Request for Incidental Harassment Authorization to Allow Harassment of Marine Mammals Incidental to Activities Associated with South Fork Wind Farm and Export Cable Construction

BOEM Lease OCS-A 0517

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List of Acronyms

AC	alternating current
AWS	Atlantic white-sided
BOEM	Bureau of Ocean Energy Management
CETAP	Cetacean and Turtles Assessment Program
CFR	Code of Federal Regulations
CHIRP	compressed high-intensity radiated pulses
COP	Construction and Operations Plan
dB	decibel
dB re 1 µPa	decibel referenced to 1 micropascal
dB re 1 µPa m	decibel referenced to 1 micropascal at 1 meter
dB re 1 μPa^2 s	decibel referenced to 1 micropascal squared second
DoN	U.S. Department of the Navy
DP	dynamically positioned
DPS	distinct population segment
DWSF	Deepwater Wind South Fork, LLC
EA	Environmental Assessment
EEZ	exclusive economic zone
EIS	environmental impact statement
ESL	exposure source level
$ER_{95\%}$	95% exposure range
ESA	Endangered Species Act
FR	Federal Register
GDEM	Generalized Digital Environmental Model
G&G	geophysical and geotechnical
HDD	Horizontal Directional Drill
HF	high-frequency
HRG	high resolution geophysical
IHA	Incidental Harassment Authorization
ISO	International Organization for Standardization
JASCO	JASCO Applied Sciences Inc.
Lease Area	Outer Continental Shelf (OCS) Lease Area OCS-A 0517
LF	low-frequency
LIPA	Long Island Power Authority
MABS	Mid-Atlantic Baseline Studies
MBES	multibeam echosounders
MF	mid-frequency
MMPA	Marine Mammal Protection Act
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NMS	Noise Mitigation System
OCS	Outer Continental Shelf
OSS	Offshore Substation
OW	otariid pinnipeds in water
PAM	Passive Acoustic Monitoring
PBR	Potential Biological Removal

List of Acronyms
(Continued)

Project Area	BOEM lease OSC-A-0517, and associated cable corridors
PSMMP	Protected Species Monitoring and Mitigation Plan
PSO	Protected Species Observer
PTS	permanent threshold shift
PW	phocid pinnipeds in water
RI-MA WEA	Rhode Island-Massachusetts Wind Energy Area
SAR	Stock Assessment Report
SBP	sub-bottom profiler
SEL	sound exposure level
SEL_{cum}	cumulative sound exposure level
SFEC	South Fork Export Cable
SFWF	South Fork Wind Farm
SL	source level
SL_{pk}	peak source level
SL_{rms}	root-mean square source level
SMA	Seasonal Management Area
SPL	sound pressure level
SPL_{pk}	peak sound pressure level (synonym of zero to peak sound pressure level)
SPL_{rms}	root-mean-square sound pressure level
SSS	side-scan sonar
TL	transmission loss
TTS	temporary threshold shift
UME	Unusual Mortality Event
U.S.	United States of America
USBL	Ultra-Short Baseline
USFWS	United States Fish and Wildlife Service
VHF	very high-frequency
VLF	very low-frequency
WEA	Wind Energy Area
WFA	weighting factor adjustments
WTG	wind turbine generator
ZOI	Zone of Influence

1.0 Description of Proposed Activities

This request for Incidental Harassment Authorization (IHA) is pursuant to 16 U.S. Code 1371 Section 101 of the Marine Mammal Protection Act (MMPA) for incidental take of small numbers of marine mammals by harassment during the construction of the South Fork Wind Farm (SFWF) and associated South Fork Export Cable (SFEC). The information provided in this document is submitted in response to the requirements of 50 Code of Federal Regulations (CFR) § 216.104.

1.1 PROJECT DESCRIPTION

South Fork Wind, LLC (SFW) (Applicant), on its behalf and on behalf of any successor in interest or assignee, submits this application to the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) requesting the issuance of an IHA to allow for the incidental harassment of small numbers of marine mammals resulting from the construction of the SFWF and SFEC.

There will be a maximum of 16 monopiles driven for SFWF. This will include up to 15 monopiles for the wind turbine generators (WTGs) with a nameplate capacity of 6 to 12 MW per turbine and one monopile for an offshore substation (OSS). In addition to pile driving, submarine cables will be installed between the WTGs (inter-array cables) and the shore (export cable). The SFWF will be located within federal waters on the outer continental shelf (OCS), specifically in the Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A 0517 (Lease Area). The Lease Area was previously part of BOEM OCS-A-0486, and in March 2020, the Lease Area was assigned to SFW as OCS-A-0517. The lease is subject to all terms and conditions of the original lease. The Lease Area is located approximately 30.6 kilometers (km) (19 miles [mi], 16.6 nautical miles [nm]) southeast of Block Island, Rhode Island, and 56.3 km (35 mi, 30.4 nm) east of Montauk Point, New York.

The SFEC is an alternating current (AC) electric cable that will connect the SFWF to the existing mainland electric grid in East Hampton, New York. The SFEC includes both offshore and onshore segments. Offshore, the SFEC is located in federal waters (SFEC – OCS) and New York State territorial waters (SFEC – NYS), and will be buried to a target depth of 1.2 to 1.8 meters (m) (4 to 6 feet [ft]) below the seabed. Onshore, the terrestrial underground segment of the export cable (SFEC – Onshore) will be located in East Hampton, New York. The SFEC – NYS will be connected to the SFEC – Onshore via the sea-to-shore transition where the offshore and onshore cables will be spliced together. The SFEC also includes a new Interconnection Facility where the SFEC will interconnect with the Long Island Power Authority (LIPA) electric transmission and distribution system in the town of East Hampton, New York.

Figure 1 shows the Lease Area and project boundaries for the SFWF and SFEC export cable routes and potential landing sites (Project Area). In October, 2018, the Applicant submitted the South Fork Construction and Operations Plan (COP) to BOEM as part of the Lease Area permitting requirements. Full details of the project components and assessment of potential environmental impacts are available in the COP at https://www.boem.gov/South-Fork/.

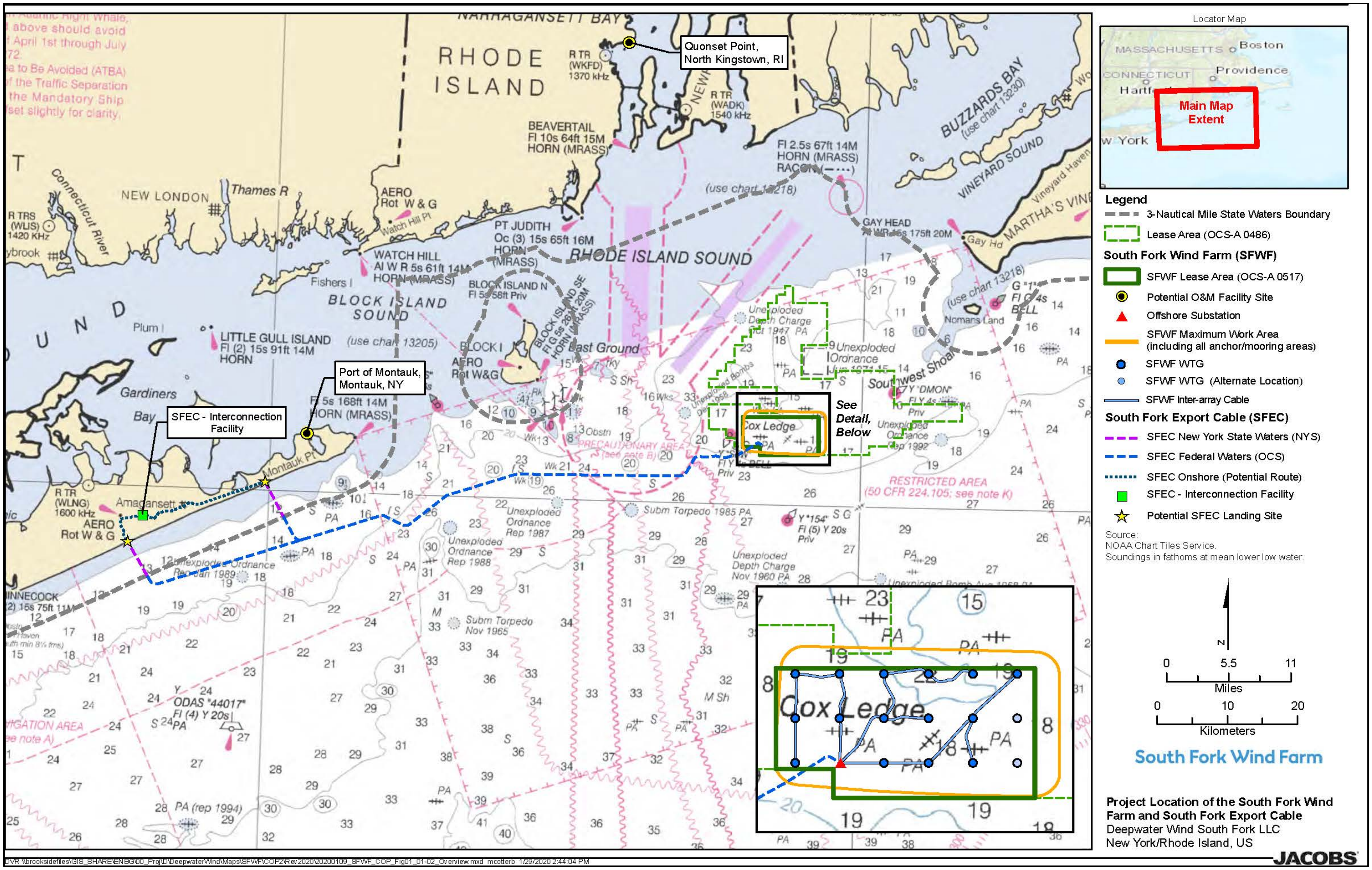

Figure 1. Location of Lease Areas OCS-0486 and 0517 along with South Fork Wind Farm (SFWF) and potential export cable (SFEC) routes.

1.2 ACTIVITIES CONSIDERED IN APPLICATION

The Applicant has evaluated all project activities for potential acoustic harassment as required under 50 CFR § 216.104. Construction of the SFWF and SFEC will include impact and vibratory pile driving; high-resolution geophysical (HRG) surveys using medium and shallow penetration sub-bottom profilers (SBPs); and cable trenching, laying, and burial activities that will include the use of vessels equipped with dynamic positioning (DP) thrusters. Vessels equipped with conventional propulsion will also be used to transport crew, supplies, and materials to the project site. Pile driving, HRG surveys, cable trenching and burial, and DP vessel activities were all considered in this Application; however, only vibratory and impact pile driving and HRG surveys could potentially cause acoustic disturbance to marine mammals during construction of the SFWF and SFEC. As such, only these activities are included in the take authorization for this Application. Justification for inclusion or exclusion of each activity is provided below.

Impact Pile Driving

Each monopile foundation will consist of a single steel pile, up to 11 m (36 ft) in diameter with a 10.3-cm (4-in) wall thickness. Piles will be impact-driven by an IHC-4,000 kilojoule (kJ) hammer, or similar, with a power pack capacity of 6,000 kilowatts (kW) to a maximum penetration depth of 50 m (164 ft).

Hydro hammer schematic operating principle

Figure 2 depicts the hydro hammer (hammer) and sensors that are key to understanding the hammer energy and monitoring thereof. When starting the hammer, the return valve closes while the pressure valve remains open. The oil under the piston lifts the ram weight. At the end of the lifting stroke, the pressure valve closes, and the return valve opens. The ram weight is then pushed downward by its own mass and the gas pressure in the cap, which also acts on top of the piston. At the end of the downward stroke, sensor B “sees” the ram weight, the return valve closes, and the pressure valve opens, completing the cycle and a new cycle will start.

A cap pressure below the specified value reduces the blow energy and the system operating pressure. The accumulators reduce the pressure and flow fluctuations caused by the continuous oil flow from the power pack and the intermittent flow in the hammer. Blow energy is controlled by varying the time that the return valve remains closed during the lifting stroke of the ram weight. The energy delivered to the pile is measured for every blow throughout sensors A and B and can be selected for display on the control unit along with the blow rate, velocity, and oil flow.

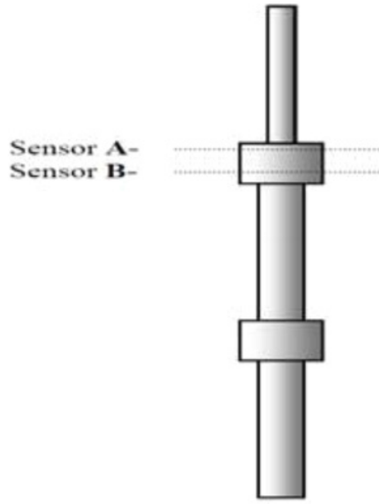

Figure 2. Hydro hammer schematic.

Impact pile driving comprises two operational phases, the soft-start (Phase 1) and the piling (Phase 2):

- **Soft-Start Measures (Phase 1)** –the soft-start is the period during which the verticality of the pile can be adjusted by means of the pile gripper. Soft start requires a series of single strikes and gradually builds up, moving then to the piling procedure (Phase 2). As long as the monopile is not self-stable, after each hammer strike, the verticality of the monopile needs to be checked and corrected, if necessary. The correction of the vertically is conducted by the pile gripper and verified by modern laser measurement/alignment technologies. This soft-start period also serves as a low-energy, low-strike-rate period that allows for protected species to move further away from the source, thus avoiding the injurious noise levels that occur during Phase 2. There is no standard duration of soft-start and it depends primarily on soil conditions and achieving pile stability. Regardless of this, SFW is able to commit to a minimum soft-start period of 20 minutes.

- **Piling Procedure (Phase 2)** – the piling procedure, or Phase 2, is the period when actual pile installation occurs. An optimal piling procedure is a complex exercise that includes a progressive build-up of energy to find the best combination between a) the actual soil resistance during pile driving, b) minimizing underwater noise levels as much as possible, and c) ensuring the hammer operating manual, refusal criteria, and optimal oil flow in the system are not jeopardised.

Phase 2 should be considered a period of continuous optimization of the installation. The idea is to keep the energy level (kJ) as low as possible, based on to the actual soil resistance experienced during pile driving operations and without jeopardizing the integrity of the hammer while achieving the highest blow rate the hammer is capable of safely achieving.

As an example, **Table 1** shows a 4,000-kJ hammer with a maximum 6,400-liter flow/rate configuration will have 32 blows/min operating at 100% energy level and 124 blows/min operating at 10% energy level.

Table 1. Example piling procedure.

Achieveable blows per minute

NHU 4400S

energy level	energy / kJ	flow rate /(L/min)	Anz Par Hose HP1	Dia Hose HP1 /m	Length Hose HP1 /m	Anz Par Hose LP1	Dia Hose LP1 /m	Length Hose LP1 /m	energy /kNm	blow rate /(1/min)	pHP PP Mean /bar
10 %	440	2500	4	0,076	200	4	0,076	200	442	123,5	308
20%	880	3000	4	0,076	200	4	0,076	200	880	73,4	283
40 %	1760	4000	4	0,076	200	4	0,076	200	1764	50,8	288
57 %	2500	5400	4	0,076	200	4	0,076	200	2505	48,4	312
70 %	3080	5500	4	0,076	200	4	0,076	200	3082	41,6	307
95 %	4180	6400	4	0,076	200	4	0,076	200	4180	34,1	305
100 %	4400	6400	4	0,076	200	4	0,076	200	4405	31,8	300

Technically, it is possible to have a soft-start (Phase 1) with low hammer energy at the start of piling procedures (Phase 2) over the soft-start period to reach the full hammer energy. It is possible to start the soft-start with single blows; however, it is not physically possible to maintain a continuous blow rate of one blow every 4 to 6 seconds as there is a minimum oil flow of 25% required to keep the ram weight moving for constant energy and blow rate in a continuous cycle. With a lower oil flow, it would not be possible to maintain a stable continuous hammer cycle. If the oil flow chosen is too low, the stabilizing functionality of the accumulators is reduced, resulting in undesired behaviour of the system, which could lead to damage to system components. Moreover, single-blow action of the hammer with less than 20% energy is possible. Depending on hammer series/E-controls, a setting of approximately 10% energy is an option, but not recommended.

Design Scenarios and Pile Schedules

There are two piling scenarios that are considered possible within the current engineering design. The most likely scenario assumes that a single 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 every 7 days such that the 16 piles are installed over a 20-day period. Within each design scenario, two pile schedules are considered; a standard pile schedule which will require an estimated 4,500 strikes for the pile to reach the target penetration depth with an average installation time of approximately 140 minutes for one pile, and a difficult pile schedule which would require 8,000 strikes and approximately 250 minutes are required to install one pile. A pile may be difficult to drive because of denser than anticipated substrate or the presence of an unavoidable boulder but no more than one difficult-to-drive pile is expected out of the total sixteen piles. As a conservative estimate, the maximum design scenario with a single difficult pile is used as the basis for take assessment in **Section 6.0**.

A soft-start procedure will be implemented at the beginning of each pile installation. The pile schedule is detailed in **Section 1.2.1.3** in the discussion of the acoustic propagation modeling parameters.

Vibratory Pile Driving

A temporary cofferdam may need to be installed where the SFEC 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. The cofferdam, if required, may be installed as either a sheet piled structure into the seafloor or a gravity cell structure placed on the seafloor using ballast weight. If the cofferdam is installed using sheet pile, installation will require vibratory piling of sheet pile. The nearshore location of the cofferdam will be less than 600 m (1,969 ft) from the mean high water line in 7.6 to 12.2 m (25 to 40 ft) water depth, depending on the final siting point. If the cofferdam is installed, a vibratory hammer will be used to drive sheet pile sidewalls and endwalls into the seabed. Installation of a cofferdam will take approximately 1 to 3 days, with vibratory driving taking place for no longer than 18 hours over the installation period. Removal of the cofferdam will be accomplished using a vibratory extractor, and is expected to take up to 18 hours. Acoustic analysis of vibratory piling is provided in **Section 1.2.1.3**.

Within-Construction High-Resolution Geophysical Surveys

HRG surveys are required throughout construction. Survey activities will include multibeam depth sounding, seafloor imaging, and shallow and medium penetration sub-bottom profiling within the wind farm area and export cable route. An estimated 1,000 survey line km, plus in-fill and re-surveys, are anticipated necessary to perform construction surveys of the inter-array cable and the export cable. While the final survey plans will not be completed until construction contracting commences, HRG surveys are anticipated to operate during any month of the year for a maximum of 60 vessel days surveying, on average, 70 line km per day at 4 knots (kn).

1.2.1 Acoustic Analysis of Proposed Activities

1.2.1.1 Acoustic Terminology

This document follows guidance from the International Organization for Standardization (ISO) 18405:2017 (ISO, 2017) for all acoustic terminology. Acoustic source levels, exposure levels, and associated measurements are expressed in decibels (dB). The dB is a logarithmic unit that must be referenced to the measurement properties. In the case of underwater acoustics, the dB is used as a unit of SPL (sound pressure level) referenced to 1 micropascal (μPa). In turn, SPL units can be expressed in several ways depending on the measurement properties. **Table 2** provides a list of the acoustic units used in this document.

Table 2. Sound pressure level (SPL) definitions and units of measurement used in this document.

Quantity	Abbreviation	Symbol	Units	Reference
Level		L	dB	
Sound Pressure Levels				
Sound pressure level (sound pressure level is a synonym of SPL_{rms})	SPL	L_p	dB re 1 μPa	ISO 18405[1]
Root-mean-square sound pressure level (SPL_{rms} is a synonym of sound pressure level)	SPL_{rms}	$L_{p,\mathrm{rms}}$	dB re 1 μPa	ISO 18405[1]
Peak sound pressure level (zero to peak synonym)	SPL_{pk}	$L_{p,\mathrm{0\text{-}pk}}$	dB re 1 μPa	ISO 18405[1]
Sound Exposure Levels				
Sound exposure level	SEL	L_E	dB re 1 μPa^2 s	ISO 18405[1]
Cumulative sound exposure level	SEL_{cum}	$L_{E,\mathrm{cum}}$	dB re 1 μPa^2 s	ISO 18406[2]
Source Levels				
Source Level	SL	$L_{\mathrm{S,rms}}$	dB re 1 μPa m	ISO 18405[1]

dB re 1 μPa = decibel referenced to 1 micropascal; dB re 1 μPa m = decibel referenced to 1 micropascal meter;
dB re 1 μPa^2 s = decibel referenced to 1 micropascal squared second; ISO = International Organization for Standardization;
rms = root-mean-square.
[1]ISO, 2017a.
[2]ISO, 2017b.

1.2.1.2 Regulatory Criteria

The MMPA defines two levels of marine mammal harassment, Level A and Level B. Level A harassment is statutorily defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild. The MMPA defines Level B harassment as any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. The included analysis applies the most recent noise exposure criteria utilized by NMFS, Office of Protected Resources to estimate acoustic harassment (NMFS, 2018). The NMFS acoustic criteria were purposely developed to be protective of all marine mammal species from exposure to high SPLs, primarily to address the regulatory requirements of the MMPA. In 2018, NMFS published a revision to acoustic guidance thresholds for marine mammals for use in impact assessments (NMFS, 2018).

<u>*Marine Mammal Hearing Groups*</u>

Recognizing that marine mammal species do not have equal hearing capabilities, marine mammals are separated into hearing groups (Southall et al., 2007, Southall et al., 2019, NMFS, 2018). Hearing groups are used in acoustic impact assessment through the application of frequency weighting functions. Frequency weighting functions use physiological parameters to scale a species' sensitivity to a propagated sound source depending on the spectral content of the sound source and the hearing acuity of that animal to that spectral content. Sound energy contained within the hearing range of an animal has the potential to affect hearing while sound energy outside an animal's hearing range is unlikely to affect its hearing. Regulatory marine mammal hearing groups, originally identified by Southall et al. (2007) then later modified by Finneran (2016) and adopted by NMFS (2018), are categorized as low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, phocid pinnipeds in water (PW), and otariid pinnipeds in water (OW). Each category has a defined auditory weighting function and estimated acoustic threshold for the onset of temporary and injury-level hearing impacts. More recently, Southall et al. (2019) conducted a broad, structured assessment of the audiometric, physiological, and acoustic output bases for the categorization of these hearing groups using the best available data at that time. Their assessment revealed several important features and distinctions present within the cetaceans that were not reflected in the less robust assessments used in previous categorizations of hearing groups. These include a probable distinction within the baleen whales to include a very low-frequency (VLF) and an LF group. An additional distinction is made among many of the odontocetes to include a distinction of an MF group containing the beaked, killer, and sperm whales from other HF cetaceans. The very high-frequency (VHF) specialists include porpoises, river dolphins, and a few delphinids, resulting in a total of five possible groups. However, Southall et al. (2019) acknowledge that there is presently insufficient direct data within the VHF and MF groups to explicitly derive distinct thresholds and weighting functions. They thus propose retaining the thresholds and functions developed by Finneran (2016) and adopted by NMFS (2018), but with slightly different categorical identifiers (**Table 3**). These result in slightly different grouping nomenclature from the NMFS (2018) designations (see table below), but the overall conclusions of Southall (2019) remain congruent with the current existing regulatory guidance (NMFS, 2018).

Table 3. Hearing group categories based on National Marine Fisheries Service (NMFS) (2018) and Southall et al. (2019).

NMFS (2018) Hearing Group Designation	Southall et al. (2019) Hearing Group Designation	General Hearing Frequency Range
LF	VLF	7 Hz to 35 kHz
	LF	
MF	MF	150 Hz to 160 kHz
	HF	
HF	VHF	275 Hz to 160 kHz
PPW	PCW	50 Hz to 86 kHz

HF = high-frequency; LF = low-frequency; MF = mid-frequency; PCW = phocid carnivores in water; PPW = phocid pinnipeds in water; VHF = very-high frequency; VLF = very-low frequency.

<u>*Sound Source Categories*</u>

In addition to variability in marine mammal hearing sensitivities, science recognizes different sound source types do not equally affect marine mammals, particularly when considered in the context of accumulated sound levels. Repeated exposure to sounds is potentially more damaging, as it increases the accumulation of received sound necessary to meet temporary or permanent threshold shifts (TTS or PTS, respectively). NMFS has identified two main types of sound sources: impulsive and non-impulsive. Non-impulsive sources are further broken down into the categories of continuous (e.g., vessel noise) or intermittent (e.g., shallow SBPs, multibeam echosounders). These classifications are assigned unique threshold levels depending on how the animal is likely to perceive the sound and the resulting potential for auditory injury. Within each sound source and hearing group, onset threshold levels are identified depending on the group-specific hearing capabilities and how they relate to the resulting potential for TTS and PTS. The potential for impact differs based on the source characteristic and how it propagates through the water column. Impulsive noise exposures result in TTS and PTS at lower accumulated sound levels than non-impulsive sounds given their rapid onset and broadband nature. Consequently, they are also subject to dual thresholds (Popper et al., 2014, Southall et al., 2007 [adopted by Finneran (2016) and adopted by NMFS (2018)]).

