sighting rate among years, indicating consistent annual seasonal use of the area by North Atlantic right whales over the timespan of the surveys (Kraus *et al.*, 2016). However, as described previously, North Atlantic right whale presence is increasingly variable in identified core habitats, including the area south of Martha's Vineyard and Nantucket islands (northeast of the proposed SFWF) where both visual and acoustic detections of North Atlantic right whales indicate a nearly year-round presence (Oleson *et al.*, 2020), although seasonal trends are still prominent (Hayes *et al.*, 2020).

Due to this seasonal pattern in North Atlantic right whale occurrence in the project area, NMFS expects the most significant measure in minimizing impacts to North Atlantic right whales to be the proposed seasonal closure that would occur from January through April, when North Atlantic right whale abundance in the project area is greatest. In addition, proposed mitigation measures outside of those months—including a 5 km clearance zone facilitated through PAM and PSOs—will greatly minimize any takes that may otherwise occur outside of the months of peak abundance in the area. As a result of these mitigation measures, NMFS expects the already small potential for North Atlantic right whales to be exposed to project-related sound above the Level A harassment threshold to be eliminated. Therefore, South Fork did not request nor is NMFS proposing to authorize take by Level A harassment. NMFS also expects these proposed measures to greatly reduce the amount of exposures to project-related noise above the Level B harassment threshold, and the duration and intensity of any exposures above the Level B harassment threshold that do occur. No serious injury or mortality of North Atlantic right whales would be expected even in the absence of the proposed mitigation measures.

Instances of Level B harassment of North Atlantic right whales will be reduced to the level of least practicable adverse impact through use of proposed mitigation measures, including soft start

and exclusion zones larger than the Level A harassment zone. Any individuals that are exposed above the Level B harassment threshold are expected to move away from the sound source and temporarily avoid the areas of pile driving. Therefore, North Atlantic right whales taken by the activity are likely to be exposed to lower noise levels (closer to the 120dB threshold than the Level A harassment threshold) and therefore, behavioral reactions are expected to be less intense than during exposures to louder sounds (but still below the Level A harassment threshold). NMFS expects that any avoidance of the project area by North Atlantic right whales would be temporary in nature and that any North Atlantic right whales that avoid the project area during construction would not be permanently displaced. Even limited repeated Level B harassment of some small subset of the overall stock, although not expected to occur given the transitory nature of marine mammals in the project area, is unlikely to result in any significant realized decrease in fitness or viability for the affected individuals, and thus would not result in any adverse impact to the stock as a whole.

Prey for North Atlantic right whales are mobile and broadly distributed throughout the project area; therefore, North Atlantic right whales that may be temporarily displaced during construction activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because of the temporary nature of the disturbance and the availability of similar habitat and resources in the surrounding area, the impacts to North Atlantic right whales and the food sources that they utilize are not expected to cause significant or long-term consequences for individual North Atlantic right whales or their population. In addition, there are no North Atlantic right whale mating or calving areas within the proposed project area.

As described above, North Atlantic right whales are experiencing an ongoing UME. However, as described above, no injury of North Atlantic right whales as a result of the proposed project is expected or proposed for authorization, and Level B harassment takes of North Atlantic right whales are expected to be in the form of avoidance of the immediate area of construction. As no injury or mortality is expected or proposed for authorization, and Level B harassment of North Atlantic right whales will be reduced to the level of least practicable adverse impact through

use of proposed mitigation measures, the proposed authorized takes of North Atlantic right whales would not exacerbate or compound the effects of the ongoing UME in any way.

NMFS concludes that the additional proposed mitigation measures would ensure that any exposures above the Level B harassment threshold would result in only short-term effects to individuals exposed. With implementation of the proposed mitigation requirements, take by Level A harassment is unlikely and is therefore not proposed for authorization. Potential impacts associated with Level B harassment would include only low-level, temporary behavioral modifications, most likely in the form of avoidance behavior or potential alteration of vocalizations.