The sound sources of potential concern during proposed construction activities include impulsive sources (impact pile driving) and non-impulsive, continuous sources (vibratory pile driving). Supporting geophysical surveys may use both impulsive, (e.g., sparkers) and non-impulsive, intermittent sources (e.g., compressed high-intensity radiated pulses [CHIRPs]). Acoustic thresholds, as defined in the following section, are used to establish the total ensonified area of sound received by the animal at levels that may result in either Level A or Level B exposures, depending on marine mammal hearing capabilities and source type.

<u>*Auditory Impact Levels*</u>

Level A harassment under the MMPA comprises the onset of a PTS, a condition that occurs when sound intensity is very high and/or of sufficient duration that, based on the hearing sensitivities of the animal, could result in a loss in hearing that is irreversible (Southall et al., 2007). For impact pile driving, dual Level A criteria are applied so that an animal could meet the Level A threshold criteria from a received peak sound pressure level (SPL_{pk}) or a received cumulative sound exposure level (SEL_{cum}).

Level B harassment under the MMPA comprises TTSs and behavioral responses. A TTS results when sounds of sufficient loudness or duration cause a transient condition in which an animal's hearing sensitivity over the frequency band of exposure is impaired for a period of time (minutes to days). A TTS does not cause permanent damage and is not considered a tissue injury (Richardson et al., 1995;

Southall et al., 2007). Similarly, underwater sound may elicit a behavioral response from marine mammals that may or may not be biologically significant. In principle, behavioral thresholds are lower than TTS onset thresholds. Separate TTS thresholds are defined in the 2018 criteria; however, TTS thresholds and behavioral response thresholds have not yet been separated within a regulatory framework and are all considered Level B harassment. NMFS currently uses a step function at an unweighted root-mean-square sound pressure level (SPL_{rms}) to assess Level B behavioral impacts (NMFS, 2018, 2019a).

Because TTS onset and behavioral thresholds have not been separated within the regulatory criteria (i.e., both TTS and behavioral disturbance constitute Level B take) and because pure behavioral disturbance thresholds have not yet been defined, the regulatory framework uses interim guidance to define Level B thresholds (NMFS, 2019a). The corresponding Level A and Level B acoustic threshold criteria are summarized in **Table 4**. It is worth nothing that while the Level B threshold for non-impulsive sources is an SPL_{rms} of 120 dB re 1 µPa, non-impulsive sources that have signals that sweep through a range of frequencies (i.e., CHIRPs) are assigned a threshold level of 160 dB re 1 µPa.

Table 4. Summary of National Marine Fisheries Service (NMFS, 2018, 2019a) regulatory levels for marine mammal Level A and Level B acoustic threshold level exposure from impulsive and non-impulsive sources.

Marine Mammal Hearing Group	Source Type				
	Non-Impulsive		Impulsive		
	Level B Criteria[1]	Level A SEL_{cum} Criteria[2]	Level B Criteria[1]	Level A SPL_{pk} Criteria[2]	Level A SEL_{cum} Criteria[3]
Low-frequency Cetacean	120	199	160	219	183
Mid-frequency Cetacean		198		230	185
High-frequency Cetacean		173		202	155
Phocid Seals (in water)		201		218	185

SEL_{cum} = cumulative sound exposure level; SEL_{pk} = peak sound pressure level.
[1]Level B criteria expressed as root-mean-square sound pressure level (SPL_{rms}) decibels referenced to 1 micropascal.
[2]SPL_{pk} values given in decibels referenced to 1 micropascal.
[3]SEL_{cum} values given in decibels referenced to 1 micropascal squared second (weighted).

1.2.1.3 Pile Driving Acoustic Modeling Assessment

JASCO Applied Sciences Inc. (JASCO) conducted acoustic propagation modeling based on the expected operational parameters for construction of the SFWF and SFEC (Denes et al., 2020a). Modeling was conducted to fulfill multiple permitting requirements associated with this project, and only results pertaining to marine mammals and the activities defined in **Section 1.2** will be presented in this Application. The sound propagation modeling incorporated site-specific environmental data that describes the bathymetry (SRTM-TOPO 15+), sound speed in the water column (averaged seasonally over the work area from U.S. Navy Generalized Digital Environmental Model [GDEM]), and seabed geoacoustics in the proposed construction area. Ranges to pre-determined threshold levels (**Table 4**) were obtained from the calculated sound fields for use in evaluating potential impacts to marine mammals. The water depths at the site locations were extracted from existing bathymetry data collected by the Applicant. Modeling methods, threshold criteria, and resulting impact isopleths are different for installation of monopile foundations and the installation and removal of the cofferdam due to the different piling methods. Pile driving parameters used to estimate the range to regulatory injury and behavioral disturbance thresholds were based on engineering and project design assumptions. While not expected, some of the assumptions and design criteria may change slightly up to the start of construction. To account for this potential, the Applicant has used the most accurate and current parameters expected for the project, and where there is uncertainty, a conservative approach was used.

Monopile foundation installation

Installation of the SFWF monopile foundations were modeled at two sites that were selected to produce representative sound fields for the full construction area. For impact pile driving (impulsive sounds), time-domain representations of the pressure waves generated in the water are required to calculate the SPL_{rms}, SEL_{cum}, and SPL_{pk}. The source signatures of each pile were predicted with a finite-difference model that determined the physical vibration of the pile caused by hammer impact. The sound field radiating from the pile was simulated using a linear array of point sources. The synthetic pressure waveforms were computed using a Full Waveform Range-dependent Acoustic Model, which is JASCO's acoustic propagation model capable of producing time-domain waveforms.

As discussed in **Section 1.2**, three hammering schedules were incorporated into the monopile foundation model: a soft-start sequence, a standard pile schedule, and a difficult pile schedule, each of which accounts for the varying hammering energies encountered throughout the installation of a pile (Denes et al, 2020a). The model assumes 4,500 strikes in a 24-hour period for a standard pile schedule and 8,000 strikes for a pile schedule that encounters difficult installation parameters (e.g., greater seabed resistance). The soft-start sequence, standard pile schedule, and difficult pile schedule are provided in **Table 5**, **Table 6**, and **Table 7** respectively.

Table 5. Generic soft-start sequence reflecting the corresponding hammer energy, strike count, and duration of the strike sequence that will be implemented at the beginning of each pile installation.

% of Maximum Hammer Blow Energy	Soft Start 10–20%
Monopile blow energy	600–800 kJ
Strike Rate	4–6 strikes/min
Duration	Minimum of 20 minutes or greater until pile verticality/self-stability is secured

kJ = kilojoule; min = minutes.

Table 6. Standard pile schedule reflecting the corresponding hammer energy, strike count, and penetration depth of the strike sequence that will be implemented after the soft start (Denes et al., 2020a).

Energy Level (kJ)	Strike Count	Penetration Depth (m)
~1,000	~500	6
~1,500	~1,000	17.5
~2,500	~1,500	17.5
~4,000	~1,500	4

kJ = kilojoule; min = minutes.

Table 7. Difficult pile schedule reflecting the corresponding hammer energy, strike count, and penetration depth of the strike sequence that will be implemented after the soft start (Denes et al., 2020a).

Energy Level (kJ)	Strike Count	Penetration Depth (m)
~1,000	~800	6
~1,500	~1,200	17.5
~2,500	~3,000	17.5
~4,000	~3,000	4

kJ = kilojoule; min = minutes.

To further account for the variability in hammer energies encountered during installation of a pile, the linear ranges to regulatory SPL_{pk} acoustic thresholds (**Table 4**) were modeled for four hammer energies to best characterize the potential impact distances. Because the SEL_{cum} threshold considers all sound sources an animal may experience within a 24-hour period, distances to these criteria were modeled for the pile schedule as a whole.

Pile driving activities produce noise over a broad range of frequencies; however, the intensity of noise in individual frequency bands throughout the source spectrum is not uniform, with some frequency bands containing more energy than others. Frequency weighting factors, as determined by NMFS (2018), consider the heterogeneity of the source spectrum with the differences in marine mammal hearing between the various hearing groups (**Section 1.2.1.2**) to produce a more reasonable interpretation of the sound levels at which various groups are anticipated to meet auditory thresholds. Regulatory acoustic guidance only recognizes frequency weighting for injury thresholds. Typically, only unweighted behavior thresholds are used for take estimation; however, both weighted and unweighted modeled Level B distances are presented in the reference modeling report (Denes et al., 2020a) to illustrate potential differences between hearing groups.

Additionally, noise attenuation was applied to the propagation models based on planned use of a Noise Mitigation System (NMS) comprising device or combination of devices (e.g., bubble curtain, hydro-damper) to reduce noise propagation during monopile foundation pile driving (**Section 11.0**). While seabed-radiated sound dominates some transmission of impact pile driving noise into the water column, a reduction of in-water transmission can be successfully achieved with the implementation of noise attenuation or abatement methods. It is useful to keep in mind that a reduction of 10 dB means reducing the sound energy level by 90%, thus providing a significant reduction in the propagated sound levels and resulting impact isopleths. The acoustic model applied 6, 10, 12, and 15 dB broadband noise attenuation through the use of a bubble curtain, or similar, to gauge the effects of the mitigation on the ranges to thresholds (**Section 11.1**). These attenuation levels are based on the best available science from published sources and field reports that indicate, for Southfork site conditions and modelled foundation locations, operations can expect to achieve broadband reduction of up to 10 dB when using a single bubble curtain and up 12 to 15 dB reduction if using a double bubble curtain (Gottsche et al., 2013; Bellmann et al., 2014, 2020). Newer field information from Orsted and INSTITUT FÜR TECHNISCHE UND ANGEWANDTE PHYSIK GMBH (ITAP) indicates that a 10 dB broadband reduction is consistently achievable in offshore wind WTG piling operations using a single bubble curtain (Bellmann, 2019; Bellmann et al., 2020).

An NMS applied during pile driving will reduce the broadband SPLs; however, each NMS will reduce varying spectral components of the sound source with varying efficiencies. The spectral levels attenuated in the sound fields depend on the source characteristics (how the sound is generated during pile driving) and interactions with the environment as sound propagates away from the source combined with the characteristics of the NMS. Sounds produced by piles are low-frequency (<1000 Hz) and best hearing range varies with hearing group, so the effects of noise reduction differs by species. Based on the published results in Bellmann et al., 2020, the received sound levels used to predict exposure levels using 10 dB attenuation are achievable with the use of available NMS technologies. The NMS for SFW pile driving is not specified at this stage; however SFW has committed to achieving the ranges modeled with 10 dB broadband noise reduction for the predicted received sound fields used to estimate exposures.

Acoustic Ranges

Acoustic range modeling relies solely on sound propagation through the environment and assumes a stationary receiver (i.e., animal) to predict the maximum distance at which that receiver could receive enough acoustic energy over a 24-hour period to exceed the threshold criteria. For impact pile driving, the

SEL_{cum} standard pile schedule distances result from pile installation requiring roughly 4,500 strikes, while the SEL_{cum} difficult pile schedule distances result from installation of a difficult pile requiring roughly 8,000 strikes.

Summaries of the mean acoustic ranges to Level A SPL_{pk} and SEL_{cum} acoustic thresholds resulting from acoustic propagation modeling are provided in **Tables 8** and **Table 9**, respectively. **Table 10** provides the maximum ranges to Level B thresholds. The SEL_{cum} threshold is the only metric that is affected by the number of strikes within a 24-hour period; therefore, it is only this acoustic threshold that showed different ranges between the standard pile schedule and the difficult pile schedule (**Table 9**). The maximum distances provided for the other two metrics (SPL_{pk} and SPL_{rms}) are equal for both schedules 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). Distances provided include the application of 0, 6, 10, 12, and 15 dB broadband noise attenuation as discussed in **Section 1.1**.

Table 8. Mean acoustic range to Level A peak sound pressure level (SPL_{pk}) acoustic thresholds (NMFS, 2018) for marine mammals due to impact pile driving of an 11-m pile with 0, 6, 10, 12, and 15 dB broadband noise attenuation applied (Denes et al., 2020a).

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	8	7	2
Mid-frequency cetaceans	230	8	2	2	1	1
High-frequency cetaceans	202	1,545	541	301	183	108
Phocid pinnipeds	218	101	26	10	8	2

dB re 1 µPa = decibel referenced to 1 micropascal.

Table 9. Mean acoustic range to Level A cumulative sound exposure level (SEL_{cum}) acoustic thresholds (NMFS, 2018) for marine mammals due to impact pile driving of an 11-m pile for the installation of a standard pile schedule (~4,500 strikes) and a difficult pile schedule (~8,000 strikes) with 0, 6, 10, 12, and 15 dB broadband noise attenuation applied (Denes et al., 2020a).

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*	
		Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult
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 μPa^2 s = decibel referenced to 1 micropascal squared second.

Table 10. Mean acoustic range to unweighted Level B root-mean-square sound pressure level (SPL_{rms}) acoustic threshold (NMFS, 2018) for marine mammals due to impact pile driving of an 11-m pile with 0, 6, 10, 12, and 15 dB broadband noise attenuation applied (Denes et al., 2020a)

Marine Mammal Hearing Group	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*
Cetaceans and Pinnipeds	160	11,382	6,884	4,684	4,164	3,272

dB re 1 μPa = decibel referenced to 1 micropascal.

Exposure ranges

Modeled distances to threshold levels may overestimate the actual distances at which animals receive exposures meeting the threshold criteria. Modeled acoustic ranges to thresholds assume that animals are stationary. Therefore, such ranges are not realistic, particularly for accumulating metrics like SEL_{cum}. Applying animal movement and exposure models (**Section 6.1.2**) provides a more realistic indication of the distances at which acoustic thresholds are met. The 95% exposure ranges ($ER_{95\%}$) are the distances at which a Level A exposure is likely to occur for each species based on animal movement modeling rather than a static animal at a specified distance. Notably, the $ER_{95\%}$ are species-specific rather than categorized only by hearing group, which affords more biological content to be considered when assessing impact ranges. The $ER_{95\%}$ for SEL_{cum} are provided in **Table 11** and are smaller than those calculated using propagation modeling alone (**Table 9**).

Table 11. Exposure-based ranges ($ER_{95\%}$) to Level A cumulative sound exposure level (SEL_{cum}) acoustic thresholds (NMFS, 2018) for marine mammals resulting from the maximum design scenario (piling for 6 days in a 7 day period) with a standard pile schedule (~4,500 strikes) and with inclusion of single a difficult to drive pile (~8,000 strikes) with 0, 6, 10, 12, and 15 dB broadband noise attenuation applied (Denes et al. 2020b,c; Zeddies., pers. Com.).

Species	$ER_{95\%}$ to SEL_{cum} thresholds (m)									
	0 dB attenuation		*6 dB attenuation*		*10 dB attenuation*		*12 dB attenuation*		*15 dB attenuation*	
	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult
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

Table 11. (Continued).

Species	ER$_{95\%}$ to SEL$_{cum}$ thresholds (m)									
	0 dB attenuation		*6 dB attenuation*		*10 dB attenuation*		*12 dB attenuation*		*15 dB attenuation*	
	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult
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 = decibel.
* = species listed under the Endangered Species Act.
[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" o 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 NMS will be used during vibratory piling. Summaries of the maximum ranges to Level A thresholds and unweighted Level B thresholds resulting from propagation modeling of vibratory pile driving are provided in **Table 12**.

The large Level B isopleths (**Table 12**) resulting from vibratory piling installation and removal is an artifact of the very low regulatory threshold set for behavioral disturbance from a non-impulsive noise. As discussed further in **Section 7.0**, the behavioral 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 species.

Table 12. Distances to weighted Level A cumulative sound exposure level (SEL_{cum}) acoustic thresholds (NMFS, 2018) and unweighted Level B root-mean-square sound pressure level (SPL_{rms}) acoustic thresholds (NMFS, 2019a) for marine mammals 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 unweighted 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; µPa^2 s = decibel referenced to 1 micropascal squared second.

1.2.1.4 HRG Survey Acoustic Assessment

Operational SLs and operational parameters will vary throughout the survey and therefore a level of judgment is required to establish appropriate parameters and SLs to estimate the distances to regulatory thresholds. Typically, field-measured data is considered the best available science for HRG sources due to the high site- and result-specific variables that direct frequency content, power, beamwidths, and other user-defined parameters. The same equipment used in a deep-water, clay bottom environment may be operated very differently and therefore produce different acoustic propagation characteristics than if it were operated in a shallow water, sand bottom environment. However, recent communication with NMFS Office of Protected Resources indicates that, due to inconsistencies in field verifications conducted on existing wind leases, Crocker and Fratantonio (2016) measurements are preferable to field measurement results. Therefore, the following hierarchy was used for selecting input to the NMFS User Spreadsheet Tool (NMFS, 2020a) and transmission loss (TL) equations:

1. For equipment that was measured in Crocker and Fratantonio (2016), the reported SL for the most likely operational parameters was selected;
2. For equipment not measured in Crocker and Fratantonio (2016), the best available manufacturer specifications were selected. Use of manufacturer specifications represent the absolute maximum output of any source and do not adequately represent the operational source. Therefore, they should be considered an overestimate of the sound propagation range for that equipment; and
3. For equipment that was not measured in Crocker and Fratantonio (2016) and did not have sufficient manufacturer information, the closest proxy source measured in Crocker and Fratantonio (2016) was used.

The operational parameters (e.g., operating frequency, SL, pulse duration, ping rate) for each piece of equipment, as well as the output parameters (e.g., SPLs, propagation distance, frequency content) are generally similar within each category and therefore the overall magnitude of impact radii can often be predicted based on the equipment category (Crocker and Fratantonio, 2016).

The operational characteristics and supplemental source information considered in the analyses for this Application, as well as justification for selected proxy equipment, and categories excluded from analysis, are provided below.

Shallow Penetration SBPs (CHIRPs) are used to map the near-surface stratigraphy (top 0 to 5 m) of sediment below seabed. A CHIRP system emits sonar pulses that increase in frequency from approximately 2 to 20 kHz over time. The pulse length frequency range can be adjusted to meet project variables. These shallow penetration SPBs are typically mounted on a pole, either over the side of the vessel or through a moon pool in the bottom of the hull.

Medium Penetration SBPs (Boomers) are used 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 commonly mounted on a sled and towed behind the vessel.

Medium Penetration SBPs (Sparkers) are used to map deeper subsurface stratigraphy as needed. Sparkers create acoustic pulses from 50 Hz to 4 kHz omnidirectionally from the source that can penetrate several hundred meters into the seafloor. Sparkers are typically towed behind the vessel with adjacent hydrophone arrays to receive the return signals.

Acoustic Corers, unlike the other mobile geophysical sources, acoustic corers are stationary and made up of three distinct sound sources comprised of a HF parametric sonar (which will not be included in this assessment), a HF CHIRP sonar, and a LF CHIRP sonar with each source having its own transducer. The corer is seabed-mounted; therefore, measurements for similar towed equipment are unlikely to be fully comparable.

The beam width of the parametric sonar is narrow (3.5 to 8°) and the sonar is operated roughly 3.5 m above the seabed with the transducer pointed directly downward. This configuration represents the expected operation of the acoustic corer during the survey to maximize the energy channeled into the seabed and subsequently results in nominal horizontal propagation. There are no relevant information sources or measurement data within the Crocker and Fratantonio (2016) reference for acoustic corers; however, an acoustic assessment similar to a sound field verification and a modeling assessment were conducted for the acoustic corer by the manufacturer. The modeling assessment showed much larger propagation distances than those that were measured in the field (Pangeo Subsea, 2018), further demonstrating the significant reduction in operational propagation distances for these highly directional, seabed-mounted sources.

Because of the operation close to the seabed and minimal resulting propagation distances, no Level A or Level B exposures can be reasonably expected from the operation of these sources; therefore, the acoustic corers were not carried forward in the Application analysis.

Parametric SBPs, also called sediment echosounders, are used for providing high data density in sub-bottom profiles that are typically required for cable routes, very shallow water, and archaeological surveys. Parametric SPBs are typically mounted on a pole, either over the side of the vessel or through a moon pool in the bottom of the hull. there are no relevant information sources or measurement data within the Crocker and Fratantonio (2016) reference for parametric SBPs. Source information is available from the manufacturer; however, no field measurements or propagation characteristics are provided with the manufacturer specifications. Due to the highly specialized nature of these sonars (high frequencies and narrow beamwidths), the source information alone is not sufficient to fully evaluate the expected propagation. Like the Ultra-Short Baseline (USBL) positioning systems, the parametric SBPs are moonpool- or side pole-mounted and not towed behind the vessel. This configuration significantly reduces the likelihood of the beam intersecting an animal.

The specific parametric sonar proposed for the HRG work, the Innomar SES-2000 SBP, uses the principle of "parametric" or "nonlinear" acoustics to generate short, very narrow-beam sound pulses at very high frequencies (generally around 85-100 kHz). The transducer projects a beamwidth of approximately 1 to 3.5°. The narrow beamwidth significantly reduces the impact range of the source while the high frequencies of the source are rapidly attenuated in sea water. Neither are well-captured in the NOAA User Spreadsheets used to calculate Level A isopleths. Therefore, the manufacturer reported root-mean-square source level (SL_{rms}) was converted to sound exposure source level (ESL), then exposure distances were calculated for each hearing group following guidance provided by NMFS OPR (NMFS, 2019b) which considers both the beamwidth and frequency absorption as previously mentioned. Because of the high frequency of the source and narrow bandwidth, parametric SBPs do not produce Level A isopleths beyond 2 m and do not produce Level B isopleths beyond 4 m. No Level A or Level B exposures can be reasonably expected from the operation of these sources; therefore, the Innomar parametric SBPs were not carried forward in the Application analysis.

USBL Positioning systems are used to provide high accuracy ranges by measuring the time between the acoustic pulses transmitted by the vessel transceiver and a transponder (or beacon) necessary to produce the acoustic profile. It is a two-component system with a moonpool- or side pole-mounted transceiver and one or several transponders mounted on other survey equipment. There are no relevant information sources or measurement data within the Crocker and Fratantonio (2016) reference for USBLs and only limited manufacturer SL_{rms} information. However, USBL sound field verifications conducted by the Applicant resulted in no Level A thresholds being met and Level B zones less than 7 m (Marine Acoustics, Inc., 2018). USBLs have a wide variety of configurations, source levels, and beamwidths but have been shown to produce extremely small acoustic propagation distances due to their typical operating configuration. There are numerous options for make and model of USBLs, and of combinations pairing USBL transceivers and beacons. Eleven USBL systems have been identified as possible equipment on the site characterization surveys; therefore, the proxy source used was the Sonardyne Ranger 2 operating with an omnidirectional beamwidth, representative of the maximal proxy because it has the highest reported SL_{rms} at 194 dB re 1 µPa m.

Geophysical sources have been extensively reviewed in the Gulf of Mexico OCS due to the large amount of ongoing and planned oil and gas geophysical and geotechnical (G&G) surveys. A programmatic environmental impact statement (EIS) was issued for G&G surveys in the Gulf of Mexico in 2017. Within this EIS, non-airgun HRG sources were considered for potential impacts. USBLs were not considered in the assessment. Additionally, in the most recent petition for a Gulf of Mexico incidental take regulation, USBLs were not considered for take requests by NMFS in the proposed rule issued on 22 June 2018 (83 *Federal Register* [*FR*] 29212). In the proposed rule, HRG surveys with equipment comparable to the equipment proposed in these activities were fully evaluated and USBLs were not considered in the take evaluation.

There is, therefore, precedence for not considering USBLs as sound sources likely to propagate sound levels reaching Level A or Level B thresholds. Based on this information, no Level A or Level B exposures can be reasonably expected from the operation of these sources; therefore, the Innomar parametric SBPs were not carried forward in the Application analysis.

Multibeam Echosounders (MBESs) are used 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. The proposed MBESs all have operating frequencies >200 kHz, they are outside the general hearing range of marine mammals likely to occur in the Project Area and are not likely to affect these species. Therefore, this equipment category will not be discussed further in this Application.

Side-scan Sonars (SSS) are used for seabed sediment classification purposes and to identify natural and man-made acoustic targets on the seafloor. 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 column. 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. SSSs are typically towed beside or behind the vessel or from an autonomous vehicle. The proposed SSSs all have operating frequencies

>200 kHz, they are outside the general hearing range of marine mammals likely to occur in the Project Area and are not likely to affect these species. Therefore, this equipment category will not be discussed further in this Application.

The operational parameters for each piece of equipment are typically provided as a range of options that can be specified by the user. The precise settings are often field-specific depending on each contractor's individual survey methodologies and data needs. The selected parameters will affect the impact analysis for each piece of equipment within each category; therefore, the parameters used in the analysis must be as closely aligned as possible with the expected operation at the time of the survey. This information helps determine the expected acoustic output for this project by selecting the appropriate measurements reported in Crocker and Fratantonio (2016). For equipment that were not measured by Crocker and Fratantonio (2016), manufacturer information was used with the most applicable operational parameters (**Table 13**).

Although the final equipment choices will vary depending on the final survey design, vessel availability, make and model updates, and survey contractor selection, all sources that are representative of those that could be employed during the HRG surveys are provided in **Table 13** along with details of the parameters used in acoustic analyses within this Application.

Table 13. List of all representative geophysical sound sources that may be used during the site characterization surveys that were assessed for potential acoustic impacts. All source information that was used to calculate threshold isopleths are provided in the table.

Equipment	Source Type	Frequency used for WFA in User Spreadsheets (kHz)[1]				Reference for SL	Operational Parameters						
		Low-frequency Cetaceans	Mid-frequency Cetaceans	High-frequency Cetaceans	Phocid Pinnipeds in Water	**CF**= Crocker and Fratantonio (2016) **MAN** = Manufacturer	Operating Frequency (kHz)	SL_{rms} (dB re 1 μPa m)	SL_{pk} (dB re 1 μPa m)	Pulse Duration (width) (millisecond)	Repetition Rate (Hz)	Beamwidth (degrees)	**T** = towed; **PM** = pole-mounted; **HM**= hull-mounted; **SM** = seabed-mounted; **EM** = equipment-mounted
Shallow Sub-bottom Profilers (CHIRP Sonars)													
ET 216 (2000DS or 3200 top unit)	Non-impulsive, mobile, intermittent	2	16	16	6.2	MAN	2–16 2–8	195	-	20	6	24	PM/T
ET 424	Non-impulsive, mobile, intermittent	4	24	24	6.2	CF	4–24	176	-	3.4	2	71	PM/T
ET 512	Non-impulsive, mobile, intermittent	1.7	12	12	6.2	CF	0.7–12	179	-	9	8	80	PM/T
GeoPulse 5430A	Non-impulsive, mobile, intermittent	2	17	17	6.2	MAN	2–17	196	-	50	10	55	PM/T
Teledyne Benthos Chirp III - TTV 170	Non-impulsive, mobile, intermittent	2	7	7	6.2	MAN	2–7	197	-	60	15	100	PM/T

Table 13. (Continued).

Equipment	Source Type	Frequency used for WFA in User Spreadsheets (kHz)[1]				Reference for SL	Operational Parameters						
		Low-frequency Cetaceans	Mid-frequency Cetaceans	High-frequency Cetaceans	Phocid Pinnipeds in Water	**CF**= Crocker and Fratantonio (2016) **MAN** = Manufacturer	Operating Frequency (kHz)	SL_{rms} (dB re 1 µPa m)	SL_{pk} (dB re 1 µPa m)	Pulse Duration (width) (millisecond)	Repetition Rate (Hz)	Beamwidth (degrees)	**T** = towed; **PM** = pole-mounted; **HM**= hull-mounted; **SM** = seabed-mounted; **EM** = equipment-mounted
Medium Sub-bottom Profilers (Sparkers & Boomers)													
AA, Dura-spark UHD (400 tips, 500 J)[2]	Impulsive, mobile	1				CF	0.3–1.2	203	211	1.1	4	Omni	T
AA, Dura-spark UHD (400+400)[2]	Impulsive, mobile	1				CF (AA Dura-spark UHD Proxy)	0.3–1.2	203	211	1.1	4	Omni	T
GeoMarine, Geo-Source dual 400 tip sparker (800 J)[2]	Impulsive, mobile	1.5				CF (AA Dura-spark UHD Proxy)	0.4–5	203	211	1.1	2	Omni	T
GeoMarine Geo-Source 200 tip light weight sparker (400 J)[2]	Impulsive, mobile	1				CF (AA Dura-spark UHD Proxy)	0.3–1.2	203	211	1.1	4	Omni	T
GeoMarine Geo-Source 200-400 tip freshwater sparker (400 J)[2]	Impulsive, mobile	1				CF (AA Dura-spark UHD Proxy)	0.3–1.2	203	211	1.1	4	Omni	T
AA, triple plate S-Boom (700–1,000 J)	Impulsive, mobile	3.4				CF	0.1–5	205	211	0.6	4	80	T

- = not applicable; NR = not reported; dB re 1 µPa m = decibel referenced to 1 micropascal meter; AA = Applied Acoustics; ET = EdgeTech; J = joule; Omni = omnidirectional source; re = referenced to; SL = source level; SL_{pk} = peak source level; SL_{rms} = root-mean-square source level; UHD = ultra-high definition; WFA = weighting factor adjustments.

[1]WFAs were selected in the User Spreadsheet (NMFS, 2020a) for each marine mammal hearing group based on estimated hearing sensitivities of each group and the operational frequency of the source.

[2]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.

Ranges to acoustic thresholds resulting from HRG surveys

The SEL_{cum} metric was applied to non-impulsive sources to estimate the range to acoustic thresholds. Because impulsive sources use dual metrics (SEL_{cum} and SPL_{pk}) for Level A exposure criteria, the metric resulting in the largest isopleth distance was used for exposure estimation. Weighting factor adjustments (WFAs) for Level A isopleths used to account for differences in marine mammal hearing were determined by examining the frequency range and spectral densities for each source. The selected WFAs were then compared to the Applicable Frequencies Table located in the WFA tab of the NMFS User Spreadsheet Tool (NMFS, 2020a). If the determined frequency was lower than the applicable frequency for all hearing groups, it was entered as the WFA. When the frequency of a source exceeded the applicable frequency for a certain hearing group, an additional worksheet was created that applied the "use" frequency of the exceeded hearing group as indicated by NMFS (NMFS, 2020a).

The User Spreadsheet does not calculate distances to Level B thresholds; the range to the Level B thresholds was determined by applying spherical spreading loss to the SL for that equipment. The operational depth and directionality can greatly influence how the sound propagates and can influence the resulting isopleth distance, so these parameters were considered for sources that had reported beamwidths. Surface-towed omnidirectional sources (e.g., sparkers, boomers) and equipment with wide (>180°) reported beamwidths are expected to propagate further in the horizontal direction and produce larger ensonified fields. For these sources, the rate of TL was estimated using spherical spreading loss to calculate the distance to the Level B threshold.

Sources that project a narrow beam, often in frequencies above 10 kHz directed at the seabed, are expected to have smaller isopleths and less horizontal propagation due to the directionality of the source and faster attenuation rate of higher frequencies. Narrow beamwidths allow geophysical equipment to be highly directional, focusing its energy in the vertical direction and minimizing horizontal propagation, which greatly reduces the possibility of direct path exposure to receivers (i.e., marine mammals) from sounds emitted by these sources. Therefore, for sources with beamwidths <180°, isopleth distances were calculated following NMFS OPR interim guidance (NMFS, 2019b) to account for the influence of beamwidth and frequency on the horizontal propagation of these sources. The estimated distances to Level A and Level B HRG survey isopleths calculated for each marine mammal hearing group are given in **Table 14**.

Table 14. Distance to weighted Level A and unweighted Level B thresholds for each HRG sound source or comparable sound source category for marine mammal hearing groups[1,2].

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 (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; AA = Applied Acoustics; CHIRP = Compressed High-Intensity Radiated Pulse; ET = EdgeTech; HF = high-frequency; J = joules; LF= low-frequency; MF = mid-frequency; PW = Phocids in water; SBP = sub-bottom profiler; SEL_{cum} = cumulative sound exposure level in decibels (dB) referenced to (re) 1 micropascal squared (μPa^2) s; SPL_{0-pk} = zero to peak sound pressure level in dB re 1 micropascal (µPa); SPL_{rms} = root-mean-square sound pressure level in dB re 1 µPa; TB = teledyne benthos; UHD = ultra-high definition; USBL = ultra-short baseline.

[1]The Level A and B isopleths were calculated to comprehensively assess the potential impacts of the predicted source operations as required for this Application. However, as described in **Section 5.0**, Level A takes are not expected.

[2]The Level A distances for the Innomar parametric sonar are based on sound source level and use beamwidth and frequency absorption factors (NMFS, 2019b) rather than the National Oceanic and Atmospheric Administration User Spreadsheet.

1.2.2 Environmental Assessments of Similar Construction Activities

Pile driving has been addressed in multiple commercial wind lease issuance and site assessment Environmental Assessments (EAs) prepared by BOEM, including those in New York (BOEM, 2016) and Rhode Island-Massachusetts (RI-MA) (BOEM, 2012). Reasonably foreseeable activities and impact-producing factors associated with the Project were fully assessed in the revised BOEM RI-MA EA (BOEM, 2013) which declared a Finding of No Significant Impact.

Results from the BOEM EAs of modeled acoustic propagation from impact pile driving showed that the distances to various acoustic thresholds from the sources varied based on the location, pile diameter, and hammer energy. BOEM (2012) modeled distances from three different projects offshore Delaware, New Jersey, and Nantucket for 3 and 5.05 m (10 and 16.57 ft) monopiles using a 900 and 1,200 kJ hammer. The SPL_{rms} 180 dB isopleth distances ranged from 500 m (1,640 ft) to 1,000 m (3,281 ft) while the 160 dB isopleth distances were between 3,400 m (11,155 ft) and 7,230 m (23,721 ft) for all three locations.

The modeled ranges by Denes et al. (2020a) to unweighted SPL_{rms} isopleths provided in this Application were not readily comparable to the ones calculated by BOEM (2012), given the differences in monopile sizes, hammering configuration and hammer energy. Site specific environmental data such as bathymetry, sediment type, and the sound speed profile of the water column, when included in the model, can have a substantial impact on the propagation of sound through the water column. The time of year can also play a role in sound propagation, as this will effect environmental variables which contribute to underwater sound propagation.

2.0 Construction Dates, Duration, and Specific Geographic Region

2.1 CONSTRUCTION ACTIVITY DATES AND DURATION

Construction of the SFWF and SFEC will occur between 2022 and 2023. During this time period, activities will occur 24 hours a day to minimize the overall duration of activities and the associated period of potential impact on marine species. While not anticipated, pile driving during nighttime hours could potentially occur. The total number of construction days will be dependent on a number of factors, including environmental conditions, planning, construction and installation logistics. The general installation schedule is provided in **Table 15**; however, the installation schedule was approximated based on several factors including the estimated timeframe in which permits are received, anticipated regulatory seasonal restrictions, environmental conditions, planning, and logistics. The installation schedule includes both piling and non-piling activities.

Table 15. Anticipated installation schedule for South Fork Wind Farm (SFWF) and South Fork Export Cable (SFEC) containing activities addressed in the application.

Project Component	Milestone	Expected Duration
SFWF	Foundation installation[1]	4 months
	HRG Surveys	4 months
SFEC	Sea-to-shore installation (including HDD)[2]	6 to 9 months
	HRG Surveys	6 to 9 months

HDD= Horizontal directional drilling.
[1]Pile driving is expected to occur over 30 days at the SFWF between May 1st and December 31st.
[2]Pile driving is expected to occur for 2 days at the cofferdam between October 1st and May 31st.

Impact pile driving activities at SFWF are expected to take place between May 1 and December 31. There are two piling scenarios that are considered possible within the current engineering design. The most likely 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 every 7 days such that the 16 piles are installed over a 20-day period.

SFW has committed to no pile driving between January 1st and April 30th to minimize potential impacts to the North Atlantic right whale. This ultimately restricts the commencement of the wind farm installation process and sequence. To minimize time spent working offshore during hazardous weather conditions and to meet SFW’s contractual in-service obligation, all major components of the project must be installed within a few months of monopile foundation installation.

It is necessary that SFW maintain the ability to install piles in the month of May. The entire construction schedule is comprised of the installation of multiple project components (e.g., onshore cable and interconnection, subsea export cable, inter-array cables, foundations, wind turbine generators). Project component installation schedules can run concurrently, overlap, be sequential, and all have interdependencies. Monopile foundation installation is one of the first steps in the overall offshore construction sequence and is necessary prior to the installation of other components. The monopile foundations must be in place to provide connection points for the export cable and inter-array cables, as well as for the installation of the wind turbine generators and offshore substation. Therefore, it is crucial that monopile foundation installation occur early in the offshore work window to provide as much time as possible to complete the overall wind farm and export cable installation.

Working in the offshore environment presents numerous challenges that can result in delays to installation. As construction progresses into the fall and winter seasons, hazardous weather conditions become more prominent. In addition, issues such as unforeseen equipment complications and other state and federal environmental permit windows may further restrict the SFWF construction sequence and schedule. The installation vessels, vendors, and supply chains used in the offshore wind industry are extremely specialized and will be in high demand as worldwide offshore wind production increases, therefore timing and availability of such resources may further complicate construction planning.

A cofferdam may be installed for the sea-to-shore cable connection and, if required, would be installed between October 1st and May 31st. Overall construction of the cofferdam is expected to take 1 to 3 days with vibratory piling of the sheet piles occurring for approximately 18 hours within the installation period window. Removal of the cofferdam will be done using a vibratory extractor and would be expected to also require 18 hours for sheet pile removal. No bubble curtain would be used for the cofferdam installation due to the short time period and operational considerations in shallow water.

2.2 SPECIFIC GEOGRAPHIC REGION

The Applicant's activities will occur within federal waters in the Lease Area OCS-A 0517 (Lease Area) and along potential submarine cable routes to landfall locations in Long Island, New York (**Figure 1**). Water depths, in the area where WTG are proposed to be installed, range from approximately 33 to 41 m (108 to 134 ft). Water depth of the export cable routes range from approximately 0 m (0 m) in New York State waters to 48 m (158 ft) in federal waters.

3.0 Species and Numbers of Marine Mammals

3.1 PROTECTED POPULATIONS

All marine mammal species are protected under the MMPA. Some marine mammal *stocks* (defined as a group of nonspecific individuals that are managed separately) (NMFS, 2020b) may be designated as *strategic* under the MMPA, which requires the jurisdictional agency (NMFS or U.S. Fish and Wildlife Service [USFWS]) to impose additional protection measures.

A stock is considered strategic if:

- Direct human-caused mortality exceeds its Potential Biological Removal (PBR) level (defined as the maximum number of animals, not including natural mortality, that can be removed from the stock while allowing the stock to reach or maintain its optimum sustainable population level);
- It is listed under the ESA;
- It is declining and likely to be listed under the Endangered Species Act (ESA); or
- It is designated as *depleted* under the MMPA.

A depleted species or population stock is defined by the MMPA as any case in which:

- The Secretary, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals established under MMPA Title II, determines that a species or population stock is below its optimum sustainable population;
- A State, to which authority for the conservation and management of a species or population stock is transferred under Section 109 of the MMPA, determines that such species or stock is below its optimum sustainable population; or
- A species or population stock is listed as an *endangered* species or a *threatened* species under the ESA.

Some species are further protected under the ESA. Under the ESA, a species is considered endangered if it is "in danger of extinction throughout all or a significant portion of its range." A species is considered threatened if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

3.2 MARINE MAMMAL SPECIES

There are 36 species of marine mammals in the western North Atlantic OCS Region that are protected by the MMPA (**Table 16**) (BOEM, 2012). The marine mammal assemblage comprises cetaceans (whales, dolphins, and porpoises), pinnipeds (seals), and sirenians (manatee).

There are 31 cetaceans, including 25 members of the suborder Odontoceti (toothed whales, dolphins, and porpoises) and 6 of the suborder Mysticeti (baleen whales) within the region. Five whale species listed as endangered under the ESA have ranges that include the Project Area:

- Fin whale (*Balaenoptera physalus*);
- Sei whale (*Balaenoptera borealis*);
- Blue whale (*Balaenoptera musculus*);
- North Atlantic right whale (*Eubalaena glacialis*); and
- Sperm whale (*Physeter macrocephalus*).

Along with cetaceans, seals are also protected under the MMPA. There are four species of phocids (true seals) with ranges that include the Project Area, including harbor seals, gray seals, harp seals, and hooded seals (Waring et al., 2008). Finally, one species of sirenian, the Florida manatee, *Trichechus manatus*, is an occasional visitor to the region during summer months (USFWS, 2019). The manatee is listed as threatened under the ESA and is protected under the MMPA along with the other marine mammals.

The expected occurrence of each species in the Project Area is based on information provided in the BOEM RI-MA EA (BOEM, 2012), the IHA issued to Deepwater Wind, LLC for marine construction activity off the coast of New York (82 *FR* 32330), and the Northeast Large Pelagic Survey (Kraus et al., 2016), and/or species habitat models (Best et al., 2012; Roberts et al., 2016; Roberts, 2018, 2020) available for the region. Five categories for marine mammal occurrence within the Project Area are applied in this application, including:

- Common – Occurring consistently in moderate to large numbers;
- Regular – Occurring in low to moderate numbers on a regular basis or seasonally;
- Uncommon – Occurring in low numbers or on an irregular basis;
- Rare – Records for some years but limited; and
- Not expected – Range includes the Project Area but due to habitat preferences and distribution information species are not expected to occur in the Project Area although records may exist for adjacent waters.

The protection status, stock identification, occurrence, and abundance estimates of each marine mammal species with geographic ranges that include the Project Area are listed in **Table 16**. Species potentially affected by the project are discussed in detail in **Section 4.0**.

Table 16. Marine mammals with geographic ranges that include the Project Area (Waring et al., 2015; NMFS, 2020b; USFWS, 2019).

Common Name	Scientific Name	Stock	Federal ESA/MMPA Status	Relative Occurrence in the Project Area	Best Estimate[1]
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Minke whale	*Balaenoptera acutorostrata*	Canadian East Coast	Non-strategic	Common	21,968
Sei whale	*Balaenoptera borealis*	Nova Scotia	ESA Endangered/Depleted and Strategic	Regular	6,292
Blue whale	*Balaenoptera musculus*	Western North Atlantic	ESA Endangered/ Depleted and Strategic	Rare	402
Fin whale	*Balaenoptera physalus*	Western North Atlantic	ESA Endangered/Depleted and Strategic	Common	6,802
North Atlantic right whale	*Eubalaena glacialis*	Western North Atlantic	ESA Endangered/ Depleted and Strategic	Common	412
Humpback whale	*Megaptera novaeangliae*	Gulf of Maine	Non-strategic	Common	1,393
Suborder Odontoceti (toothed whales, dolphins, and porpoises)					
Sperm whale	*Physeter macrocephalus*	North Atlantic	ESA Endangered/Depleted and Strategic	Regular	4,349
Pygmy sperm whale	*Kogia breviceps*	Western North Atlantic	Non-strategic	Rare	7,750

Table 16. (Continued).

Common Name	Scientific Name	Stock	Federal ESA/MMPA Status	Relative Occurrence in the Project Area	Best Estimate[1]
Dwarf sperm whale	*Kogia sima*	Western North Atlantic	Non-strategic	Rare	7,750
Northern bottlenose whale	*Hyperoodon ampullatus*	Western North Atlantic	Non-strategic	Not Expected	unknown
Cuvier's beaked whale	*Ziphius cavirostris*	Western North Atlantic	Non-strategic	Rare	5,744
Mesoplodon beaked whales	*Mesoplodon spp.*	Western North Atlantic	Depleted	Rare	10,107
Killer whale	*Orcinus orca*	Western North Atlantic	Non-strategic	Rare	unknown
False killer whale	*Pseudorca crassidens*	Western North Atlantic	Strategic	Rare	1,791
Pygmy killer whale	*Feresa attenuata*	Western North Atlantic	Non-strategic	Not Expected	unknown
Short-finned pilot whale	*Globicephala macrorhynchus*	Western North Atlantic	Strategic	Rare	28,924
Long-finned pilot whale	*Globicephala melas*	Western North Atlantic	Strategic	Common	39,215
Melon-headed whale	*Peponocephala electra*	Western North Atlantic	Non-strategic	Not Expected	unknown
Risso's dolphin	*Grampus griseus*	Western North Atlantic	Non-strategic	Common	35,493
Common dolphin	*Delphinus delphis*	Western North Atlantic	Non-strategic	Common	172,974
Fraser's dolphin	*Lagenodelphis hosei*	Western North Atlantic	Non-strategic	Rare	unknown
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Western North Atlantic	Non-strategic	Common	93,233
White-beaked dolphin	*Lagenorhynchus albirostris*	Western North Atlantic	Non-strategic	Rare	536,016
Pantropical spotted dolphin	*Stenella attenuata*	Western North Atlantic	Non-strategic	Rare	6,593
Clymene dolphin	*Stenella clymene*	Western North Atlantic	Non-strategic	Not Expected	4,237
Striped dolphin	*Stenella coeruleoalba*	Western North Atlantic	Non-strategic	Rare	67,036
Atlantic spotted dolphin	*Stenella frontalis*	Western North Atlantic	Non-strategic	Uncommon	39,921
Spinner dolphin	*Stenella longirostris*	Western North Atlantic	Non-strategic	Rare	4,102
Rough toothed dolphin	*Steno bredanensis*	Western North Atlantic	Non-strategic	Rare	136
Common bottlenose dolphin	*Tursiops truncatus*	Western North Atlantic, offshore	Non-strategic	Uncommon	62,851
Harbor porpoise	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	Non-strategic	Common	95,543

Table 16. (Continued).

Common Name	Scientific Name	Stock	Federal ESA/MMPA Status	Relative Occurrence in the Project Area	Best Estimate[1]
Order Carnivora					
Suborder Pinnipedia					
Hooded seal	*Cystophora cristata*	Western North Atlantic	Non-strategic	Rare	unknown
Gray seal	*Halichoerus grypus*	Western North Atlantic	Non-strategic	Regular	27,131
Harp seal	*Pagophilus groenlandica*	Western North Atlantic	Non-strategic	Rare	unknown
Harbor seal	*Phoca vitulina*	Western North Atlantic	Non-strategic	Regular	75,834
Order Sirenia					
Florida manatee[2]	*Trichechus manatus*	-	ESA Threatened/ Depleted and Strategic	Rare	13,000[3]

ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act.
[1]Best estimate from the most recently updated National Oceanic and Atmospheric Administration Stock Assessment Reports (NMFS, 2020b).
[2]Under management jurisdiction of United States Fish and Wildlife Service rather than National Marine Fisheries Service (USFWS, 2019).
[3]Current range-wide estimate from the USFWS (2019).

4.0 Affected Species Status and Distribution

Of the 36 marine mammal species with geographic ranges that include the Project Area (**Figure 1**), 16 species can be reasonably expected to reside, traverse, or routinely visit the Project Area in densities that could experience acoustic exposures during the short construction period, and therefore, be considered *affected species*. Affected species are those that have a common, uncommon, or regular relative occurrence in the Project Area (**Table 16**), or have a very wide distribution with limited distribution or abundance details (i.e., blue whale). Species not expected or rare are not carried forward in this Application. Therefore, the Applicant has assessed the following 16 species for potential take requests resulting from Level A and/or B disturbance (**Section 6.0**) and are described further in the following sections:

- Fin whale (*Balaenoptera physalus*);
- Minke Whale (*Balaenoptera acutorostrata*);
- Sei whale (*Balaenoptera borealis*);
- Humpback whale (*Megaptera novaeangliae*);
- North Atlantic right whale (*Eubalaena glacialis*);
- Blue whale (*Balaenoptera musculus*);
- Sperm whale (*Physeter macrocephalus*);
- Long-finned pilot whale (*Globicephala melas*);
- Atlantic spotted dolphin (*Stenella frontalis*);
- Atlantic white-sided dolphin (*Lagenorhynchus acutus*);
- Common dolphin (*Delphinus delphis*);
- Risso's dolphin (*Grampus griseus*);
- Common bottlenose dolphin (*Tursiops truncatus*);
- Harbor porpoise (*Phocoena phocoena*);
- Grey seal (*Halichoerus grypus*); and
- Harbor seal (*Phoca vitulina*).