Although acoustic masking may occur, based on the acoustic characteristics of noise associated with impact pile driving (e.g., frequency spectra, short duration) and HRG surveys (e.g., higher frequency, intermittent signals) and the limited duration of vibratory pile driving activity, NMFS expects masking effects to be minimal (e.g., pile driving) to none (e.g., HRG surveys). As mentioned previously, masking events that might be considered Level B harassment have already been accounted for in the exposure analysis as they would be expected to occur within the behavioral harassment zones predetermined for pile driving. Avoidance of the SFWF or SFEC during construction would represent a potential manifestation of behavioral disturbance. Although the project area is located within the migratory BIA for North Atlantic right whales, impact pile driving of monopile foundations would only occur on 16 days (one pile would be driven per day for a maximum of 3 hours), and vibratory pile driving would be limited to a maximum of 36 hours of the 12-month project. Further, seasonal restrictions preclude impact pile driving during the months in which North Atlantic right whale occurrence is expected to be highest (January through April). If avoidance of the project area by North Atlantic right whales occurs, it is expected to be temporary. Finally, consistent North Atlantic right whale utilization of the habitat south of Martha's Vineyard and Nantucket Islands (Oleson *et al.*, 2020) indicates that suitable alternative nearby habitat would be available to North Atlantic right whales that might avoid the project area during construction.

In order to evaluate whether or not individual behavioral responses, in

combination with other stressors, impact animal populations, scientists have developed theoretical frameworks which can then be applied to particular case studies when the supporting data are available. One such framework is the population consequences of disturbance model (PCoD), which attempts to assess the combined effects of individual animal exposures to stressors at the population level (NAS 2017). Nearly all PCoD studies considering multiple marine mammal species and experts agree that infrequent exposures of a single day or less are unlikely to impact individual fitness, let alone lead to population level effects (Booth *et al.*, 2016; Booth *et al.*, 2017; Christiansen and Lusseau 2015; Farmer *et al.*, 2018; Harris *et al.*, 2017; Harwood *et al.*, 2014; Harwood and Booth 2016; King *et al.*, 2015; McHuron *et al.*, 2018; NAS 2017; New *et al.*, 2014; Pirota *et al.*, 2018; Southall *et al.*, 2007; Villegas-Amtmann *et al.*, 2015). Since NMFS expects that any exposures would be brief (no more than 3 hours per day for impact pile driving or 36 hours over 6 days for vibratory pile driving, and likely less given probable avoidance response), and repeat exposures to the same individuals are unlikely, any behavioral responses that would occur due to animals being exposed to construction activity are expected to be temporary, with behavior returning to a baseline state shortly after the acoustic stimuli ceases, similar to findings during European wind farm construction. Given this, and NMFS' evaluation of the available PCoD studies, any such behavioral responses are not expected to impact individual animals' health or have effects on individual animals' survival or reproduction, thus no detrimental impacts at the population level are anticipated. North Atlantic right whales may temporarily avoid the immediate area but are not expected to permanently abandon the area. NMFS does not anticipate North Atlantic right whales takes that would result from the proposed project would impact annual rates of recruitment or survival. Thus, any takes that occur would not result in population level impacts.

All Other Marine Mammal Species

Impact pile driving has source characteristics (short, sharp pulses with higher peak levels and sharper rise time to reach those peaks) that are potentially injurious or more likely to produce severe behavioral reactions. No Level A harassment from HRG surveys or vibratory pile driving is expected, even in the absence of mitigation; therefore, our discussion regarding auditory injury is limited to impact pile driving.

Modeling indicates there is limited potential for auditory injury to humpback whales during pile driving even in the absence of the proposed mitigation measures; the remaining fifteen species are predicted to experience no Level A harassment, based on modeling results that assumed 10 dB attenuation (Table 16).

NMFS expects that any exposures above the Level A harassment threshold would be in the form of slight PTS, *i.e.* minor degradation of hearing capabilities within regions of hearing that align most completely with the energy produced by pile driving (*i.e.* the low-frequency region below 2 kHz), not severe hearing impairment. If hearing impairment occurs, it is most likely that the affected animal would lose a few decibels in its hearing sensitivity, which in most cases is not likely to meaningfully affect its ability to forage and communicate with conspecifics, much less impact reproduction or survival.

Additionally, the number of Level A harassment takes proposed for authorization are relatively low for all marine mammal stocks and species: For three of the stocks, only one take by Level A harassment is proposed for authorization (*i.e.*, fin whale, sei whale, and minke whale), and for most of the remaining stocks, NMFS does not propose to authorize any takes by Level A harassment over the duration of the project; for the remaining stock (*i.e.*, humpback whale), NMFS proposes to authorize four takes by Level A harassment. As described above, any PTS incurred would be no more than a few decibels of lost hearing sensitivity that would not impact annual rates of recruitment or survival for any individual.