Species will not be equally affected by the proposed activities due to individual exposure patterns, the context in which noise is received, and, most prominently, individual hearing sensitivities. To account for this sensitivity, marine mammal species are categorized into functional hearing groups that are designated to better predict and quantify impacts of noise (NMFS, 2020b; Southall et al., 2007). These functional hearing groups are described in **Section 1.2.1.2** with associated reference frequencies. While all of these species likely hear beyond these bounds, primary sensitivities fall within the listed frequencies.

Protected Species Observers (PSOs) and Passive Acoustic Monitoring (PAM) observers deployed during the 2017 and 2018 high-resolution geophysical and geotechnical surveys conducted within Lease Area OCS-A 0486 (prior to assignment of OCS-A-0517) recorded marine mammal species detected during all operations. Species in these detection records align with the species estimated to occur in the SFWF and SFEC Project area. The number of detections for each species observed during these surveys are provided in **Table 17**. The records serve only to provide supplementary information regarding species content and abundances that could be expected within the region during subsequent activities. Results show opportunistic sightings and acoustic detections during geophysical and geotechnical survey transects and should not be viewed as abundance or takes estimates for this region.

Table 17. Summary of marine mammals detections during geotechnical and geophysical site characterization surveys conducted within Lease Area OCS-A-0486 in 2017 and 2018.

Species	Number of detections (Visual & Acoustic)		
	Summer 2017 (July–August)	Fall 2017 (September–November)	Fall 2018 (September)
North Atlantic right whale	0	0	3
Fin whale	23	6	3
Humpback whale	51	9	2
Minke whale	12	1	43
Sperm whale	4	1	0
Common dolphin	57	201	102
Delphinid spp.	120	221	319
Unidentified whale	61	6	10
Harbor porpoise	1	1	0
Harbor seal	0	2	0
Gray seal	0	2	0
Unidentified seal	0	1	0

The following sections summarize data on the status, population trends, distribution, habitat preferences, behavior, life history, and auditory capabilities of marine mammals considered likely to occur in the Project Area. Species information was based on a review of available information from published literature and reports, including NMFS stock assessment reports (SARs) (Waring et al., 2007, 2010, 2014, 2015; Hayes et al., 2017, 2018, 2019, 2020; NMFS, 2020b); regional survey records (e.g., Cetacean and Turtle Assessment Program [CETAP], 1982; Atlantic Marine Assessment Program for Protected Species, 2010 to 2014; North Atlantic Right Whale Sighting Survey, 2003 to 2013; BOEM RI-MA EA [BOEM, 2012]); and preliminary results (unpublished) of mitigation surveys conducted during 2017 and 2018, as well as other available publications.

4.1 MYSTICETES

4.1.1 North Atlantic Right Whale (*Eubalaena glacialis*)

The North Atlantic right whale is the only member of the mysticete family Balaenidae found in North Atlantic waters. It is medium sized when compared to other mysticete species, with adult sizes ranging from 14 to 17 m (Waring et al., 2015). They are skim feeders relying primarily on zooplankton prey, including copepods, euphausiids, and cyprids. The North Atlantic right whale is listed as endangered under the ESA and is considered one of the most endangered large whale species in the world (Jefferson et al., 2011). The most recent draft 2020 NMFS SAR estimates a population size of only 412 individuals (NMFS, 2020b) which has recovered only slightly from the estimated 100 individuals in the 1930s just prior to the species being afforded protection (Reeves, 2001). The minimum population size for this stock is estimated to be 408, based on a published state-space model of the sighting histories of individual whales using a photo-identification recapture database which included information up to January 2018 (NMFS, 2020b).

Right whales have been sighted in the region during all months of the year but show peak abundances to the north in Cape Cod Bay during late winter and Georges Basin in late summer (Winn et al., 1986; Kenney et al., 1995, 2001). Krause et al. (2016) observed North Atlantic right whales in the Wind Energy Area (WEA) during the winter and spring. However, the North Atlantic right whale has the potential to occur within the waters off Rhode Island and Massachusetts any time of the year. Typically, right whale sightings begin in December and continue through April. A total of 77 individuals were sighted in the RI-MA WEA from October 2011 to June 2015 (Krause et al, 2016). The greatest numbers are seen in March. The Muskeget Channel and south of Nantucket were also identified as right whale hotspots during the spring. These areas are located within the RI-MA WEA (Kraus et al., 2016).The most recent NMFS SAR (NMFS, 2019a) identified seven areas where western North Atlantic right whales aggregate seasonally: the coastal waters of the southeastern United States; the Great South Channel; Jordan Basin; Georges Basin along the northeastern edge of Georges Bank; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Roseway Basin on the Scotian Shelf (Brown et al., 2001; Cole et al., 2013). Several of these congregation areas correlate with seasonal copepod concentrations (Pendleton et al., 2009). New England waters are a primary feeding habitat for the North Atlantic right whale during late winter through spring with feeding moving into deeper and more northerly waters during summer and fall. Less is known regarding winter distributions; however, it is understood that calving takes place during this time in coastal waters of the southeastern United States.

Passive acoustic studies of North Atlantic right whales have demonstrated their year-round presence in the Gulf of Maine (Morano et al., 2012; Bort et al., 2015), New Jersey (Whitt et al., 2013), and Virginia (Salisbury et al., 2016). Additionally, right whales were acoustically detected off Georgia and North Carolina in 7 of 11 months monitored (Hodge et al., 2015). Krause et al. (2016) detected right whale up calls on acoustic recorders deployed in the RI-MA WEA during 30 out of 36 recording months. All of this work further demonstrates the highly mobile nature of right whales. Movements are extensive between and within the southern and northern critical habitats. Davis et al. (2017) recently examined detections from passive acoustic monitoring devices and documented broad-scale use of a wider range of the U.S. eastern seaboard than previously believed, and an apparent shift in habitat use to the south of traditionally identified North Atlantic right whale congregations. Increased use of Cape Cod Bay and decreased use of the Great South Channel were observed as well (Davis et al., 2017).

The major threat to the North Atlantic right whale stock is human-caused mortality through incidental fishery entanglement that averaged 6.85 incidents per year and ship strikes that averaged 1.3 incident records per year based on data from 2014 through 2018 (NMFS, 2020b). In 2017, NMFS declared an Unusual Mortality Event (UME) following an increase in North Atlantic right whale mortalities in the U.S. and Canada. As of 8 January 2021, a total of 32 dead stranded whales have been reported, 21 in Canada, and 11 in the U.S., and the preliminary cause of death for most of these cases was determined to be due to vessel strike or entanglement (NMFS, 2021a). The SAR for North Atlantic right whales sets the PBR level at 0.8; therefore, any mortality or serious injury for this stock can be considered significant. The Western North Atlantic stock is considered strategic by NMFS because the average annual human-related mortality and serious injury exceeds PBR, and because the NARW is an endangered species (NMFS, 2020b).

Seasonal Management Areas (SMAs) for reducing ship strikes to the North Atlantic right whale have also been designated in the U.S. and Canada. All vessels greater than 19.8 m (65 ft) in overall length must operate at speeds of 10 kn or less within these areas during specified time periods. The Project Area is located within the Block Island Sound SMA which is in effect, seasonally, from November 1 to April 30 (**Figure 3**).

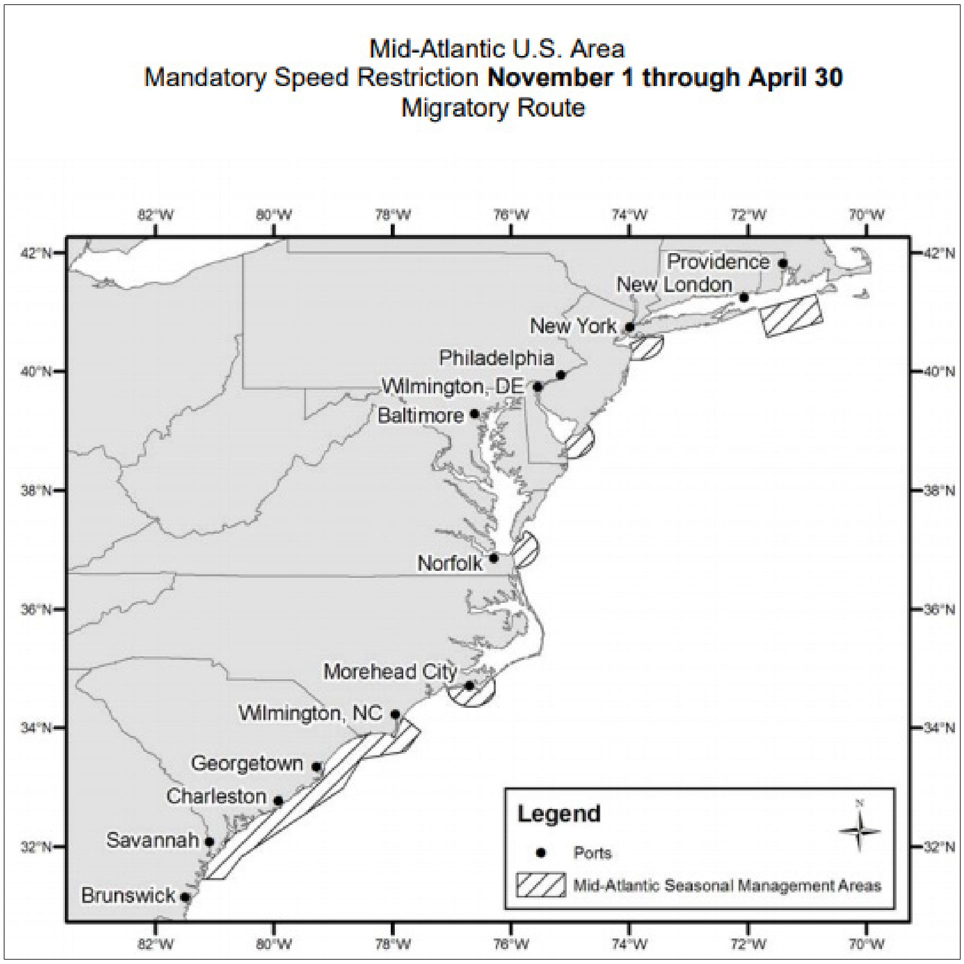

Figure 3. Mid-Atlantic Seasonal Management Areas for North Atlantic right whales.

The North Atlantic right whale underwent a NMFS 5-year review in 2017, which resulted in no change to its listing status. In 2009, NMFS received a petition to expand the critical habitat, and the agency agreed continuing its ongoing rulemaking process. In January 2016, two additional units comprising 29,763 nmi^2 of marine habitat were designated as critical habitat to encompass the northeast feeding area in the Gulf of Maine/Georges Bank and the southeast calving grounds from North Carolina to Florida.

The following final rules notices are associated with the North Atlantic right whale:

- Critical Habitat Designation: 59 *FR* 28805, June 3, 1994.
- Atlantic Large Whale Take Reduction Plan: 62 *FR* 39157, July 22, 1997.
- Federal Regulations Governing the Approach to North Atlantic Right Whales: 69 *FR* 69536, November 30, 2004.
- Final Rule to Implement Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales: 73 *FR* 60173, October 10, 2008.
- Findings on Petition to Revise Critical Habitat: 75 *FR* 61690, October 6, 2010.
- Final Rule to Remove the Sunset Provision of the Final Rule Implementing Vessel Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales 78 *FR* 73726 December 9, 2013.
- Final Rule for North Atlantic Right Whale (*Eubalaena glacialis*) Critical Habitat 81 *FR* 4838, January 27, 2016.

North Atlantic right whales are classified as LF cetaceans that vocalize using a number of distinctive call types, most of which have peak acoustic energy below 500 Hz. Most vocalizations do not go above 4 kHz (Matthews et al., 2014). One typical right whale vocalization is the “up call”; a short sweep that rises from roughly 50 to 440 Hz over a period of 2 seconds. These up calls are characteristic of right whales and are used by research and monitoring programs for species presence. A characteristic “gunshot” call is believed to be produced by male right whales. These pulses can have SLs of 174 to 192 dB re 1 µPa m with frequency range from 50 to 2,000 Hz (Parks et al., 2005; Parks and Tyack, 2005). Other tonal calls range from 20 to 1,000 Hz and have SLs between 137 and 162 dB re 1 µPa m. These low-frequency signals can be masked by human activities. Studies have shown that right whales increase their call amplitude in response to rising background noise levels, indicating that right whales may attempt to modify their vocalizations to compensate for increased noise within their acoustic environment (Parks et al., 2011). Rolland et al. (2012) correlated noise pollution to an increase in stress-related fecal hormone metabolites in North Atlantic right whales, suggesting that noise pollution may affect the recovery of the species.

4.1.2 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is a robust and medium-sized mysticete, with adults ranging from 15 to 18 m (50 to 60 ft) in length. Humpback whales are distinguished from all other cetaceans by their long flippers, which are approximately one-third the length of the body (Jefferson et al., 2008). One species of the humpback whale is currently recognized (Committee on Taxonomy, 2018). Humpback whales are largely piscivorous, feeding primarily on herring, sand lance, and other small fishes, as well as euphausiid crustaceans in the Gulf of Maine (NMFS, 2020b). Humpbacks show fidelity to feeding sites; however, local distribution is driven by prey availability and bathymetry, resulting in the whales transiting widely throughout their feeding habitat between spring and fall in search of prey. Feeding is the principal activity of humpback whales in New England waters, and their distribution in this region has been largely correlated to prey species and abundance (Payne et al., 1986; Payne and Heinemann, 1990).

The humpbacks occurring within the Project Area are believed to be mainly part of the Gulf of Maine stock (NMFS, 2020b). Humpback whales have a worldwide distribution and follow a migratory pattern of feeding in the high latitudes during summers and spending winters in the lower latitudes for calving and mating. The Gulf of Maine stock follows this pattern with winters spent in the Caribbean and West Indies; although acoustic recordings show a small number of males persisting in Stellwagen Bank throughout the year (Vu et al., 2012). The Gulf of Maine stock is estimated at 1,393 individuals (NMFS, 2020b).

Sightings of humpback whales in the region are common (Barco et al., 2002), as are strandings (Wiley et al., 1995). In 2016, a high number of humpback mortalities prompted NMFS to declare a UME starting in January 2016 for Atlantic coast humpbacks (NMFS, 2021b). During that time period, a total of 145 humpback whales were found dead between Maine and North Carolina. Partial or full necropsies were performed on approximately half these whales, and about 50% showed signs of human interaction from either ship strike or entanglement (NMFS, 2021b).

On September 8, 2016, NMFS published a final decision changing the status of humpback whales under the ESA (81 *FR* 62259), effective as of October 11, 2016. Previously, humpback whales were listed under the ESA as an endangered species worldwide. In the 2016 decision, NMFS recognized the existence of 14 distinct population segments (DPSs), of which four were listed as endangered, one was listed as threatened, and the remaining nine did not warrant protection under the ESA. A status review of the humpback whale was undertaken by NMFS in 2015 (Bettridge et al., 2015) to identify taxonomic units such as DPSs and assess the extinction risk of these units. To be considered a DPS, a population, or group of populations, must be “discrete” from the remainder of the taxon to which it belongs; and “significant” to the taxon to which it belongs. Information on distribution, ecological situation, genetics, and other factors is used to evaluate a population's discreteness and significance. This review process resulted in the identification of a West Indies DPS which includes the Gulf of Maine stock. The West Indies DPS was considered not to be at risk of extinction. Subsequently, the Gulf of Maine stock is not a strategic stock and no critical habitat has been designated for the humpback whale (NMFS, 2020b).

Primary threats to humpback whales are fishing gear entanglements and ship strikes. Mortality and serious injury records for large whales in the Western North Atlantic over a 40-year period (1970 to 2009) were reviewed for assessing the magnitude of human related mortalities (van der Hoop et al., 2013). Results showed that roughly 27% of mortalities and serious injuries were humpback whale records. Of the humpback records where a cause could be determined (203 records), 57% of mortalities were caused by entanglements in fishing gear and 15% were attributable to vessel strikes. Glass et al. (2009) reported that between 2002 and 2006, humpback whales belonging to the Gulf of Maine stock were involved in 77 confirmed fishing gear entanglements and nine confirmed ship strikes. Records assessed between 2014 and 2018 resulted in a minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine stock of 15.25 animals per year (NMFS, 2020b). This value includes an annual rate of incidental fishery interactions (9.45) and vessel strikes (5.8) (NMFS, 2020b).

Humpbacks are LF species but have one of the most varied vocal repertoires of the baleen whales. Male humpbacks will arrange vocalizations into a complex, repetitive sequence to produce a characteristic "song". Songs are variable but typically occupy frequency bands between 300 and 3,000 Hz and last upwards of 10 minutes. Songs are predominately produced while on breeding grounds; however, they have been recorded on feeding grounds throughout the year (Clark and Clapham, 2004; Vu et al., 2012). Typical feeding calls are centered at 500 Hz with some other calls and songs reaching 20 kHz. Common humpback calls also contain series of grunts between 25 and 1,900 Hz as well as strong, low-frequency pulses between 25 and 90 Hz with SLs up to 176 dB re 1 µPa m (Clark and Clapham, 2004; Vu et al., 2012).

4.1.3 Fin Whale (*Balaenoptera physalus*)

Fin whales are a widely distributed species found in all oceans of the world. The fin whale is listed as endangered under the ESA and a Final Recovery Plan for fin whales is available for review (NMFS, 2010). Fin whales are large whales that can reach lengths between 24 and 27 m (78 to 89 ft) (Jefferson et al., 2008). Fin whales transit between summer feeding grounds in the high latitudes and the wintering, calving, or mating habitats in low latitudes or offshore. However, acoustic records indicate that fin whale populations may be less migratory than other mysticetes whose populations make distinct annual migrations (Watkins et al., 2000). Fin whales typically feed in New England waters on fishes (e.g., sea lance, capelin, herring), krill, copepods, and squid in deeper waters near the edge of the continental shelf (90 to 180 m [295 to 591 ft]), but will migrate towards coastal areas following prey distribution. Seasonal areas of importance for fin whale feeding near the Project Area are off eastern Long Island and along the northern edge of Georges Bank (CETAP, 1982; Waring and Finn, 1995).

Along the Atlantic seaboard they are mainly found from Cape Hatteras northward with distribution in both shelf and deep water habitats (NMFS, 2021c). Fin whales accounted for 46% of the large whales sighted during aerial surveys along the continental shelf (CETAP, 1982) between Cape Hatteras and Nova Scotia from 1978 to 1982. Surveys conducted as a part of the Mid-Atlantic Baseline Studies (MABS) reported two fin whales during winter and two during spring (Williams et al., 2015a,b). The fin whales that occur with the Project Area are part of the Western North Atlantic stock of fin whales. This is considered a strategic stock because fin whales are listed as endangered throughout their range. In February 2019, NMFS undertook a 5-year status review (NMFS, 2019c) of the fin whale and determined that there should be no change in its listing status.

There is no designated critical habitat for the fin whale (Waring et al., 2015). The best population abundance estimate is 6,802 individuals (NMFS, 2020b).

Threats to fin whales are entanglements in fishing gear and ship strikes. For the time period between 2014 through 2018, the minimum annual rate of human-caused mortality and serious injury to fin whales was 2.35 individuals per year. This value includes 1.55 fishery interaction records per year and 0.8 vessel strike records per year (NMFS, 2020b). The total human-caused mortality and serious injury is less than the calculated PBR; however, it cannot be considered insignificant due to uncertainties regarding these estimates and the current endangered status of this population which make this a strategic stock under the MMPA. There is no designated critical habitat for this stock (NMFS, 2020b).

Fin whales are LF cetaceans that produce short duration, down sweep calls between 15 and 30 Hz, typically termed "20-Hz pulses" as well as tonal calls up to 150 Hz. The SL of the fin whale vocalizations can reach 186 dB re 1 µPa m, making it one of the most powerful biological sounds in the ocean (Charif et al., 2002).

4.1.4 Sei Whale (*Balaenoptera borealis*)

Sei whales are a widespread species throughout the world's temperate, subpolar, subtropical, and tropical oceans. The sei whale is the third largest cetacean (following the blue and fin whales), with adult length ranging from 16 to 20 m (52 to 66 ft) (Waring et al., 2015). It is very similar in appearance to fin and Bryde's whales. Two subspecies of sei whales are currently recognized, limited by their distributions in the northern hemisphere and southern hemisphere (Committee on Taxonomy, 2018). Sei whales in the Project Area are the northern subspecies (*B. b. borealis*) belonging to the Nova Scotia stock (formerly the Western North Atlantic stock). Sei whales are most common in deeper waters along the continental shelf edge (NMFS, 2020b) but will forage occasionally in shallower, inshore waters. There is no designated critical habitat for this species.

Sei whales are most abundant in Northeastern U.S. waters during spring, with sightings concentrated along the eastern and southwestern margins of Georges Bank in the area of Hydrographer Canyon (CETAP, 1982). Only one sei whale was reported during the MABS surveys, and this sighting occurred during the winter survey (Williams et al., 2015a,b). The sei whale feeds primarily on euphausiids and copepods, but will also prey upon fish, and local abundance is largely driven by prey availability. The occurrence and abundance of sei whales on feeding grounds may shift dramatically from one year to the next (Hayes et al., 2017).

The best abundance estimate for the Nova Scotia stock is 6,292 individuals (NMFS, 2020b). From 2014 through 2018, the minimum rate of confirmed human-caused serious injury and mortality to the Nova Scotia stock was 1.2 record per year, which was attributed to fisheries interactions (0.4) and vessel strikes (0.8) (NMFS, 2020b). The Nova Scotia stock is strategic because the species is listed as endangered under the ESA and the average human-related mortality and serious injury exceeds the PBR. There is no designated critical habitat for this species (NMFS, 2020b).

There are limited confirmed sei whale vocalizations; however, studies indicate that this species belong to the LF hearing group and produce several, mainly low-frequency (<1,000 Hz) vocalizations. Several calls attributed to sei whales include pulse trains up to 3 kHz, broadband "growl" and "whoosh" sounds between 100 and 600 Hz, tonal calls and up sweeps between 200 and 600 Hz, and down sweeps between 34 and 100 Hz (Baumgartner et al., 2008; Rankin and Barlow, 2007; McDonald et al., 2005).

4.1.5 Minke Whale (*Balaenoptera acutorostrata*)

The minke whale is a small mysticete that is divided into two species: the common minke whale and the Antarctic minke whale. The common minke whale is further divided into three subspecies (Committee on Taxonomy, 2018). The subspecies *B. a. acutorostrata*, or North Atlantic minke whale, occurs throughout the North Atlantic, including the Project Area. Adult common minke whales reach a length of 8.8 m (29 ft) (Jefferson et al., 2008; Waring et al., 2015). Generally, minke whales occupy warmer waters during winter and travel north to colder regions in summer, with some animals migrating as far as the ice edge. Little is known about their specific movements through the region; however, acoustic detections show that minke whales migrate south in mid-October to early November, and return from wintering grounds starting in March through early April (Risch et al., 2014). Northward migration appears to track the warmer waters of the Gulf Stream along the continental shelf, while southward migration is made farther offshore (Risch et al., 2014). The MABS surveys reported six minke whales between 2012 and 2014; one during spring surveys, two during fall surveys, and three during winter surveys (Williams et al., 2015a,b).

The minke whales that occur within the Project Area are part of the Canadian East Coast stock, which is one of four stocks in the North Atlantic. This stock is not considered strategic under the MMPA because minke whales are not listed as threatened or endangered. The best population estimate for the Canadian East Coast stock is 24,202 individuals (NMFS, 2020b). Minkes are frequently observed in coastal or shelf waters, along with humpback and fin whales, owing to their piscivorous feeding habitats where prey includes sand lance and herring (NMFS, 2020b).

Like other baleen whales, threats to minke whales include ship strikes and fisheries interactions. However, unlike the larger whales, minke whales are more susceptible to bycatch threats from bottom trawls, lobster trap/pot, gillnet, and purse seine fisheries. During the period from 2014 to 2018, the average annual minimum detected human-caused mortality and serious injury was 10.55 minke whales per year. This number was composed of 0.2 whales per year from U.S. fisheries bycatch, 8.95 whales per year from unobserved fisheries interactions, 1.2 whale per year from ship strikes, and 0.2 from other human interactions (NMFS, 2020b). Estimated rates of serious injury and mortality are less than the calculated PBR, but it cannot be considered insignificant or approaching zero (NMFS, 2020b). Since January 2017, a UME has been declared due to minke whale mortalities occurring between Maine and South Carolina. As of 8 January 2021, a total of 103 strandings have been reported, with 16 of those occurring in New York and 10 in New Jersey (NMFS, 2021d). Examinations for several of the whales showed evidence of human interactions such as vessel strike or entanglement, or infectious disease (NMFS, 2021d). Additionally, minke whales continue to be hunted as part of an ongoing whaling industry in the northeastern North Atlantic, the North Pacific, and Antarctic (Reeves et al., 2012).

Minke whale recordings have resulted in some of the most variable and unique vocalizations of any marine mammals. Common calls for minke whales found in the North Atlantic include repetitive, low-frequency (100 to 500 Hz) pulse trains that may consist of either grunt-like pulses or thump-like pulses. The thumps are very short duration (50 to 70 ms) with peak energy between 100 and 200 Hz. The grunts are slightly longer in duration (165 to 320 ms) with most energy between 80 and 140 Hz. In addition, minke whales will repeat a 6 to 14 minute pattern of 40 to 60 second pulse trains over several hours (Risch et al., 2014). Minke whales produce a unique sound called the "boing" which consists of a short pulse at 1.3 kHz followed by an undulating tonal call around 1.4 kHz. This call was widely recorded but unidentified for many years and had scientists widely speculating as to its source (Rankin and Barlow, 2005). The call frequency of minke whales suggest a hearing sensitivity higher than that of other baleen whales.

4.1.6 Blue Whale (*Balaenoptera musculus*)

The blue whale is the largest cetacean, although its size range overlaps with that of fin and sei whales. The species is currently divided into five subspecies (Committee on Taxonomy, 2018) and only the northern hemisphere subspecies (*B. m. musculus*) is known to occur within the region. Most adults of this subspecies are 23 to 27 m (75 to 90 ft) in length (Jefferson et al., 2008). In the western North Atlantic Ocean, the blue whale's range extends from the Arctic to Cape Cod, Massachusetts, although it is frequently sighted off eastern Canada (i.e., Newfoundland) (Waring et al., 2010). Using U.S. Navy asset hydrophone arrays, Clark and Gagnon (2004) identified blue whales as far south as Bermuda (but rarely farther south). Yochem and Leatherwood (1985) suggest an occurrence of this species south to Florida and the Gulf of Mexico. In general, the blue whale's range and seasonal distribution is governed by the availability of prey (NMFS, 2021e).

The blue whale is considered by NMFS as an occasional visitor in U.S. Atlantic exclusive economic zone (EEZ) waters, which may represent the current southern limit of its feeding range (Waring et al., 2010). Blue whales feed almost exclusively on krill (Kenney and Vigness-Raposa, 2010). There are limited observations of blue whales in the Project Area, and reported sightings have all been in summer months when blue whales are thought to have a more northerly distribution (Waring et al., 2010; Kenney and Vigness-Raposa, 2010).

The blue whale is listed as an endangered species, species-wide and range-wide, under the ESA. Blue whales in the North Atlantic were exploited heavily. A full assessment of present status has not been carried out, though available evidence suggests they are increasing in numbers at least in the area of the central North Atlantic, though they remain rare in the northeastern Atlantic where they were once common. There are insufficient data to determine the current abundance of the Western North Atlantic stock, however photo-identification surveys of this species between 1980 and 2008 indicate the minimum abundance estimate for this stock is 402 whales (Hayes et al., 2020). This stock is listed as strategic and depleted under the MMPA because the species is listed as endangered under the. There is no designated critical habitat for this species within the proposed survey area (Hayes et al., 2020).

Threats to North Atlantic blue whales are unknown, but may include threats faced by other large whale species such as ship strikes, pollution, fisheries interaction, and factors affecting prey abundance (Waring et al., 2010). There have been no observed fishery-related mortalities or serious injuries for this species, and the only confirmed human-caused mortality or serious injury occurred in March 1998 when a deceased blue whale was observed draped over the bow of a tanker in Rhode Island waters (Waring et al., 2010; Hayes et al., 2020).

Blue whales are LF cetaceans that produce very-low-frequency sounds (<100 Hz). Similar to humpbacks, blue whales have been recorded producing sequences of low-frequency tonal sounds, or songs, with components ranging from 9 to 80 Hz (Mellinger and Clark, 2003). Blue whales produce some of the loudest calls with SL up to 189 dB re 1 µPa, at the lowest frequencies which enable these calls to be detected approximately 200 km from the source (Kraus et al., 2016; Erbe et al., 2017).

4.2 ODONTOCETES

4.2.1 Sperm Whale (*Physeter macrocephalus*)

Sperm whales are the largest of the odontocetes and can reach up to 18 m (59 ft) in length (Jefferson et al., 2008). They are a wide ranging species distributed primarily over deeper waters of the continental shelf edge and slope in U.S. waters. Their distribution is thought to be associated with the Gulf Stream and other oceanographic features (Waring et al., 2015). There is insufficient data to determine if sperm whales in the western North Atlantic are a distinct population from the eastern North Atlantic, and currently only one North Atlantic stock is recognized (Waring et al., 2015).

In winter, sperm whales concentrate east and northeast of Cape Hatteras. In spring, distribution shifts northward to east of Delaware and Virginia, and is widespread throughout the central Mid-Atlantic Bight and the southern part of Georges Bank. In the fall, sperm whale occurrence on the continental shelf south of New England reaches peak levels, and there remains a continental shelf edge occurrence in the Mid-Atlantic Bight (Waring et al., 2015). No sperm whales were recorded during the MABS surveys. CETAP and NMFS Northeast Fisheries Science Center sightings in shelf-edge and off-shelf waters included many social groups with calves/juveniles (CETAP, 1982). Sperm whales were usually seen at the tops of the seamounts and rises and did not generally occur over the slopes. Sperm whales were recorded over depths varying from 800 to 3,500 m (2,625 to 11,483 ft). Although the likelihood of occurrence within the Project Area remains very low, the sperm whale was included in the affected species because of its high seasonal densities east of the Project Area, and results of previous surveys indicating they do occur in the SFWF area.

Sperm whales are listed as endangered under the ESA and are considered a strategic stock by NMFS (Hayes et al., 2020). Data are insufficient to assess population trends, and the current abundance estimate was based on only a fraction of the known stock range (Waring et al., 2007). The annual average human-caused mortality for 2008 to 2012 was estimated to be 0.8 individuals due to entanglement and vessel strikes. During this same period, a total of 14 sperm whale strandings have been reported in the U.S. and while the reasons for stranding could not be determined for all these cases, possible causes include vessel strikes, entanglement, pollution, and changes to their environment (Waring et al., 2015). However, there were no documented reports of human-caused mortality or serious injury for the period between 2013 and 2017 (Hayes et al., 2020). The best recent abundance estimate for sperm whales is the sum of the estimates from 2016 surveys totaling 4,349 individuals with a minimum population estimate of 3,451 individuals (Hayes et al., 2020; NMFS, 2020b).

Sperm whales are in the MF hearing group, with an estimated auditory range of 150 Hz to 160 kHz (Southall et al., 2007). Sperm whales produce short-duration repetitive broadband clicks used for communication and echolocation. These clicks range in frequency from 0.1 to 30 kHz, with dominant frequencies between the 2 to 4 kHz and 10 to 16 kHz ranges (Department of the Navy [DoN], 2008). Echolocation clicks from adult sperm whales are highly directional clicks and have a SL estimated at up to 236 dB re 1 µPa m.

4.2.2 Long-finned Pilot Whale (*Globicephala melas*)

There are two species of pilot whale in the western North Atlantic, long-finned (*G. melas*) and short-finned (*G. macrorhynchus*). Pilot whales attain a body length of 7.2 m (24 ft) (short-finned pilot whale) and 6.7 m (22 ft) (long-finned pilot whale) (Jefferson et al., 2011; Waring et al., 2015). The distribution of the two species overlap, they are difficult to tell apart during visual surveys, and parameters that define their distributions are not well differentiated. However, it is generally accepted that pilot whale sightings above approximately 42° N are most likely long-finned pilot whales (Waring et al., 2015). Additionally, in the northern extent of the ranges, long-finned pilot whales occupy inshore areas, whereas short-finned pilot whales remain in offshore habitats. Therefore, the pilot whales that occur within the Project Area are most likely long-finned pilot whales that are part of the western North Atlantic stock.

Long-finned pilot whales occur over the continental slope in high densities during winter and spring then move inshore and into shelf waters during summer and autumn following prey populations of squid and mackerel (Reeves et al., 2012). They will also readily feed on other fish, cephalopods, and crustaceans. Pilot whales are common in the central and northern Georges Bank, Great South Channel, Stellwagen Bank, and Gulf of Maine during the summer and early fall (May and October) (Hayes et al., 2020). Long-finned pilot whales concentrate along the Northeast U.S. shelf edge between the 100 m and 1,000 m isobaths during mid-winter and early spring (CETAP, 1982). In late spring, pilot whales move from the mid-Atlantic region onto Georges Bank and the Scotian Shelf, and into the Gulf of Mexico, where they remain through late autumn (CETAP, 1982). Pilot whales generally occur in areas of high relief or submerged banks and are also associated with the Gulf Stream wall and thermal fronts along the continental shelf edge (Hamazaki, 2002). Pilot whales are highly social and vocal and are typically observed in groups of 10 to 20 surface-active individuals.

Long-finned pilot whales are not listed as threatened or endangered, and the western North Atlantic stock is not considered strategic under the MMPA. The best population estimate for the western North Atlantic stock of long-finned pilot whales is 39,215 individuals (Hayes et al., 2020; NMFS, 2020b). A source of mortality and injury to long-finned pilot whales is through bycatch during gillnet fishing, pelagic trawling, longline fishing, and purse seine fishing. For the period between 2013 and 2017, the observed average fishery-related mortality or serious injury was 21 long-finned pilot whales per year (Hayes et al., 2020). The highest observed bycatch rate for all pilot whales occurred in the pelagic longline fishery with peak bycatch occurring during September and November along the mid-Atlantic coast (Hayes et al., 2020). However, based on biopsy data, the majority, if not all, of the bycatch whales were short-finned. Other fisheries mortalities (i.e., bottom trawls, mid-water trawls, gillnet) are more frequently observed north of 40° N; therefore, these fisheries likely have a higher proportional impact on long-finned pilot whales. Mean human-caused annual mortality and serious injury does not exceed the calculated PBR for this stock; however, it is not considered insignificant or approaching zero. There is no designated critical habitat for this species (Hayes et al., 2020).

Long-finned pilot whales also demonstrate a propensity to mass strand; however, the role that human activities play in these strandings is not known. From 2013 to 2017, 16 long-finned pilot whales stranded between Maine and Florida (Hayes et al., 2020). Bioaccumulated toxins are also a potential source of human-caused source of mortality in pilot whales. Polychlorinated biphenyls and chlorinated pesticides (e.g., DDT, DDE, dieldrin) have been found in pilot whale blubber (Muir et al., 1988; Weisbrod et al., 2000), and bioaccumulation levels of these toxins were more similar in whales from the same stranding group than from animals within the same sex or age category (Weisbrod et al., 2000).

Pilot whales are acoustic MF specialists with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Pilot whales echolocate and produce tonal calls. The primary tonal calls of the long-finned pilot whale range from 1 to 8 kHz with a mean duration of about 1 second. The calls can be varied with seven categories identified (level, falling, rising, up-down, down-up, waver, and multi-hump) and are likely associated with specific social activities (Vester et al., 2014).

4.2.3 Risso's Dolphin (*Grampus griseus*)

Risso's dolphins are large dolphins with characteristic blunt head and light coloration, often with extensive scarring. Adults reach body lengths of over 3.8 m (12.5 ft) (Jefferson et al., 2008; Waring et al., 2015).

Risso's dolphins are widely distributed in tropical and temperate seas. In the western North Atlantic, they occur from Florida to eastern Newfoundland (Leatherwood et al., 1976; Baird and Stacey, 1991). Risso's dolphins occur along the continental shelf edge from Cape Hatteras to Georges Bank during spring, summer, and autumn. In winter, they occur in oceanic (slope) waters within the mid-Atlantic Bight (Waring et al., 2014). The majority of sightings during the 2011 surveys occurred along the continental shelf break, with generally lower sighting rates over the continental slope (Palka, 2012).

The status of the western North Atlantic stock of the Risso's dolphin in the U.S. Atlantic EEZ is not well documented. An abundance estimate of 35,493 Risso's dolphins was generated from shipboard and aerial survey conducted between Florida and Newfoundland during 2016 (Hayes et al., 2020). Risso's dolphins are not listed as threatened or endangered under the ESA and the western North Atlantic stock is not considered strategic under the MMPA (Hayes et al., 2020).

Risso's dolphins are in the MF functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Vocalizations range from 400 Hz to 65 kHz (DoN, 2008).

4.2.4 Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided (AWS) dolphin is robust and attains a body length of approximately 2.8 m (9 ft) (Jefferson et al., 2008; Waring et al., 2015). It is characterized with a strongly "keeled" tail stock and distinctive color pattern. The AWS dolphin occurs primarily along the 100-m (328-ft) depth contour within temperate and subpolar waters of the North Atlantic. Seasonally, the AWS dolphin occupies northern, inshore waters during summer and southern, offshore waters in the winter. The AWS dolphins that potentially occur in the Project Area are all part of the western North Atlantic stock. The western North Atlantic stock inhabits waters from central West Greenland to North Carolina (about 35° N) (Waring et al., 2015). There is some evidence supporting the division of the western Atlantic population into three separate stocks; however, this has not been established.

The Virginia and North Carolina observations appear to represent the southern extent of the species' range. Prior to the 1970s, AWS dolphins in U.S. waters were found primarily offshore on the continental slope, while white-beaked dolphins (*L. albirostris*) were found on the continental shelf. During the 1970s, there was an apparent switch in habitat use between these two species. This shift may have been a result of the decrease in herring and increase in sand lance in the continental shelf waters (Katona et al., 1993; Kenney et al., 1996). White-sided dolphins are opportunistic feeders and their diet is based on available prey (Waring et al., 2007; Craddock et al., 2009). AWS dolphins feed on a variety of fish such as herring, hake, smelt, capelin, and cod as well as squid and shrimp. Like many dolphins, this species is highly gregarious and will often travel in groups of 100 or more and are highly vocal when in these aggregations. Breeding takes place between May and August with most calves born in June and July.

The estimated average annual human-related mortality does not exceed the PBR for this stock and the AWS dolphin is not listed as threatened or endangered; therefore, the stock is not considered strategic under the MMPA. The best abundance estimate for the western North Atlantic AWS dolphin stock is 93,233 (Hayes et al., 2020). Mortality to AWS dolphins resulting from fisheries interactions averaged 26 dolphins per year between 2013 and 2017. This number was comprised of recorded mortality or serious injury from gillnets (2.8 per year), bottom trawls (21 per year), and mid-water trawls (1.9 per year) (Hayes et al., 2020). There was a total of 123 documented strandings of this species during this period; human interaction, such as pollution, was indicated for four of these cases (Hayes et al., 2020).

Atlantic white-sided dolphins are in the MF functional hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Their vocalizations range from 6 to 15 kHz (DoN, 2008). Recordings from Pacific white sided dolphins show that this *Lagenorhynchus* species produces echolocation clicks centered at 115 kHz and up to 15 whistle types between 7 and 16 kHz (Rasmussen and Miller, 2002).

4.2.5 Common Dolphin (*Delphinus delphis*)

The common dolphin may be one of the most widely distributed species of cetaceans, as it is found worldwide in temperate, tropical, and subtropical seas (Waring et al., 2015). They can attain body length up to 2.6 m (8.5 ft) (Jefferson et al., 2008). Two species were previously recognized: the long beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin; however, Cunha et al. (2015) summarized the relevant data and analyses, along with additional molecular data and analysis, and recommended that *Delphinus capensis* not be further used. This taxonomic convention is used by the Society or Marine Mammalogy.

Common dolphins are distributed in waters off the eastern U.S. coast from Cape Hatteras northeast to Georges Bank (35° to 42° N) during mid-January to May and move as far north as the Scotian Shelf from mid-summer to autumn (CETAP, 1982; Selzer and Payne, 1988; Hamazaki, 2002; NMFS, 2020b). They primarily occur at the shelf and shelf break along the Gulf Stream, however, common dolphins are known to occur in many water depths including coastal waters.

The best population estimate for this stock is 172,947 individuals (NMFS, 2020b). The species is not listed as threatened or endangered under the ESA, and the stock is not classified as a strategic or depleted stock (NMFS, 2020b). Common dolphins aggregate in large schools numbering in the hundreds, although the typical group size is 30 or fewer (Reeves et al., 2012). The common dolphin feeds on small schooling fish and squid; as such, common dolphins are subject to bycatch in gillnets, pelagic trawls, and longline fisheries (Reeves et al., 2012; NMFS, 2020b). During 2014 to 2018, an estimated average of 399 common dolphins were taken each year in fisheries activities, plus 0.2 per year from research takes (NMFS, 2020b). There were also 499 common dolphins reported stranded between Maine and Florida during this period (NMFS, 2020b).

Common dolphins are in the MF functional hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Their vocalizations range widely from 200 Hz to 150 kHz (DoN, 2008).

4.2.6 Atlantic Spotted Dolphin (*Stenella frontalis*)

Atlantic spotted dolphins are widely distributed in tropical and warm temperate waters of the western North Atlantic (Leatherwood et al., 1976). They can reach 2.3 m (7.5 ft) and their body shape is thought to resemble that of common bottlenose dolphins (Jefferson et al., 2008). They range from southern New England south through the Gulf of Mexico and the Caribbean to Venezuela (Leatherwood et al., 1976; Perrin et al., 1994). They regularly occur in the inshore waters south of Chesapeake Bay and near the continental shelf edge and continental slope waters north of this region (Payne et al., 1984; Mullin and Fulling, 2003). Atlantic spotted dolphins north of Cape Hatteras also associate with the north wall of the Gulf Stream and warm-core rings (Waring et al., 2014).

Atlantic spotted dolphins are not listed as threatened or endangered under the ESA and are therefore not considered strategic under the MMPA (Hayes et al., 2020). Atlantic species of spotted dolphins were not differentiated during surveys, resulting in insufficient data to determine the population trends (Hayes et al., 2020). The best estimate of abundance for the western North Atlantic stock of Atlantic spotted dolphins is 39,921 individuals, derived from surveys conducted in 2016 surveys (Hayes et al., 2020).

Atlantic spotted dolphins are in the MF functional hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Vocalizations typically range from 100 Hz to 130 kHz (DoN, 2008).

4.2.7 Common Bottlenose Dolphin (*Tursiops truncatus*)

Adult common bottlenose dolphins range in length from 1.8 to 3.8 m (5.9 to 12.5 ft). Within the western North Atlantic, including the Project Area, there are two distinct common bottlenose dolphin forms, or morphotypes: coastal and offshore. The two forms are genetically and morphologically distinct, though regionally variable (Jefferson et al., 2008; Waring et al., 2015). Both inhabit waters in the western North Atlantic Ocean (Hersh and Duffield, 1989; Mead and Potter, 1995; Curry and Smith, 1997) along the U.S. Atlantic coast. Analysis of stranding data, satellite tagging, and genetic studies resulted in the western North Atlantic stock being divided into five geographic stocks: the Central Florida, Northern Florida, South Carolina-Georgia, Southern Migratory Coastal, and Northern Migratory Coastal stocks (Rosel et al., 2009; Waring et al., 2010). All coastal stocks are listed as depleted (Waring et al., 2010). The northern migratory stock range is listed as upper New Jersey to lower Maryland, therefore occurrence within the Project Area would be considered rare.

The western North Atlantic offshore stock is distributed primarily along the OCS and continental slope, from Georges Bank to Cape Hatteras during spring and summer (CETAP, 1982). North of Cape Hatteras, there is separation of the offshore and coastal morphotypes across bathymetric contours during summer months. Aerial surveys flown from 1979 through 1981 indicated a concentration of bottlenose dolphins in waters <25 m (<82 ft) deep corresponded with the coastal morphotype, and an area of high abundance along the shelf break, corresponded with the offshore stock (Hayes et al., 2017). Torres et al. (2003) found a statistically significant break in the distribution of the morphotypes at 34 km (21 mi) from shore. During winter months, common bottlenose dolphins are rarely observed north of the North Carolina-Virginia border, and their northern distribution appears to be limited by water temperatures <9.5°C (<49°F) (Garrison et al., 2002).

The common bottlenose dolphin is not listed as threatened or endangered under the ESA, and the western North Atlantic offshore stock is not listed as depleted under the MMPA. Stock status within U.S. Atlantic waters is unknown and data are insufficient to determine population trends. The best available abundance estimate for the offshore morphotype in the western North Atlantic is 62,851 individuals (Hayes et al., 2020).

Common bottlenose dolphins are in the MF functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Bottlenose dolphin vocalization frequencies range from 3.4 to 130 kHz (DoN, 2008).

4.2.8 Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise is the only porpoise species found in the Atlantic. It is a small, stocky cetacean with a blunt, short-beaked head. There are four subspecies, with *P. p. phocoena* residing in the North Atlantic (Committee on Taxonomy, 2018). This subspecies reaches a body length of 1.9 m (6.2 ft) (Jefferson et al., 2011). They commonly occur throughout Massachusetts Bay from September through April. During fall and spring, harbor porpoises are widely distributed along the east coast from New Jersey to Maine. During summer, the porpoises are concentrated in the Northern Gulf of Maine and Southern Bay of Fundy in water depths less than 150 m (492 ft). In winter, densities increase in waters off New Jersey to North Carolina and decrease in the waters from New York to New Brunswick, however, specific migratory timing or routes are not apparent (Waring et al., 2015).

The harbor porpoises that occur in the Project Area comprise the Gulf of Maine/Bay of Fundy stock. This stock is not considered strategic under the MMPA because they are not listed as threatened or endangered. In 2001, NMFS conducted a status review for the stock, mainly due to the level of bycatch in fisheries (66 *FR* 53195). The determination from the review was that listing the harbor porpoise under the ESA was not warranted and the species was removed from the candidate list. Population trends for this species are unknown. The best, and most recent, abundance estimate for harbor porpoise in the Gulf of Maine/Bay of Fundy stock is 95,543 individuals (NMFS, 2020b).

Harbor porpoises feed on small schooling fish such as mackerel, herring, and cod, as well as worms, squid, and sand eels. Their foraging habits and habitats make this species particularly susceptible to mortality in bottom-set gill nets (Waring et al., 2015). The average estimated human-caused mortality or serious injury between 2014 and 2018 for this stock is 150 harbor porpoises per year, derived from U.S. fisheries observer records. In 2010, a final rule was published for the existing Harbor Porpoise Take Reduction Plan in the Federal Register (75 *FR* 7383) to address closure areas and timing based on bycatch rates.

Harbor porpoises are the only potentially affected species in the Project Area within the HF hearing group. The harbor porpoise is a high-frequency specialist using ultrasonic echolocation clicks to navigate and hunt prey. The click frequency is between 110 and 150 kHz, which is consistent with harbor porpoise hearing sensitivity centered between 100 and 120 kHz (Thompson et al., 2013; Wensveen et al., 2014). Click trains can have very short inter-click intervals when close to a prey item which results in a “feeding buzz” due to the rapid succession of individual clicks.

4.3 PHOCIDS

4.3.1 Harbor Seal (*Phoca vitulina*)

The harbor seal is found in all nearshore waters of the Atlantic Ocean and adjoining seas north of 30° N (Hayes, 2019). In the western North Atlantic, they are distributed from eastern Canada to southern New England and New York, and occasionally to the Carolinas (Payne and Selzer, 1989). Harbor seals are the most abundant seals in the eastern U.S. Harbor seals occur seasonally along the Southern New England and New York coasts from September through late May (Schneider and Payne, 1983) with their seasonal interval along the Southern New England to New Jersey coasts increasing (Barlas, 1999; deHart, 2002). No pupping areas have been identified in Southern New England, and the closest haul out site to the Project Area is in Montauk, NY (Barlas, 1999; Coastal Research and Education Society of Long Island, Inc., 2019).

Harbor seals will exploit a variety of available food sources and will feed both in shallow coastal habitats and offshore (Waring et al., 2015). Typical prey items include squid and small schooling fish (i.e., herring, alewife, flounder, redfish, cod, yellowtail flounder, sand eel, hake) and spend up to 85% of the day diving, presumably foraging.