Repeated exposures of individuals to relatively low levels of sound outside of preferred habitat areas are unlikely to significantly disrupt critical behaviors. Thus, even repeated Level B harassment of some small subset of an overall stock is unlikely to result in any significant realized decrease in viability for the affected individuals, and thus would not result in any adverse impact to the stock as a whole. Level B harassment will be reduced to the level of least practicable adverse impact through use of proposed mitigation measures and, if sound produced by project activities is sufficiently disturbing, marine mammals are likely to simply avoid the area while the activity is occurring. Therefore, NMFS expects that animals disturbed by project sound would likely move away from the sound source during project activities in favor of other, similar habitats. NMFS expects

that any avoidance of the project area by marine mammals would be temporary in nature and that any marine mammals that avoid the project area during construction would not be permanently displaced.

Feeding behavior is not likely to be significantly impacted, as prey species are mobile and are broadly distributed throughout the project area; therefore, marine mammals that may be temporarily displaced during construction activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because of the temporary nature of the disturbance and the availability of similar habitat and resources in the surrounding area, the impacts to marine mammals and the food sources that they utilize are not expected to cause significant or long-term consequences for individual marine mammals or their populations. There are no areas of notable biological significance for marine mammal feeding known to exist in the project area. In addition, there are no rookeries or mating or calving areas known to be biologically important to marine mammals within the proposed project area.

NMFS concludes that exposures to marine mammals due to the proposed project would result in only short-term effects to individuals exposed. Marine mammals may temporarily avoid the immediate area but are not expected to permanently abandon the area. Impacts to breeding, feeding, sheltering, resting, or migration are not expected, nor are shifts in habitat use, distribution, or foraging success. NMFS does not anticipate the marine mammal takes that would result from the proposed project would impact annual rates of recruitment or survival.

As described above, humpback whales, minke whales, and gray and harbor seals are experiencing ongoing UMEs. For minke whales, although the ongoing UME is under investigation (as occurs for all UMEs), this event does not provide cause for concern regarding population level impacts, as the likely population abundance is greater than 20,000 whales. With regard to humpback whales, the UME does not yet provide cause for concern regarding population-level impacts. Despite the UME, the relevant population of humpback whales (the West Indies breeding population, or DPS) remains healthy. The West Indies DPS, which consists of the whales whose breeding range includes the Atlantic margin of the Antilles from Cuba to northern Venezuela, and whose feeding range primarily includes the Gulf of Maine,

eastern Canada, and western Greenland, was delisted. The status review identified harmful algal blooms, vessel collisions, and fishing gear entanglements as relevant threats for this DPS, but noted that all other threats are considered likely to have no or minor impact on population size or the growth rate of this DPS (Bettridge *et al.*, 2015). As described in Bettridge *et al.* (2015), the West Indies DPS has a substantial population size (*i.e.*, approximately 10,000; Stevick *et al.*, 2003; Smith *et al.*, 1999; Bettridge *et al.*, 2015), and appears to be experiencing consistent growth. With regard to gray seals and harbor seals, although the ongoing UME is under investigation, the UME does not yet provide cause for concern regarding population-level impacts to any of these stocks. For harbor seals, the population abundance is over 75,000 and annual M/SI (345) is well below PBR (2,006) (Hayes *et al.*, 2020). For gray seals, the population abundance is over 500,000, and abundance is likely increasing in the U.S. Atlantic EEZ and in Canada (Hayes *et al.*, 2020). Proposed authorized takes by Level A harassment of humpback whales are low (*i.e.*, no more than four takes by Level A harassment proposed for authorization) and, as described above, any Level A harassment would be expected to be in the form of slight PTS, *i.e.* minor degradation of hearing capabilities which is not likely to meaningfully affect the ability to forage or communicate with conspecifics. No serious injury or mortality is expected or proposed for authorization, and Level B harassment of humpback whales and minke whales and gray and harbor seals will be reduced to the level of least practicable adverse impact through use of proposed mitigation measures. As such, the proposed authorized takes of these species would not exacerbate or compound the effects of the ongoing UMEs on the populations.