Harbor seals are not listed as threatened or endangered. The harbor seals within the Project Area are part of the single western North Atlantic stock, which is not considered strategic under the MMPA. The best population estimate of harbor seals for this stock is 75,834 individuals (NMFS, 2020b). Fisheries interactions are common, and harbor seals are legally killed in Canada, Norway, and the United Kingdom to protect fish farms or local fisheries (Reeves et al., 2013). They are also susceptible to bycatch in gillnets, trawls, and purse seines. For the period from 2014 to 2018, the average human-caused mortality and serious injury to harbor seals was 365.2 seals per year, of which 351 occurred in fisheries interactions (NMFS, 2020b). Between July 2018 and March 2020 a UME has been declared for both the harbor seal and gray seal due to mortalities throughout the Northeast U.S. Based on results of preliminary examinations, the 3,152 strandings (which include both species) are likely the result of phocine distemper virus (NMFS, 2020c).

Male harbor seals produce underwater vocalizations during mating season to attract females and defend territories (Sabinsky et al., 2012). These calls are comprised of "growls" or "roars" with peak energy at 1.2 kHz (Sabinsky et al., 2012). Captive studies have shown that harbor seals have good (>50%) sound detection thresholds between 0.1 and 80 kHz, with primary sound detection between 0.5 and 40 kHz (Kastelein et al., 2009).

4.3.2 Gray Seal (*Halichoerus grypus*)

The gray seal ranges from Canada to New York; however, there are stranding records as far south as Cape Hatteras, North Carolina (Gilbert et al., 2005). In U.S. waters, gray seals currently pup at three established colonies: Muskeget Island, Massachusetts; Green Island, Maine; and Seal Island, Maine, as well as, more recently, at Matinicus Rock and Mount Desert Rock in Maine. Gray seals have been observed using the historic pupping site on Muskeget Island in Massachusetts since 1990. Pupping has taken place on Seal and Green Islands in Maine since at least the mid-1990s. Aerial survey data from these sites indicate that pup production is increasing. A minimum of 2,620 pups (Muskeget = 2,095, Green = 59, Seal = 466) were born in the U.S. in 2008 (Wood LaFond, 2009). Gray seals have been observed regularly visiting Long Island, NY in winter, but the nearest haul out site to the Project Area is in Montauk, NY (Coastal Research and Education Society of Long Island, Inc., 2019).

Gray seals within the Project Area are part of the western North Atlantic stock. They are not listed as threatened or endangered and the stock is not considered strategic under the MMPA. The best population estimate of gray seals for this stock is 27,131 individuals (NMFS, 2020b). However, the Canadian gray seal population was estimated to be 424,300 individuals in 2016 (NMFS, 2020b).

Gray seals will aggregate in large numbers to breed, molt, and rest. Gray seals will exploit a variety of available food sources and will feed both in shallow coastal habitats and offshore (Waring et al., 2015). Typical prey items include cephalopods, sessile, and small schooling fish (i.e., herring, alewife, flounder, redfish, cod, yellowtail flounder, sand eel, hake), and crustaceans. Gray seals will go on extensive dives to depths to 475 m (1,558 ft) to capture food (Waring et al., 2015). Gray seals are susceptible to bycatch and fisheries interactions and, like the harbor seal, are legally killed in some countries to protect fisheries resources. The gray seal is also taken commercially outside the U.S. The average estimated human-caused mortality and serious injury of gray seals between 2014 and 2018 was 4,729 seals per year for both the U.S. and Canada (NMFS, 2020b). As discussed in **Section 4.3.1**, there is currently a UME declared for this population likely due to viral infection (NMFS, 2020c).

Gray seals, as with all pinnipeds, are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al., 2007). Vocalizations range from 100 Hz to 3 kHz (DoN, 2008).

5.0 Type of Incidental Take Requested

The Applicant requests an IHA pursuant to 16 U.S. Code 1371 Section 101 of the MMPA for incidental take of small numbers of marine mammals by Level A and Level B harassment during construction of the SFWF and SFEC within the Project Area. Proposed activities, as outlined in **Section 1.0**, have the potential to impact marine mammals within the Project Area from sounds generated by impact and vibratory pile driving and HRG surveys during construction.

Given the modeled threshold ranges (**Section 1.2.1.3**), there is potential for species to experience noise at or above Level A acoustic thresholds. Mitigation measures, including exclusion zones and noise abatement equipment, will be employed during all impact pile driving activities in the SFWF (**Section 11.0**) which will reduce the risk of Level A exposure in marine mammals. The noise abatement measures are expected to achieve, at minimum, 10 dB broadband reduction, effectively reducing the maximum range to Level A thresholds for both SPL_{pk} (**Table 8**) and SEL_{cum} (**Table 9**) acoustic metrics. Animal movement modeling (Denes et al., 2020b,c,d) estimated Level A exposures for only five species (fin whale, minke whale, humpback whale, North Atlantic right whale, and harbor porpoise). However, the mean $ER_{95\%}$ modeled for the maximum design scenario (6 piles every 7 days) with and without a difficult pile with 10 dB noise mitigation were 1,610 m for fin whales (range = 1,451 to 1,769 m); 1,530 m for minke whales (range = 1,488 to 1,571 m); 3,338 m for humpback whales (range = 3,034 to 3,642 m); 1,551 m for North Atlantic right whales (range = 1,481 to 1,621 m); and 222 m for harbor porpoise (range = 79 to 365 m). The $ER_{95\%}$ can be viewed as the required effective ranges for qualifying Level A take. Given the monitoring measures described in **Section 11.0**, all $ER_{95\%}$ ranges can be effectively monitored and mitigation implemented with the exception of the humpback $ER_{95\%}$ range.

The vibratory pile driving at the SFEC is not expected to produce SPLs that propagate appreciably to Level A thresholds for MF or HF cetaceans or pinnipeds. SPLs meeting Level A thresholds for LF cetaceans extend to approximately 1,400 m; however, LF species are not expected within that proximity of the cofferdam installation as it is very close to shore (less than 600 m from the high water line). Similarly, due to the small Level A ranges from HRG survey equipment (maximum 36.5 m for HF cetacean species), no Level A takes are expected to occur during this activity.

Level B exposures are anticipated to occur during impact and vibratory pile driving and HRG surveys. The Level B takes may be manifested as a TTS or a behavioral disturbance (Southall et al., 2007). A TTS onset may occur within the immediate vicinity of the sound source where the received levels of sound exposure might be high enough to cause a temporary loss of hearing sensitivity (Holt, 2008). Behavioral reactions such as avoidance and temporary displacement for some individuals or groups of marine mammals near the proposed activities can be expected. The severity of behavioral effects will vary with the duration of operations, the behavior of the animal at the time of reception of the stimulus, and the distance and received level of the sound. Potential impacts will be mitigated through a visual and acoustic monitoring program and vessel activity management program, both of which are fully described in **Section 11.0**.

6.0 Take Estimates for Marine Mammals

The Applicant is seeking authorization for potential “taking” of small numbers of marine mammals under the jurisdiction of NMFS in the proposed region of activity, as described in **Section 2.0**. The species potentially taken are described in **Section 4.0**. Each species has a geographic distribution that encompasses the Project Area and has at least a minimal potential to occur during the project window.

Authorization for Level A harassment is sought for the following 4 species:

- Fin whale (*Balaenoptera physalus*);
- Minke Whale (*Balaenoptera acutorostrata*);
- Sei whale (*Balaenoptera borealis*);
- Humpback whale (*Megaptera novaeangliae*);

Authorization for Level B harassment is sought for the following 15 species:

- Fin whale (*Balaenoptera physalus*);
- Minke Whale (*Balaenoptera acutorostrata*);
- Sei whale (*Balaenoptera borealis*);
- Humpback whale (*Megaptera novaeangliae*);
- North Atlantic right whale (*Eubalaena glacialis*);
- Sperm whale (*Physeter macrocephalus*);
- Long-finned pilot whale (*Globicephala melas*);
- Atlantic spotted dolphin (*Stenella frontalis*);
- Atlantic white-sided dolphin (*Lagenorhynchus acutus*);
- Common dolphin (*Delphinus delphis*);
- Risso’s dolphin (*Grampus griseus*);
- Common bottlenose dolphin (*Tursiops truncatus*);
- Harbor porpoise (*Phocoena phocoena*);
- Grey seal (*Halichoerus grypus*); and
- Harbor seal (*Phoca vitulina*).

The only anticipated impacts to marine mammals from noise are limited to impact and vibratory pile driving during construction (described in **Section 1.2**). The potential activities are not expected to take more than a small number of marine mammals or have more than a negligible effect on their populations based on their seasonal density and distribution and their known reactions to exposure to such underwater sound sources.

6.1 BASIS FOR ESTIMATING NUMBERS OF MARINE MAMMALS THAT MIGHT BE TAKEN BY HARASSMENT

Estimated marine mammal takes are based upon the expected densities of each species in the Project Area and the predicted three-dimensional sound field produced by pile driving activities.

6.1.1 Marine Mammal Density Calculation

The density calculation methodology applied to take estimates for this Application is derived from the model results produced by Roberts et al. (2016) and draft model results produced by Roberts (2018, 2020) for the East Coast region. These files were retrieved as raster files from the website http://cetsound.noaa.gov/cda or directly from J. Roberts with permission for use. These estimates are determined to be the best information currently available for calculating marine mammal densities in the U.S. Atlantic by NMFS.

Densities of marine mammals and their subsequent exposure risk are different for the wind farm area (where impact pile driving will occur) and the nearshore export cable area (where vibratory pile driving will occur). 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. Monthly marine mammal densities for exposure modeling were derived by JASCO using the Roberts et al. (2016) and Roberts (2018) density blocks encompassing the SFWF (see Denes et al., 2020b,c,d for further details) and are provided in **Table 18**. Roberts (2020) further updated model results for NARW by 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. These changes are designed to produce estimates that better reflect the most current, regionally specific data, and to provide better coastal resolution. The Denes et al. (2020c,d) model analysis utilized densities from the most recent survey time period, 2010 to 2018, as suggested by Roberts (2020). The maximum monthly density for each species, indicated by the highlighted cells, was used in the animal exposure model for take estimates (**Section 6.1.2**).

Marine mammal densities at the nearshore export cable area were estimated from the 10 × 10 km habitat density block from Roberts et al. (2016) and Roberts (2018, 2020) that contained the anticipated location of the cofferdam. However, the density estimates are not provided for areas adjacent to the shoreline, although some density blocks do intersect the shore. Because of this data structure, densities are artificially biased to the densities of the nearest 100 km^2 offshore and do not adequately represent the low numbers expected for some groups like large whales. Monthly marine mammal densities for the potential construction locations of the cofferdam are provided in **Table 19**. The maximum densities applied are denoted by the bold text.

Densities for HRG surveys were combined for the wind farm area (inter-array cables) and the export cable route using Roberts et al. (2016) and Roberts (2018, 2020) density blocks that encompassed those areas. The densities used for HRG surveys are provided in **Table 20**.

The species listed in each respective density table represent animals that could be reasonably expected within the propagated Level B threshold distances at each location. For this reason, several of the outer continental shelf and deeper water species that appear in the wind farm area are not included in the cofferdam species list because the densities were zero.

Table 18. Estimated densities (animals km^{-2}) used for modeling marine mammal exposures within South Fork Wind Farm (Roberts et al., 2016; Roberts, 2018; Roberts, 2020).

Common Name	Monthly Density (Animals km^{-2})[a]							
	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[b]	**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[c]	**0.03900**	0.02600	0.00874	0.00357	0.00529	0.00955	0.00630	0.03400
Harbor seal[c]	**0.03900**	0.02600	0.00874	0.00357	0.00529	0.00955	0.00630	0.03400

a. **Bold** denotes the highest monthly density estimated. This value was used in the animal exposure model.
b. Long- and short-finned pilot whales are grouped together to estimate the total density of both species.
c. Seal densities are not given for individual species, and seasons are divided into Summer (June to August) and Winter (September to May); as a result, reported seasonal densities for those months are the same (Roberts, 2018).
* = ESA-listed species.

Table 19. Estimated densities (animals km^{-2}) of marine mammals within the affected area of the cofferdam installation for all months within the planned construction schedule (Roberts et al., 2016; Roberts, 2018, 2020). List of species represents only those with potential exposures.

Species	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

Table 19. (Continued).

Species	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
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**

Bold text denotes highest density used in the animal exposure model for take estimates.
* = ESA-listed species.

Table 20. Estimated densities (animals km^{-2}) of marine mammals within the affected area of the high resolution geophysical surveys (export cable route and inter-array cables) for all months (Roberts et al., 2016; Roberts, 2018, 2020) and the annual average.

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**

Bold text denotes density used for take estimates.
* = ESA-listed species.

6.1.2 Impact Pile Driving Exposures

Animal exposure modeling, which combines acoustic propagation models with animal movement models, was conducted by JASCO to estimate the number of Level A and Level B exposures to marine mammals. Marine mammal densities used to populate the exposure model were derived from Roberts et al. (2016), and Roberts (2018, 2020) (**Section 6.1.1**). Multi-day piling scenarios were modeled to provide the most realistic exposure estimates for an operational setting.

Estimating exposures of marine mammal species assumes that exposure of an animal to a specified noise level (threshold) within the ensonified area will result in a take of that animal. For Level A exposures, as modeled animals move throughout a three-dimensional sound field, both SPL_{pk} and SEL_{cum} are calculated for each animal based on the corresponding marine mammal hearing group criteria (**Table 2**). Once an animal is "taken" within a 24-hour period, the model does not allow it to be taken a second time in that same period but rather resets the 24-hour period on a sliding scale across the 7 days of exposure (Denes et al, 2020b,c,d). An individual animal's sound exposure levels are summed over that 24-hour period, to determine its total received energy, and then compared to the threshold criteria. Potential

Level B take exposures are estimated when an animal is within the area ensonified to a SPL_{rms} exceeding 160 dB re 1 μPa (Denes et al., 2020b,c,d).

As described in **Section 2.1**, there are two potential piling scenarios for installation of the monopiles. The most likely scenario assumes that a single pile is driven every other day such that 16 monopile piles would be installed over a 30-day period. The second scenario is considered for the maximum design scenario in which six piles are driven every 7 days such that the 16 piles are installed over a 20-day period. For either scenario, more than one pile is not expected to be installed within any single 24-hour period.

6.1.3 Vibratory Pile Driving Exposures

Results of the acoustic propagation model indicate the distances to Level A thresholds during cofferdam installation and removal are relatively small (**Table 11**), as these are full acoustic ranges and not exposure ranges (i.e., these ranges assume a stationary animal receiving sound energy for 24 hours). Due to the small isopleth ranges combined with the location and duration of cofferdam installation, mitigation activities, and the low densities of most species, animal movement modeling was not conducted because no Level A exposures are anticipated.

Propagation modeling for the Level B regulatory isopleth (SPL_{rms} 120 dB re 1 μPa) produced by the non-impulsive vibratory pile driving estimated a large ensonified area (>36 km) (**Table 10**) with an areal zone of influence (ZOI) of 2,081 km^2 accounting for removal of land masses and water blocked by land masses that would not be ensonified within that 36 km range. Animal movement modeling was not used to determine potential Level B exposures from cofferdam installation as it is expected that exposures would be very low, if present at all, due to the short duration of the activity and the seasonality of large whale species. The species densities represented in the Roberts et al. (2016) and Roberts (2018, 2020) are monthly estimates, and the DoN (2017) are seasonal estimates, which are not indicative of the distribution of animals within the potential ensonified area during any single day or time.

To estimate take, the density of marine mammals within the effected area around the cofferdam (**Table 19**) (animals km^{-2}) was multiplied by the daily ensonified area (km^2). That result is then multiplied by the number of days of vibratory pile driving (i.e., 2 days) to arrive at the estimated take. This final number equals the instances of take for the entire operational period. The result is an estimate of the maximum potential number of instances that marine mammals could be exposed to sounds above the Level A or Level B harassment thresholds over the duration of survey activities.

6.1.4 HRG Survey Exposures

The maximum calculated isopleths for Level A (36.5 m) for HF cetaceans and Level B (141 m) was assumed for all HRG surveys, although it is understood that portions of surveys will likely be conducted with sources producing smaller acoustic isopleths. The selection of these distances accounts for any uncertainty in the survey plans.

Animal modeling was not conducted to estimate acoustic exposures resulting from HRG surveys. Rather, based on the mean annual densities (mean across all months) for each species, the estimated number of marine mammal takes per equipment type was determined. Calculations were based on vessel-towed or mounted geophysical survey equipment operating for 60 vessel days in Lease Area and/or the export cable route.

Estimates of take are calculated according to the following formula:

Estimated Take = D × ZOI × # of Survey Days

Where: D = average species density (km^{-2}); and ZOI = the zone of influence or the maximum ensonified area that equates to NMFS thresholds for noise impact criteria. To estimate take, the density of marine mammals within the Project Area (animals km^{-2}) was multiplied by the daily ensonified area (km^2). That result is then multiplied by the number of survey days (rounded to the nearest whole number) to arrive at the estimated take. This final number equals the instances of take for the entire operational period. The result is an estimate of the maximum potential number of instances that marine mammals could be exposed to sounds above the Level A or Level B harassment thresholds over the duration of survey activities. The Applicant has agreed to extensive mitigation measures to reduce any potential Level B harassment and eliminate the possibility of any Level A harassment.

6.2 ESTIMATED NUMBERS OF MARINE MAMMALS THAT MIGHT BE TAKEN BY HARASSMENT

The Applicant is requesting approval for the incidental harassment takes of marine mammals associated with construction of the SFWF and SFEC. Take estimates were projected based on marine mammal presence, calculated density estimates, and activity-specific sound source propagation characteristics.

6.2.1 Estimated Level A Harassment of Marine Mammals

Monopile foundation installation

Level A exposures are unlikely, but possible, during impact pile driving. The use of an NMS (e.g., bubble curtains) to achieve broadband noise attenuation is planned during impact pile driving to effectively minimizes the extent of both SPL_{pk} and SEL_{cum} impact zones (**Section 11.0**). Additional mitigation measures (**Section 11.0**) that include visual and acoustic monitoring and seasonal restrictions in impact pile driving activities will be employed to reduce the risk of Level A exposures for all species. For transparency purposes, modeled Level A exposures for impact pile driving are presented for 0, 6, 10, 12, and 15 dB noise attenuation using the maximum design scenario (6 piles every 7 days) which includes a single difficult pile (~8,000 strikes) (**Section 6.1.2**). While the range of attenuation levels are presented, the Applicant estimates that 10 dB broadband attenuation levels will be consistently achieved based on the work conducted in European offshore wind construction and summarized by Bellmann et al. (2019).

Encountering a difficult-to-drive pile is a unlikely event but was considered in the take estimation to fully encompass all variables. Inclusion of the difficult pile increases Level A SEL_{cum} impact radii, demonstrating the conservative nature of using the maximum design scenario for take estimates. Denes et al. (2020b,c,d) provided monthly exposure estimates for each scenario, so the maximum potential Level A exposures are presented for impact pile schedule scenarios with (**Table 21**) and without (**Table 22**) the inclusion of a single difficult pile with application of 0, 6, 10, 12, and 15 dB noise attenuation.

Table 21. Maximum potential Level A exposures[1] to marine mammal species within each hearing group due to impact pile driving using the maximum design scenario (6 piles every 7 days) with the inclusion of a single difficult pile (~8,000 strikes) 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	7	<1	3	<1	1	<1	1	<1	<1	<1
Sei whale*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Humpback whale	21	<1	9	<1	4	<1	3	<1	3	<1
North Atlantic right whale*	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	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Atlantic white sided dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Common bottlenose dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Common dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Risso's dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pilot whale	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
High-frequency Cetaceans										
Harbor porpoise	33	23	4	7	1[2]	3	1	3	<1	1
Pinnipeds in Water										
Gray seal	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.
* = species listed under the Endangered Species Act.
[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]Calculated exposures with 10 dB for harbor porpoises were <1 but >0.5; therefore they were rounded up to the nearest whole number.

Table 22. Maximum Level A exposures[1] to marine mammal species within each hearing group due to impact pile driving using the most likely design scenario (1 pile every other day) with a standard pile schedule (~4,500 strikes) 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	9	<1	3	<1	1	<1	1	<1	<1	<1
Sei whale*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Humpback whale	21	<1	8	<1	4	<1	3	<1	1	<1
North Atlantic right whale*	3	<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	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Atlantic white sided dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Common bottlenose dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Common dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Risso's dolphin	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pilot whale	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
High-frequency Cetaceans										
Harbor porpoise	27	20	3	5	1[2]	2	1	2	<1	1
Pinnipeds in Water										
Gray seal[3]	5	<1	1	<1	<1	<1	<1	<1	<1	<1
Harbor seal[3]	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.
* = species listed under the Endangered Species Act.
[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]Calculated exposures with 10 dB for harbor porpoises were <1 but >0.5; therefore they were rounded up to the nearest whole number.
[3]Modeled seal and harbor porpoise movement resulted in some higher number of exposures for the most likely design scenario. This result is due to model randomness and not due to any piling-specific actions or reactive behavior to either scenario.

Monthly exposure estimates for the maximum design scenario using 10 dB of noise attenuation with and without inclusion of a difficult are provided in **Table 23** and **Table 24**, respectively**,** demonstrating the seasonality of exposure risk. The estimated monthly exposures are the same for scenarios including a difficult pile and not including a difficult pile; although the $ER_{95\%}$ are larger for scenarios using a single difficult pile. Therefore, take estimates and mitigation efficacy are based on the difficult pile scenarios. In **Table 23** and **Table 24**, the $ER_{95\%}$ for each species is included for reference to the distances which need to be cleared during mitigation monitoring to avoid Level A exposures.

Table 23. Maximum SEL_{cum} Level A exposures by month[1] for marine mammal species due to impact pile driving using the maximum design scenario (6 piles every 7 days) with the inclusion of a single difficult pile (~8,000 strikes) with 10 dB broadband attenuation. Positive exposures are designated by the highlighted cells. The 95% exposure range ($ER_{95\%}$) to Level A for each species is listed for reference.

Species[2]	Maximum monthly Level A (SEL_{cum}) exposure estimates (10 dB attenuation)								
	May	June	July	Aug	Sept	Oct	Nov	Dec	**$ER_{95\%}$ (m)**
Fin whale*	1	1	1	1	1	1	<1	<1	**1,769**
Minke whale	1	1	<1	<1	<1	<1	<1	<1	**1,488**
Humpback whale	2	2	1	1	4	2	1	1	**3,642**
North Atlantic right whale*	<1	<1	<1	<1	<1	<1	<1	<1	**1,621**
Harbor porpoise[3]	1	<1	<1	<1	<1	<1	<1	<1	**365**

dB = decibel; SEL_{cum} = cumulative sound exposure level.
* = species listed under the Endangered Species Act.
[1]Calculated exposure that were <1 but >0.5 were rounded up to the nearest whole number.
[2]Species with no exposures are not included in the table.
[3]Harbor porpoise exposures are higher for SPL_{pk} values; however, given the physical placement of the bubble curtain SPL_{pk} values are not expected to be realized.

Table 24. Mean SEL_{cum} Level A exposures by month[1] for marine mammal species due to impact pile driving using the maximum design scenario (6 piles every 7 days) with a standard pile schedule (~4,500 strikes) with 10 dB broadband attenuation. Positive exposures are designated by the highlighted cells. The 95% exposure range ($ER_{95\%}$) to Level A for each species is listed for reference.

Species[2]	Maximum monthly Level A exposure (SEL_{cum}) estimates (10 dB attenuation)								
	May	June	July	Aug	Sept	Oct	Nov	Dec	**$ER_{95\%}$ (m)**
Fin whale*	1	1	1	1	1	1	<1	<1	**1,451**
Minke whale	1	1	<1	<1	<1	<1	<1	<1	**1,571**
Humpback whale	2	2	1	1	4	2	1	1	**3,034**
North Atlantic right whale*	<1	<1	<1	<1	<1	<1	<1	<1	**1,481**
Harbor porpoise[3]	1	<1	<1	<1	<1	<1	<1	<1	**79**

dB = decibel; SEL_{cum} = cumulative sound exposure level.
* = species listed under the Endangered Species Act.
[1]Calculated exposure that were <1 but >0.5 were rounded up to the nearest whole number.
[2]Species with no exposures are not included in the table.
[3]Harbor porpoise exposures are higher for SPL_{pk} values; however, given the physical placement of the bubble curtain SPL_{pk} values are not expected to be realized.

Given the pile driving activity, placement and operation of a big bubble curtain, and general construction activities, aversion behavior can be reasonably expected to contribute to minimizing the risk of Level A exposures. Aversion responses (avoidance of sound levels or acoustic sources that are disturbing or injurious) by marine mammals are documented but not fully understood (Ellison et al., 2012; Dunlop et al., 2017). Three key species (humpback whale, North Atlantic right whale, and harbor porpoise) were modeled with aversion using the maximum design scenario with 10 dB attenuation. The modeled exposures with aversion reduced humpback whale, North Atlantic right whale, and harbor porpoise takes to less than 1 individual for the entire project (**Table 25**). Other species were not modeled; however using the comparable reduction in take numbers for modeled mysticete species (i.e., humpback whales and North Atlantic right whales) and odontocete species (i.e., harbor porpoise) it is expected the Level A exposure estimates will be reduced during construction activities.

Table 25. Modeled Level A exposures for three representative species with and without aversion behavior applied to the most likely pile scenario (1 pile every other day) with a standard pile schedule (~4,500 strikes).

Species	Level A exposures with 0 dB attenuation		Level A exposures with 10 dB attenuation	
	No Aversion	With Aversion	No Aversion	With Aversion
Humpback whale	21	12	4	<1
North Atlantic right whale	3	<1	<1	<1
Harbor porpoise	29	<1	1	<1

dB = decibel.

<u>Cofferdam installation and removal</u>

The estimated Level A takes for the cofferdam installation and removal using species density × ZOI based on acoustic ranges × number of operational days (2) is provided in **Table 26**. No Level A takes from cofferdam installation and removal are expected. The 1,470 m Level A acoustic range for low-frequency cetaceans would require that a baleen whale enter the 1,470 m and remain there for the 18 hours to accumulate enough acoustic energy. This is not only biologically unlikely, itis also not representative of sheet piling because the piling activity is intermittent. Although vibratory piling is still classified as a continuous source, it could be argued that the intermittent nature of the actual piling could negate this as a true continuous source. As a precautionary measure, visual observers will be used to monitor the area around the cofferdam construction during vibratory pile driving and removal thus ensuring no Level A exposures are realized.

Table 26. Estimated Level A exposures by month to marine mammal species resulting from vibratory pile driving and removal of the nearshore cofferdam.

Species	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec
Fin whale*	<1	<1	<1	<1	<1	<1	<1	<1
Minke whale	<1	<1	<1	<1	<1	<1	<1	<1
Sei whale*	<1	<1	<1	<1	<1	<1	<1	<1
Humpback whale	<1	<1	<1	<1	<1	<1	<1	<1
North Atlantic right whale*	<1	<1	<1	<1	<1	<1	<1	<1
Atlantic white-sided dolphin	<1	<1	<1	<1	<1	<1	<1	<1
Common dolphin	<1	<1	<1	<1	<1	<1	<1	<1
Common bottlenose dolphin	<1	<1	<1	<1	<1	<1	<1	<1
Harbor porpoise	<1	<1	<1	<1	<1	<1	<1	<1
Gray seal	<1	<1	<1	<1	<1	<1	<1	<1
Harbor seal	<1	<1	<1	<1	<1	<1	<1	<1

* = species listed under the Endangered Species Act.

HRG Surveys

The largest Level A isopleth distance for HRG surveys is 36.5 m for HF cetaceans; the Level A isopleths for all other hearing groups were <2 m. Given the small distance and the implementation of mitigation measures (**Section 11.0**), no Level A takes are anticipated. The calculated Level A takes are provided in **Table 27**.

Table 27. Calculated Level A exposures of marine mammal species resulting from high resolution geophysical surveys. Calculations are based on mean annual densities and maximum Level A isopleth produced by sparker sources.

Species	Estimated Level A Exposures
Fin whale*	<1
Minke whale	<1
Sei whale*	<1
Humpback whale	<1
North Atlantic right whale*	<1
Atlantic white-sided dolphin	<1
Common dolphin	<1
Common bottlenose dolphin	<1
Harbor porpoise	11
Gray seal	<1
Harbor seal	<1

* = species listed under the Endangered Species Act.

6.2.2 Estimated Level B Harassment of Marine Mammals

Monopile foundation installation

Level B exposures resulting from impact pile driving were estimated from the modeled propagation distance to the unweighted SPL_{rms} of 160 dB re 1 µPa which was used in the animal exposure model (Denes et al., 2020b,c,d). **Table 28** provides the estimated Level B exposures for the maximum design scenario with and without the inclusion of a single difficult pile. As with the Level A estimates, the maximum monthly Level B estimates are provided with the application of 0, 6, 10, 12, and 15 dB noise attenuation that is planned for impact pile driving.

Table 28. Maximum potential Level B exposures[1] due to impact pile driving using the maximum design scenario (6 piles every 7 days) with the inclusion of a single difficult pile (~8,000 strikes) 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	27	15	10	8	6
Sei whale*	<1	<1	<1	<1	<1
Humpback whale	13	13	8	7	6
North Atlantic right whale*	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	6	3	2	1	<1
Atlantic white-sided dolphin	322	152	107	85	48

Table 28. (Continued).

Species	Level B Exposures by Noise Attenuation Level				
	0 dB attenuation	*6 dB attenuation*	*10 dB attenuation*	*12 dB attenuation*	*15 dB attenuation*
Common dolphin	1,261	459	197	148	73
Risso's dolphin	2	1	<1	<1	<1
Common bottlenose dolphin	212	85	43	34	14
Long-finned pilot whale	<1	<1	<1	<1	<1
High-frequency Cetaceans					
Harbor porpoise	272	129	78	67	40
Pinnipeds in Water					
Gray seal	307	116	60	52	28
Harbor seal	319	119	54	45	28

dB = decibel.
* = species listed under the Endangered Species Act.
[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).

Cofferdam installation and removal

Table 29 provides the potential Level B exposures calculated by multiplying the maximum isopleth area by the species densities for two days of cofferdam installation and removal occurring between October 1 to May 31. As described in **Section 6.1.3**, these densities are not indicative of species occurring over the short operational periods expected for the cofferdam installation. As described in **Section 6.3.1**, these maximum calculated exposures are not indicative of the expected densities or animal movements expected in and around the cofferdam location.

Table 29. Potential Level B exposures, based on individual monthly densities, resulting from two 18-hour periods[1] of vibratory pile driving and removal at the cofferdam for each month between October 1 and May 31.

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[2]	1,305	1,305	1,305	1,305	1,305	1,305	1,305	1,305
Harbor seal[2]	1,305	1,305	1,305	1,305	1,305	1,305	1,305	1,305

* = species listed under the Endangered Species Act.
[1]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.
[2]Seal densities are not given for individual species, and seasons are divided into Summer (June to August) and Winter (September to May). Cofferdam installation and removal activities are anticipated to occur between October and May which falls all within Winter season, therefore reported seasonal densities and resulting exposures for these months and species are the same (Roberts, 2018).

HRG Surveys

Table 30 provides the potential Level B exposures calculated for HRG surveys.

Table 30. Calculated Level B exposures of marine mammal species resulting from high resolution geophysical surveys. Calculations are based on mean annual densities and maximum Level B isopleth.

Species	Estimated Level B Exposures
Fin whale*	3
Minke whale	1
Sei whale*	<1
Humpback whale	1
North Atlantic right whale*	3
Sperm whale*	<1
Atlantic spotted dolphin	<1
Atlantic white-sided dolphin	26
Common dolphin[1]	47
Common bottlenose dolphin	28
Risso's dolphin	<1
Long-finned pilot whale	4
Harbor porpoise	43
Gray seal	14
Harbor seal	14

* = species listed under the Endangered Species Act.

6.2.3 Requested Takes

It is necessary for the Applicant to forecast construction parameters at the time of the IHA Application. Therefore, the requested takes for the IHA provide a conservative estimate of the potential Level A and Level B exposures to any of the species stocks expected to occur within the Project Area. Further explanation for how these take requests were computed are provided in the following sections and in the acoustic modeling report (Denes et al., 2020b,c,d).

6.2.3.1 Level A Takes

Monopile foundation installation

Mitigation measures are not expected to eliminate the potential for Level A exposures. Therefore, the Applicant is requesting authorization for both Level A exposures for impact pile driving during monopile foundation installation for all species except the North Atlantic right whale (**Table 31**). In order to present realistic, but precautionary, take estimates, the potential for Level A exposures were based on modeling (Denes et al., 2020b,c,d) and potential mitigation measures using the following parameters:

- 10 dB broadband attenuation;
- compressed build out scenario;
- inclusion of one difficult pile;
- maximum monthly density for each species;
- animal movement modeling to establish the $ER_{95\%}$; and
- no operational shutdowns.

The modeling scenario represents only the scenario that creates the largest ZOIs and may not reflect all the mitigation measures that will be employed during piling operations that will serve to reduce the ZOI or increase mitigation actions thus reducing take. Refer to **Section 11.0** for the mitigation measures that will be implemented. An attenuation level of 10 dB is considered the minimally-achievable attenuation level using a single big bubble curtain which is the most likely NMS that will be used during construction of SFW. Literature indicates that single bubble curtains applied in shallow water environments regularly achieve 7 to 8 dB broadband attenuation (Lucke et al., 2011; Rustemeier et al., 2012; Bellman, 2014, 2019). More recent *in situ* measurements during installation of large monopiles (~8 m) for WTGs in comparable water depths and conditions indicate that attenuation levels of 10 dB are readily achieved (Bellmann, 2019; Bellmann et al., 2020). Combinations of systems (e.g., double bubble curtain, hydrodamper plus single big bubble curtain) potentially achieve much higher attenuation. Attenuation of specific frequency spectra also contribute to minimizing impact ranges for some species.

Variability in monthly species densities are not considered in the take estimates and instead 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, maximum monthly densities will not to be encountered for all species.

Finally, shutdowns of hammering are not considered in the exposure modeling parameters. However, in practice, 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 SFW and/or its contractor determines shutdown is not feasible 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 feasible during operations. See the mitigation section (**Section 11.0**) for shutdown procedural details.

Mitigation measures requiring clearance of the $ER_{95\%}$ would require that an area with a maximum radius of 3,642 m be monitored to enable clearance of all marine mammals and implement potential mitigation actions. This distance is prohibitively large to be effectively monitored visually. Therefore, Level A takes could occur for humpback whales. The maximum Level A monitoring radius for fin, sei, and blue whales is 1,769 m, and 1,571 m for minke whales, which are distances that can be monitored visually under suitable conditions and can be monitored acoustically. However, given the size of these zones (1,769 and 1,571 m), the known high speed movements for these species, and sighting rates in the region during site investigation surveys over the past several years, request for Level A take was deemed prudent, though not likely to occur. The maximum Level A exposure range for North Atlantic right whales was 1,621 m. This range can be adequately monitored visually and acoustically, and because of this species known slower speed movements and lower sighting rates in the region during site investigation surveys over the past several years, no Level A exposures are expected for these species. With an $ER_{95\%}$ of 365 m and a SPL_{pk} acoustic range of 301 m, there are also no Level A exposures expected for harbor porpoises, but they are being requested due to the modeled exposures.

For the species in which modeling resulted in Level A exposures, requested takes for impact pile driving are based on the highest estimated monthly exposure calculated by Denes et al. (2020b,c,d) (**Table 31**). For blue and sei whales, odontocetes, and pinnipeds, no Level A exposures were modeled (Denes et al., 2020b,c,d) and SPL_{pk} and SEL_{cum} acoustic ranges remain small. However, due to physical similarities in appearance of this species to fin whales, and the possibility of ship-board observers reporting a fin/sei in their observations, Level A exposures are requested for sei whales based on an average group size of 1 (Kenney and Vigness-Raposa, 2010).

6.2.3.2 Level B Takes

<u>*Monopile foundation installation*</u>

Mitigation measures are not expected to eliminate the potential for Level B exposures. Therefore, the Applicant is requesting authorization for Level B exposures for impact pile driving during monopile foundation installation. Requested takes for impact pile driving are based on the highest estimated monthly exposure calculated by Denes et al. (2020b,c,d) for all species except minke and sperm whales

(**Table 31**). Modeling resulting in no Level B exposures for the sperm whale, long-finned pilot whale, or Risso's dolphin; therefore, take requests for these species were based on the following information:

- The average group size for sperm whales is 3 (Barkaszi and Kelly, 2018), and although this species is less common in the Project Area, they have been observed during site characterization surveys in the Lease Area.
- The distribution of long-finned pilot whales includes the region around the Project Area, and the mean group size for this species is 12 (Kenney and Vigness-Raposa, 2010).
- The average group size for Risso's dolphins is 30 (Barkaszi and Kelly, 2018).

Table 31. Requested Level A and Level B takes for marine mammals during impact pile driving of up to 16, 11-m monopiles under the maximum design scenario (6 piles every 7 days) with inclusion of a single difficult pile (~8,000 strikes) at South Fork Wind Farm using 10 decibel broadband noise attenuation.

Species/Stock	Population Estimate	Impact Pile Driving		
		Requested Takes[1]		% Population or Stock
Fin whale*	6,802	Level A	1	<1%
		Level B	6	<1%
Minke whale	21,698	Level A	1	<1%
		Level B	10	<1%
Sei whale*	6,292	Level A	0 (1)	<1%
		Level B	1	<1%
Humpback whale	1,393	Level A	4	<1%
		Level B	8	<1%
North Atlantic right whale*	412	Level A	0	0%
		Level B	4	1%
Blue whale*	402	Level A	0	0%
		Level B	0	0%
Sperm whale*	4,349	Level A	0	0%
		Level B	0 (3)	<1%
Pilot whales (long-finned)	39,215	Level A	0	0%
		Level B	0 (12)	<1%
Atlantic spotted dolphin	39,921	Level A	0	0%
		Level B	2	<1%
Atlantic white sided dolphin	93,233	Level A	0	0%
		Level B	107	<1%
Common dolphin	172,974	Level A	0	0%
		Level B	197	<1%
Risso's dolphin	35,493	Level A	0	0%
		Level B	1 (30)	<1%
Common bottlenose dolphin	62,851	Level A	0	0%
		Level B	43	<1%
Harbor porpoise	95,543	Level A	0	0%
		Level B	78	<1%
Gray seal	27,131	Level A	0	0%
		Level B	60	<1%
Harbor seal	75,834	Level A	0	0%
		Level B	54	<1%

* = species listed under the Endangered Species Act.
[1]Parenthesis denote changes from animal exposure model estimates.

- For species with no modeled exposures, requested takes for impact pile driving are based on mean group sizes derived from the following references:
  - Sei whale: Kenney and Vigness-Raposa, 2010;
  - Sperm whale: Barkaszi and Kelly, 2018;
  - Long-finned pilot whales: Kenney and Vigness-Raposa, 2010; and
  - Risso's dolphin: Barkaszi and Kelly, 2018.

Cofferdam installation and removal

Due to the highly contextual nature of responses to the non-impulsive Level B thresholds, the calculated exposures based only on density do not translate directly into the expected takes for vibratory pile driving. Specifically, cofferdam sheet pile installation and removal will be completed within two corresponding 18-hour periods. The species densities represented in the Roberts et al. (2016) and Roberts (2018, 2020) data are provided as monthly estimates and are not indicative of a single-day distribution of animals within the potential ensonified area. Additionally, the 100 km^2 density blocks provided in Roberts et al. (2016) and Roberts (2018, 2020) do not fully encompass the shoreline, rather, parts of predominately offshore blocks intersect some coastal areas which skews densities toward the deeper water habitats. This is particularly true of baleen whale species densities in relation to the coastal location of the cofferdam, lending to a lower risk of Level B takes to this group of marine mammals. Requested takes in **Table 32** were estimated by multiplying the ZOI by the species density by 2 days of vibratory pile driving; however, due to lower densities, transitory nature of marine mammals, and the very short duration of vibratory pile driving, these estimates are likely conservative. The maximum potential Level B exposures from vibratory pile driving and removal over a maximum period of 2 days is provided in **Table 32**.

Table 32. Requested Level B takes resulting from vibratory pile driving and removal and the percentage of each population or stock taken.

Species/Stock	Population Estimate	Vibratory Pile Driving	
		Requested Level B Takes[1]	% Population or Stock
Fin whale*	6,802	2	<1%
Minke whale	21,968	3	<1%
Sei whale*	6,292	1	<1%
Humpback whale	1,396	1	<1%
North Atlantic right whale*	412	6	1%
Atlantic white sided dolphin	93,233	1	<1%
Common dolphin	172,974	4	<1%
Common bottlenose dolphin	62,851	2,007	<1%
Harbor porpoise	95,543	11	<1%
Gray seal	27,131	1,305	5%
Harbor seal	75,834	1,305	2%

[1]Level B takes for vibratory pile driving are based on mean group sizes derived from the following references:
- Sei whale: Kenney and Vigness-Raposa, 2010.

Baleen whales in this region are highly transient and not anticipated to occur in within the ensonified area for the full 2-day period over which exposures were calculated. Most dolphin and porpoise species have a more coastal distribution, and the densities for these species near the cofferdam were generally higher than the large whale species (**Table 19**). However, species in this area are still relatively transient, and given the likelihood of aversion responses (**Section 7.2**) the risk of Level B exposures overall is very low.

Seals are only expected to be seasonally present in the area, and there are no known rookeries near the cofferdam location (**Section 4.3**). There are a few documented haul out sites along the southern coast of Long Island, NY, but the nearest site is in Montauk Point, approximately 40 km northeast of the cofferdam location, where they are primarily observed in winter (Coastal Research and Education Society of Long Island, Inc., 2019). Seals typically haul out in large groups to protect themselves from predators (NMFS, 2021f); however, this assessment focuses on potential impacts from underwater noise and in the water the average group size is estimated to be 1-3 animals depending on the distance to shore (Herr et al., 2009). Larger groups of seals (more than 3 animals) in water are typically only observed near haul out sites, and it is unlikely seals will approach shore or haul out near the location of the cofferdam because it is a more populated area, so seals that may occur in the region during vibratory pile driving would be transiting the area. Also, seals are expected to avoid the ensonified area while pile driving activities occur and would not remain in this location for an extended amount of time.

HRG Surveys

Mitigation measures are not expected to fully eliminate the potential for Level B exposures during geophysical surveys required for construction and installation. Therefore, the Applicant is requesting authorization for Level B exposures for geophysical surveys (**Table 33**). Requested takes are based on the highest estimated monthly exposure calculated.

Table 33. Requested Level B takes for high resolution geophysical (HRG) surveys conducted during South Fork Wind Farm construction.

Species/Stock	Population Estimate	HRG Survey Take Estimate	
		Requested Level B Takes[1]	% Population or Stock
Fin whale*	6,802	3	<1%
Minke whale	21,968	1 (19)	<1%
Sei whale*	6,292	0 (1)	<1%
Humpback whale	1,363	1	<1%
North Atlantic right whale*	412	3	1%
Sperm whale*	4,349	0 (3)	<1%
Long-finned pilot whale	39,215	4	<1%
Atlantic spotted dolphin	39,921	0 (13)	<1%
Atlantic white sided dolphin	93,233	26	<1%
Common dolphin	172,974	47 (1,175)	1%
Risso's dolphin	35,493	0 (30)	<1%
Common bottlenose dolphin	62,851	28	<1%
Harbor porpoise	95,543	43	<1%
Gray seal	27,131	14	<1%
Harbor seal	75,834	14	<1%

[1] Parenthesis denote changes from animal exposure model estimates for Level B impact pile driving takes as follows:

- The seasonal mean number of minke whales (**Table 17**) during 2017 and 2018 HRG surveys was 19; therefore requested Minke whale takes for HRG surveys increased from 1 to 19.
- Common dolphin: preliminary PSO reports from SFWF during 2019 and 2020 HRG surveys show a high number of common dolphin detections within Level B zones. Given a mean group size of 25, we are estimating 47 x group size for Level B exposures thus increasing from 47 to 1,175.
- There were no takes calculated for several species however, as a precautionary measure, Level B takes are requested for those species based on mean group size from the following sources:
  - Sei whale: Kenney and Vigness-Raposa, 2010;
  - Sperm whale: Barkaszi and Kelly, 2018;
  - Atlantic spotted dolphin: Barkaszi and Kelly, 2018; and
  - Risso's dolphin: Barkaszi and Kelly, 2018;

6.2.3.3 Combined Activity Take Requests

Level A and Level B take requests for the combined activities of impact pile driving using an NMS, vibratory pile driving, and HRG surveys are provided in **Table 34**. The mitigation measures provided in **Section 11.0** are activity-specific and are designed to minimize or eliminate acoustic exposures to marine mammal species.

Table 34. Requested Level A and Level B takes for all activities[1] conducted during South Fork Wind Farm construction.

Species/Stock	Population Estimate	Combined Take Request for All Construction Activities			
		Requested Level A Takes	% Population or Stock	Requested Level B Takes	% Population or Stock
Fin whale*	6,802	1	<1%	11	0.16%
Minke whale	21,968	1	<1%	32	0.15%
Sei whale*	6,292	1	<1%	3	0.05%
Humpback whale	1,393	4	<1%	10	0.72%
North Atlantic right whale*	412	0	0%	13	3.16%
Blue whale*	402	0	0%	0	0.00%
Sperm whale*	4,349	0	0%	6	0.14%
Pilot whales (long-finned)	39,215	0	0%	16	0.04%
Atlantic spotted dolphin	39,921	0	0%	15	0.04%
Atlantic white sided dolphin	93,233	0	0%	134	0.14%
Common dolphin	172,974	0	0%	1,376	0.80%
Risso’s dolphin	35,493	0	0%	60	0.17%
Common Bottlenose dolphin	62,851	0	0%	2,078	3.31%
Harbor porpoise	95,543	0	0%	132	0.14%
Gray seal	27,131	0	0%	1,379	5.08%
Harbor seal	75,834	0	0%	1,373	1.81%

* = species listed under the Endangered Species Act.
[1]Activities include impact pile driving using a noise mitigation system (NMS), vibratory pile driving, and HRG surveys.

7.0 Effects on Marine Mammal Species or Stocks

Marine mammals exposed to natural or man-made sound may experience auditory and non-auditory impacts, which range in severity (Southall et al., 2007; Wood et al., 2012; NMFS, 2018). The potential exists for marine mammals to be exposed to underwater sound associated with SFWF and SFEC construction activities. These impacts are likely to affect individual species but have only negligible effects on their local populations (stocks) and, therefore, will not adversely affect the population of any species.

7.1 NEGLIGIBLE IMPACTS

Under the requirements of 50 CFR § 216.104, NMFS has defined negligible impact as an impact that is not reasonably expected to adversely affect a species or stock through effects on annual rates of recruitment or survival. NMFS may only authorize the incidental taking of *small numbers* of marine mammals. The definition of small numbers is not defined in implementing regulations, and the small numbers requirement is not based on take estimates alone; rather, for NMFS to make a negligible impact determination, small numbers must denote that the portion of a marine mammal species or stock in the take estimates will have a negligible impact on that species or stock.

As discussed in **Sections 9.0** and **10.0**, vessel strikes are not expected to occur and auditory injuries (PTS) are possible but unlikely given the expected aversion responses and enhanced mitigation measures employed during impact pile driving. Long-term impacts on marine mammal habitat or their prey species may occur as a result of the monopile foundations being present during the life of the wind farm and potentially altering prey distribution, but these impacts are expected to be minimal and not necessarily adverse. Temporary auditory masking may occur in localized areas for short periods of time when an animal is in proximity to the construction activity; however, due to movement of the animals within the open ocean environment of the Project Area, masking effects are expected to be negligible and will not contribute significantly to other non-project related sources of noise currently operating in the region. Thus, reasonably expected impacts from the proposed activities are based on exposures to auditory thresholds that can potentially elicit a behavioral response and are categorized as Level B takes under the MMPA.

Unlike Level A (PTS) thresholds, NMFS is in the process of evaluating Level B (behavior) thresholds and intends to develop related guidance for use in its regulatory processes. At the current time, however, the threshold of SPL_{rms} 120/160 dB re 1 µPa for non-impulsive and impulsive sources, respectively, are the standards used in take assessments for the MMPA. These thresholds are an “all or nothing” approach to animal noise exposure such that a marine mammal that encounters an SPL above these thresholds is determined to be taken. However, in the case of Level B exposures, it is well-known that behavioral responses to acoustic exposure are generally more variable, context-dependent, and less predictable than effects of noise exposure on hearing or physiology (Southall et al., 2007). There is no consensus on the appropriate noise exposure metric for assessing behavioral reactions, and thus it is recognized that many variables other than exposure level affect the nature and extent of responses to a particular stimulus (Ellison et al., 2012; Southall et al., 2007). In addition, it is often difficult to differentiate brief, minor, biologically unimportant reactions from profound, sustained, and/or biologically meaningful responses related to growth, survival, and reproduction (National Research Council, 2005; Southall et al., 2007). Consequently, there is a trend toward adopting continuous functions for behavioral responses rather than simple thresholds (Finneran and Jenkins, 2012; Wood et al., 2012).