In summary and as described above, the following factors primarily support NMFS' preliminary determination that the impacts resulting from this activity are not expected to adversely affect the species or stock through effects on annual rates of recruitment or survival:

- No mortality or serious injury is anticipated or proposed for authorization;
- No Level A harassment of North Atlantic right whales would occur and Level B harassment will be minimized via extended mitigation measures;
- The anticipated impacts of the proposed activity on marine mammals would be temporary behavioral changes (primarily avoidance of the project area) and limited instances of Level A

harassment of humpback whales in the form of a slight PTS;

- Potential instances of exposure above the Level A harassment threshold are limited to four of the 16 species expected to occur in the project area and are expected to be relatively low, and the severity of any PTS would be minimized by proposed mitigation measures including clearance zones;

- The availability of alternate areas of similar habitat value for marine mammals to temporarily vacate the project area during the proposed project to avoid exposure to sounds from the activity;

- Effects on species that serve as prey species for marine mammals from the proposed project are expected to be short-term and are not expected to result in significant or long-term consequences for individual marine mammals, or to contribute to adverse impacts on their populations;

- There are no known important feeding, breeding or calving areas in the project area. A biologically important migratory area exists for North Atlantic right whales; however, the proposed seasonal moratorium on construction is expected to largely avoid impacts to the North Atlantic right whale migration, as described above.

- The proposed mitigation measures, including visual and acoustic monitoring, clearance and exclusion zones, soft start (pile driving only), ramp up (HRG only), shutdown, are designed to reduce frequency and intensity of exposures and are, therefore, expected to minimize potential impacts to marine mammals.

- Total proposed authorized takes as a percentage of population are very low for all species and stocks (*i.e.*, less than 3.5 percent for four stocks, and less than 1 percent for the remaining 12 stocks);

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the proposed monitoring and mitigation measures, NMFS preliminarily finds that the total marine mammal take from the proposed activity will have a negligible impact on all affected marine mammal species or stocks.

Small Numbers

As noted above, only small numbers of incidental take may be authorized under sections 101(a)(5)(A) and (D) of the MMPA for specified activities other than military readiness activities. The MMPA does not define small numbers and so, in practice, where estimated numbers are available, NMFS compares the number of individuals taken to the

most appropriate estimation of abundance of the relevant species or stock in our determination of whether an authorization is limited to small numbers of marine mammals. When the predicted number of individuals to be taken is less than one third of the species or stock abundance, the take is considered to be of small numbers. Additionally, other qualitative factors may be considered in the analysis, such as the temporal or spatial scale of the activities.

NMFS proposes to authorize incidental take of 16 marine mammal stocks. The total amount of taking proposed for authorization is less than 3.5 percent for four of these stocks, and less than 1 percent for the 12 remaining stocks (Table 23), which NMFS preliminarily finds are small numbers of marine mammals relative to the estimated overall population abundances for those stocks.

Based on the analysis contained herein of the proposed activity (including the proposed mitigation and monitoring measures) and the anticipated take of marine mammals, NMFS preliminarily finds that small numbers of marine mammals will be taken relative to the population size of all affected species or stocks.

Unmitigable Adverse Impact Analysis and Determination

There are no relevant subsistence uses of the affected marine mammal stocks or species implicated by this action. Therefore, NMFS has determined that the total taking of affected species or stocks would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence purposes.

Endangered Species Act

Section 7(a)(2) of the ESA (16 U.S.C. 1531 *et seq.*) requires that each Federal agency insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. To ensure ESA compliance for the issuance of IHAs, NMFS consults internally whenever we propose to authorize take for endangered or threatened species.

NMFS is proposing to authorize take of North Atlantic right, fin, sei, and sperm whales, which are listed under the ESA. The NMFS Office of Protected Resources has requested initiation of Section 7 consultation with the NMFS Greater Atlantic Regional Fisheries Office for the issuance of this IHA. NMFS will conclude the ESA

consultation prior to reaching a determination regarding the proposed issuance of the authorization.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to South Fork Wind for conducting construction activities southeast of Rhode Island for a period of one year, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. A draft of the proposed IHA can be found at: www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act.

Request for Public Comments

NMFS requests comment on the analyses, the proposed authorization, and any other aspect of this Notice of Proposed IHA for the proposed construction of the South Fork Wind offshore wind project. NMFS also requests comment on the potential for renewal of this proposed IHA as described in the paragraph below. Please include with your comments any supporting data or literature citations to help inform NMFS' final decision on the request for MMPA authorization.

On a case-by-case basis, NMFS may issue a one-time, 1 year IHA renewal with an expedited public comment period (15 days) when: (1) Another year of identical or nearly identical activities as described in the Specified Activities section is planned or (2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the *Dates and Duration* section, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to expiration of the current IHA;

- The request for renewal must include the following:

- (1) An explanation that the activities to be conducted under the proposed Renewal are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (*e.g.*, reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the Renewal); and

- (2) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do

not indicate impacts of a scale or nature not previously analyzed or authorized;

- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS

determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

Dated: January 29, 2021.

Donna Wieting,

*Director, Office of Protected Resources,
National Marine Fisheries Service.*

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