Sensitivity to behavioral responses will vary by species as well as within individual behavioral types. Key contextual information should be included in the assessment of any potential behavioral disturbance. Context that influences the biological consequence from disturbance include:

- seasonality,
- listing status of the species,
- population demographics and life stages,
- habitat use and availability, and
- individual sensitivities.

Given the large ZOIs that encompass behavioral disturbance criteria, particularly for the cofferdam installation and removal, and the fact that behavioral criteria are not based on SEL_{cum} (meaning there is not a clear component defining the required duration of exposure to elicit a behavioral response), species are expected to be exposed to SPL_{rms} meeting behavioral thresholds during installation of the monopiles and during installation and removal of the temporary cofferdam. However, exposure to an SPL_{rms} at a specified threshold level does not equate a behavioral response or a biologically significant consequence. Animals in an area of exposure may move locations depending on their acoustic sensitivity, life stage, and acclimation (Wood et al., 2012), and may or may not demonstrate behavioral responses. Therefore, the number of takes and the affected population percentages presented in this application represent the maximum potential take numbers. In actuality, it is expected that a lower, or limited number of marine mammals may realize behavioral modification.

Therefore, impacts associated with the proposed project are expected to be **negligible** because only a small proportion of each stock will be temporarily impacted by sound pressure levels that may result only in behavioral disturbance.

7.2 MITIGATION AND AVERSION

Mitigation measures are referenced in **Section 11.0**. For this project, mitigation measures comprise an NMS, soft starts, *in situ* monitoring, and delay protocols. These measures will serve to reduce the risk of any adverse impacts on marine mammals and minimize potential sound exposures. Aversion behavior is not considered or applied in the take estimates (**Section 6.2**); however, animal movement modeling that includes aversive behavior was conducted for several key species, demonstrating that the actual Level A and Level B exposures are expected to be less than predicted (**Table 22**).

Aversion is a common response of marine mammals to sound, particularly at relatively high sound exposure levels (Ellison et al., 2012). As received sound level generally decreases with distance from a source, this aspect of natural behavior can strongly influence the estimated maximum sound levels an animal is predicted to receive and significantly affects the probability of more pronounced direct or subsequent behavioral effects. Additionally, animals are less likely to respond to sound levels distant from a source, even when those levels elicit response at closer ranges; both proximity and received levels are important factors to consider in aversion responses (Dunlop et al., 2017). Aversion parameters to sound level were implemented for North Atlantic right whales in recognition of their critically endangered status, harbor porpoises which have demonstrated a strong aversive response to pile driving sounds in multiple studies, and humpback whales as they are an abundant regular species in the area (**Table 22**). In all cases, Level A and Level B exposures were each reduced by more than 50%.

Although the proposed mitigation (**Section 11.0**) is implemented to reduce the risk for Level A takes, it will also serve to reduce the exposure of animals to source levels that could constitute Level B takes. In the RI-MA EA (BOEM, 2012), the modeled area of ensonification for construction activities showed potential Level B thresholds at distances beyond what could be effectively visually monitored for the presence of marine mammals. However, NMFS determined that with the standard operating conditions and the reasonable and prudent measures, the proposed activities may adversely affect, but are not likely to jeopardize, the continued existence of North Atlantic right, humpback, fin, sei, or sperm whales. This suggests that installation of the SFWF and SFEC would not jeopardize the sustainability of other cetaceans, particularly other LF and MF species that occupy the same acoustic habitat.

7.3 SUMMARY

The potential impacts on marine mammals from exposure to construction-related underwater sound will be limited to behavioral responses that do not necessarily constitute *biologically significant* or long-term changes in biologically important behaviors. The National Research Council (2005) noted that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce, wherein an impact on individuals can lead to population-level consequences and affect the viability of the species. Due to the variability in species reaction to sound sources, temporary nature of construction activities, and use of mitigation measures, any behavioral reactions are expected to be short-term and to have **negligible** effects on individuals. It is expected that behavioral reactions will mainly comprise a temporary shift in spatial use (i.e., short-term displacement or avoidance of discrete areas within the project footprint). No long-term population effects are expected from the behavioral reactions to the proposed activities.

8.0 Minimization of Adverse Effects to Subsistence Uses

This section addresses NFMS' requirement to identify methods to minimize adverse effects of the proposed activity on subsistence uses.

There are no current subsistence hunting areas in the vicinity of the proposed Project Area, and there are no activities related to the proposed activities that may affect the availability of a species or stock of marine mammals for subsistence uses. Consequently, there are no applicable methods to minimize potentially adverse effects to subsistence uses.

9.0 Anticipated Impacts on Habitat

This section addresses NFMS' requirement to characterize the short- and long-term impacts of the proposed activity on marine mammals associated with the predicted loss or modification of habitat and to address available methods and likelihood of restoration of lost or modified habitat. Some long-term impacts are anticipated due to the presence of the SFWF foundations, but these impacts are not expected to be major or necessarily adverse. Predicted impacts to marine mammal habitat have been summarized in the following sections.

9.1 SHORT-TERM IMPACTS

The proposed activities have the potential to affect marine mammal habitat primarily through short-term impacts from increases in ambient noise levels from pile driving and vessel activities.

A variety of impact producing factors (i.e., seafloor disturbance, noise, discharges, physical presence of vessels and equipment, lights, and turbidity) with the potential to temporarily affect marine mammal prey availability may be expected as a result of proposed activities. The marine mammal species found within the Project Area feed on various pelagic and benthic fish species, cephalopods, and crustaceans. Elevated noise levels, installation of structures that disturb the seafloor, and other factors associated with project vessels and equipment may cause some prey species to leave the immediate area of operations, temporarily reducing the availability of prey within the area and thus disrupting feeding behavior and efficiency. Displaced prey species are expected to return shortly after construction is completed.

Seafloor disturbance is expected during seafloor preparation, pile driving, placement of scour protection, and installation of the SFEC. The disturbance would be limited to the immediate area surrounding the activity with a temporary footprint to include the monopile foundation and scour protection totaling approximately 3,700 m^2 (39,765 ft^2) per foundation. The inter-array cable is expected to disturb roughly 9.3 hectares (ha) (20.2 acres) that will largely return to pre-construction conditions due to burial of the cable in the sediment. The SFEC will also be buried, and will disturb up to 224.7 ha (555.3 acres) during installation. Vessel anchoring within the SFWF and SFEC corridors may disturb small areas of seafloor. All seafloor disturbance and associated water turbidity is expected to be short-term and temporary with minimal effects on marine mammal habitat or prey items.

Rising sound levels have the potential to affect local prey populations, which might indirectly affect marine mammals by altering prey abundance, behavior, and distribution (McCauley et al., 2003; Popper and Hastings, 2009; Slabbekoorn et al., 2010). Marine fish are typically sensitive to noise in the 100 to 500 Hz range, which coincides with the primary frequency range of vessels and pile driving activities. Noise generated by both impact and vibratory pile driving has the potential to elicit behavioral responses in fish, and impact pile driving also has the potential to cause harassment or injury through the generation of intense underwater sound pressure waves and particle motion. Laboratory pile driving studies demonstrated swim bladder damage in Chinook salmon and documented tissue damage in other species (Halvorsen et al., 2012). The most common behavioral responses to anthropogenic noise are avoidance, alteration of swimming speed and direction, and alteration of schooling behavior (Vabø et al., 2002; Handegard and Tjøstheim, 2005; Sarà et al., 2007; Becker et al., 2013). Noise from pile driving and vessel activities may cause prey species to temporarily vacate the area. Squid (*Sepioteuthis australis*) are an extremely important food chain component for many higher order marine predators, and while limited information is available for noise impacts on invertebrate species, squid are known to be able to detect particle motion. McCauley et al. (2000) recorded caged squid responding to airgun signals, suggesting behavioral responses are probable from other anthropogenic sources like pile driving. Crustaceans have also shown behavioral responses to pile driving (Tidau and Briffa, 2016). Disturbances associated with noise produced by construction activities are expected to be short-term and temporary with minor impacts to marine mammal prey species.

Potential discharges from vessels and other construction equipment will be localized near their source and are not expected to adversely affect prey species or habitat. While the physical presence of vessels and deployed equipment may produce avoidance behavior, night lighting may serve to attract fishes and squid. Neither physical presence nor night lighting are expected to adversely affect prey species.

9.2 LONG-TERM IMPACTS

The presence of the monopile foundations and associated scour protection would result in a conversion of the existing sandy bottom habitat to a hard bottom habitat with areas of vertical structural relief (monopile foundations). This could potentially trigger an "artificial reef effect" in which benthic and pelagic fish species would be attracted to the new hard-bottom habitat (Wilhelmsson et al., 2006; Reubens et al., 2013). Numerous studies have documented significantly higher fish concentrations including species like cod and pouting (*Trisopterus luscus*), flounder (*Platichthys flesus*), eelpout (*Zoarces viviparus*), and eel (*Anguila anguilla*) near the foundations than in surrounding soft bottom habitat (Langhamer and Wilhelmsson, 2009; Bergström et al., 2013; Reubens et al., 2013). In the German Bight portion of the North Sea, fish were most densely congregated near the anchorages of jacket foundations, and the structures extending through the water column were thought to make it more likely that juvenile or larval fish encounter and settle on them (RICRMC, 2010; Krone et al., 2013). In addition, at these structures fish can take advantage of the shelter provided while also being exposed to stronger currents created by the structures, which generate increased feeding opportunities and decreased potential for predation (Wilhelmsson et al., 2006). The presence of the foundations and resulting fish aggregations around the foundations is expected to be a long-term habitat impact, but the increase in prey availability could potentially be beneficial for marine mammals.

10.0 Anticipated Effects of Habitat Impacts on Marine Mammals

This section addresses the NFMS requirement to characterize the short- and long-term impacts of the predicted habitat loss or modification due to the proposed activities on affected marine mammal species. Loss or modification of marine mammal habitat could arise from alteration of benthic habitat, degradation of water quality, or effects of noise, and was detailed in **Section 9.1** and **9.2**. These impacts could be short- or long-term in nature. However, no significant short- or long-term impacts on marine mammals from alteration of their habitat are expected. The predicted impacts on marine mammals due to changes to their habitat have been summarized in **Sections 10.1** and **10.2**.

10.1 SHORT-TERM IMPACTS

Marine mammals use sound to navigate, communicate, find open water, avoid predators, and find food. Acoustic acuity within their habitat must be available for species to conduct these ecological processes. If noise levels within critical frequency bands preclude animals from accessing the acoustic properties of that habitat, then availability and quality of that habitat has been diminished. The sounds that marine mammals hear and produce will vary in terms of dominant frequency, bandwidth, energy, temporal pattern, and directionality. The same variables in ambient noise will, therefore, affect a marine mammal's acoustic resource availability. Anthropogenic noise can be viewed as a form of habitat fragmentation resulting in a loss of acoustic space for marine mammals that could otherwise be occupied by vocalizations or other ecologically significant acoustic cues (Rice et al., 2014). Primary acoustic habitat for a species will be focused within the vocal ranges for that species; therefore, habitat impact assessment should be conducted within those vocal ranges. The functional extent of the ensonified space around specific construction activities would require an understanding of the distribution of SPLs by their spectral probability densities and knowledge of exposure levels received by the animals coordinated with species densities expected in the region. Acoustic propagation modeling conducted by JASCO (Denes et al., 2020a) partially accounts for spectral characteristics of the sound received by animals through the application of NMFS marine mammal weighting functions, and it can be assumed animals within the behavior threshold isopleths may encounter a loss of acoustic space. Therefore, marine mammals may experience some short-term loss of acoustic habitat, but the nature and duration of this loss due to the temporary nature of the proposed activities is not expected to represent a significant loss of acoustic habitat.

Due to the small footprint of any sediment disturbance caused by installation of the monopile foundations and export cable combined with the temporary nature of the activities and likely availability of similar benthic habitat around the sampling location, it is expected that construction activities would have negligible benthic effects that could impact marine mammals.

10.2 LONG-TERM IMPACTS

The long-term habitat alteration due to the presence of monopile foundations and scour protection provides hard-bottom habitat for potential marine mammal prey species and may increase the availability of prey species as discussed in **Section 9.2**. This could potentially alter marine mammal distribution and behavior patterns by increasing number of marine mammals using this habitat for foraging. Studies have observed seals concentrating their foraging efforts around wind farms and oil and gas platforms with successful foraging as indicated by the seals returning to these sites (Russel et al., 2014; Arnould et al., 2015). Projects to restore artificial reefs noted an increase in the presence of harbor porpoises at the new artificial reef site compared to surrounding habitats, and it was hypothesized they were following prey species (Mikkelsen et al., 2013). Successful foraging near the foundations could promote return to these sites resulting in a minimal long-term but potentially beneficial change in marine mammal habitat use.

11.0 Mitigation Measures

This section addresses NMFS' IHA requirement to assess the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or means of effecting the least practicable impact upon affected species or stock, their habitat, and their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

The Applicant has demonstrated a strong commitment to minimizing impacts to marine mammal species through a comprehensive and progressive mitigation and monitoring program. The marine mammal mitigation program will provide the framework for mitigation and monitoring during all proposed activities. The Applicant commits to engaging in ongoing consultations with the NMFS and has committed to following a comprehensive set of mitigation and monitoring measures during construction of the SFWF and SFEC. These measures include the following components:

- Noise attenuation through use of an NMS;
- Seasonal restrictions;
- Establishment of exclusion zones;
- Visual and passive acoustic monitoring;
- Area clearance;
- Soft start procedures;
- Operational shutdowns and delays;
- Survey sighting coordination; and
- Vessel strike avoidance procedures.

All mitigation measures as well as comprehensive monitoring measures are fully described in the attached Protected Species Monitoring and Mitigation Plan (PSMMP) (**Appendix**). Additionally, SFW will conduct sound field measurements on at least one pile. Measurement methodologies are detailed in **Attachment 4** of the PSMMP (**Appendix**). SFW may request a modification to the size of exclusion and monitoring zones based on the results of pile measurements.

12.0 Arctic Plan of Cooperation

This requirement is applicable only for activities that occur in Alaskan waters north of 60° N latitude. The proposed activities will not take place within the designated region and, therefore, will not have an adverse effect on the availability of marine mammals for subsistence uses. As such, there is no need to address such a plan.

13.0 Monitoring and Reporting

As required in Lease OCS-A-0517, The Applicant will comply with the marine mammal reporting requirements for construction activities detailed below.

Reporting Injured or Dead Species. The Applicant will ensure that sightings of any injured or dead marine mammals are reported to the Greater Atlantic (Northeast) Region Marine Mammal and Sea Turtle Stranding & Entanglement Hotline within 24 hours of a sighting, regardless of whether the injury or death is caused by a vessel. In addition, if the injury or death was caused by a collision with a project-related vessel, the Applicant will ensure that NMFS is notified of the strike within 24 hours. The notification of such strike will include the date and location (latitude/longitude) of the strike, the name of the vessel involved, and the species identification or a description of the animal, if possible. If the project activity is responsible for the injury or death, the Applicant will supply a vessel to assist in any salvage effort as requested by NMFS.

Reporting Observed Impacts to Species. The observers will report any observations concerning impacts on marine mammals to NMFS within 48 hours. Any observed takes of listed marine mammals resulting in injury or mortality must be reported within 24 hours to NMFS.

Report of Activities and Observations. The Applicant will provide NMFS with a report within 90 calendar days following the completion of construction activities, including a summary of the construction activities and an estimate of the number of marine mammals taken during these activities.

Report Information. Data on all marine mammal observations will be recorded and based on standards of marine mammal observer collection data by the PSOs. This information will include dates, times, and locations of survey operations; time of observation, location and weather; details of marine mammal sightings (e.g., species, numbers, behavior); and details of any observed taking (e.g., behavioral disturbances or injury/mortality).

14.0 Suggested Means of Coordinated Research

This section addresses the IHA requirement to suggest means of learning of, encouraging, and coordinating research opportunities, plans, and activities related to reducing incidental take and evaluating its effects.

While no direct research on marine mammals or marine mammal stocks is expected from the project, there is the opportunity for the proposed activity to contribute greatly to the noise characterization in the region and to specific sound source measurements. Sound field measurements of at least one pile with an NMS will be conducted during installation to verify that the received sound levels produced are comparable to the modeled sound fields and, therefore, meet the assumptions used in the take estimates and the monitoring and mitigation programs. The details of the pile selection and measurement protocol will be determined prior to construction; however, the measurement plan is provided in **Attachment 4** of the PSMMP (**Appendix**). Mitigation measures will be implemented during all piling activity as described in **Section 5.0** of the PSMMP (**Appendix**). The results of the measurements will serve to provide industry and regulatory communities necessary information regarding the efficacy of sound attenuation devices in both broadband and frequency-specific attenuation when applied in the U.S. Northeast wind development areas.

Data acquired during the protected species mitigation and monitoring program may provide valuable information to direct or refine future research on marine mammal species present in the area. Sightings data (e.g., date, time, weather conditions, species identification, approximate sighting distance, direction, heading in relation to sound sources, behavioral observations) may be useful in designing the location and scope of future marine mammal survey and monitoring programs.

All marine mammal data collected by the Applicant during marine construction activities will be provided to NMFS, BOEM, and other interested government agencies. In addition, the data, upon request, will be made available to educational institutions and environmental groups.

The PSMMP (**Appendix**) also provides a framework for long term ecological monitoring as part the SFWF development and operations.

15.0 List of Preparers

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Appendix: Protected Species Monitoring and Mitigation Plan

Protected Species Mitigation and Monitoring Plan

South Fork Wind, LLC

South Fork Wind | Powered by Ørsted & Eversource

27 January 2021

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List of Acronyms

AAR	autonomous acoustic recorder
ASV	autonomous surface vehicle
AUV	autonomous underwater vehicle
BBC	Big bubble curtain
BO	Biological Opinion
BOEM	Bureau of Ocean Energy Management
Cm	centimeter
COP	Construction and Operations Plan
CTV	crew transfer vessel
DASBRS	Drifting Autonomous Spar Buoy Recorders
dB	decibel
DIFAR	Directional Frequency Analysis and Recording
DMA	Dynamic Management Area
DZ	Disturbance Zone
ESA	Endangered Species Act
EZ	Exclusion Zone
ft	foot
GPS	global positioning system
HD	high definition
HRG	high-resolution geophysical
HSD	Hydro Sound Damper
Hz	hertz
IHA	Incidental Harassment Authorization
IR	infrared
ISO	International Organization for Standardization
kHz	kilohertz
km	kilometer
Lease Area	BOEM-designated Renewable Energy Lease Area
m	meter
µPa	Micropascal
mm	millimeter
MMPA	Marine Mammal Protection Act
NARW	North Atlantic right whale
NMFS	National Marine Fisheries Service
NVD	night vision device

NMS	noise mitigation system
OCS	outer continental shelf
O&M	operations and maintenance
OSS	offshore substation
PAM	passive acoustic monitoring
PECP	Permits and Environmental Compliance Plan
Project	South Fork Wind Farm Project
POC	point of contact
PSMMP, or Plan	Protected Species Mitigation and Monitoring Plan
PSO	Protected Species Observer
PTS	permanent threshold shift
QA	quality assurance
QC	quality control
rms	root mean square
ROD	Record of Decision
SAS	Sighting Advisory System
SEL_{cum}	cumulative sound exposure level
SFV	sound field verification
SFEC	South Fork export cable
SFW	South Fork Wind, LLC (applicant), South Fork Wind (project)
SFWF	South Fork Wind Farm
SMA	Seasonal Management Area
SNR	Signal to Noise Ratio
SOV	service operation vessel
SPL	sound pressure level
SPL_{pk}	peak sound pressure level
UHF	Ultra-High frequency
UHRS	Ultra-High Resolution Seismic
USCG	United States Coast Guard
VHF	very high frequency
WFA	Wind Farm Area
WTG	wind turbine generator
ZOI	Zone of Influence

Glossary

Acoustic range	Range to acoustic thresholds calculated using acoustic modeling which assumes a stationary receiver and only considers sound propagation
Autonomous acoustic recorder	Self-contained acoustic recording device designed for long-term deployment and data collection
Autonomous surface vehicle	Unmanned surface vehicle or boat operated without a crew onboard
Buffer zone	An area added to any existing zone, usually prior to specific operations, to enhance the effectiveness of mitigation such that there is a buffer in space and time during which the mitigation can be applied
Clearance zone	The area that must be visually clear of protected species prior to starting an activity that produces sound at frequencies and amplitudes that could result in Level A or Level B exposures (e.g., HRG sources with operating frequencies <200 kHz; impact and vibratory pile driving)
Construction and operations plan	Plan submitted to BOEM by developers as required by 30 CFR part 585 to describe all planned facilities proposes for construction and use for the Project, along with all proposed activities including the proposed construction activities, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities
Dynamic Management Area	Areas established by NMFS to protect North Atlantic right whales in which a voluntary speed restriction of 10 knots or less is encouraged while transiting through these areas
Ecological monitoring	Used to assess the effectiveness of mitigation measures within the context of long term or ecosystem-based assessments outside of any mitigation requirements
Exclusion Zone	The area in which shut down or other active mitigation measures must be applied once a source is active if a protected species is sighted inside the corresponding zone
Exposure range	Ranges to acoustic thresholds calculated using acoustic modeling which considers animal movement and behavior
Hydrophone	Microphone/audio recorder designed for use underwater

Incidental harassment authorization	Authorization from NMFS per the MMPA for the "taking" of small numbers of marine mammals resulting from Project activities
Level A Zone	The area encompassed by the water from a sound source to an isopleth that meets a threshold at which onset of a permanent threshold shift (PTS) in hearing can occur
Level B Zone	The area encompassed by the water from a sound source to an isopleth that meets a threshold at which onset of a behavioral disturbance can occur
Mitigation	the set of personnel, equipment and protocols that are in place to minimize the risk of any potential impacts to marine mammals that could result from project activities
Mitigation monitoring	Typically comprised of PSOs who visually and acoustically monitor specified zones, during Project activities
Monitoring zone	The body of water around an activity that is visually and/or acoustically monitored for the presence of marine protected species
Noise Mitigation System	Any device or suite of devices that reduces pile driving sound levels that are transmitted through the water. Primary systems reduce the source levels produced by the pile and secondary systems reduce the propagated sound levels of the piling.
Offshore substation	Stations that collect and export the power generated by the WTGs, to be installed on either monopile or jacket foundations within the SFW Lease Area
Passive acoustic monitoring	Real-time monitoring using an underwater recorder during Project activities for the presence of marine mammal vocalizations
Project Area	SFW Lease Area (OCS-A 0517) and associated export cable routes
Protected species observer	NMFS-approved visual observers trained to monitor the area around vessel or platform during Project activities for the presence of protected species and implement appropriate mitigation as necessary
Record of decision	Decision issued by BOEM following review of the COP which described their decision, any alternatives considered, and plans for mitigation and monitoring, as necessary
Seasonal Management Area	Areas established by NMFS along the U.S. east coast at certain times throughout the year in which all vessels greater than 65 ft are required to travel and 10 knots or less while transiting these areas to reduce the threat of vessel strikes on North Atlantic right whales

Sound field verification	Acoustic measurements taken in the field of specific Project activities used to verify modeling results and confirm the monitoring and mitigation methods implemented for the Project are appropriate
Wind farm area	Maximum work area surrounding the South Fork Lease Area (BOEM Lease OCS-A 0517)
Wind turbine generator	A device that converts wind energy into electricity, to be installed on monopile foundations within the SFW Lease Area
Zone of influence	The area within which potential impacts to species are assessed and estimated

1 Protected Species Monitoring and Mitigation Plan

This protected species mitigation and monitoring plan (PSMMP) is in place for high-resolution geophysical (HRG) survey, construction, and operations and maintenance (O&M) activities planned for South Fork Wind LLC's (SFW) South Fork Wind Farm (SFWF) located in the Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A-O517 and the associated South Fork Export Cable(SFEC); herein referred to as the Project Area.

1.1 Purpose of PSMMP

The objective of this PSMMP is to provide protocols and guidelines for mitigation and monitoring marine mammals. The PSMMP also serves as Section 11 (Mitigation Measures to Protect Marine Mammals and their Habitat) of the Incidental Harassment Authorization (IHA) for the Project. The PSMMP provides consistency in the monitoring and mitigation methods employed across all Orsted and Orsted partnership wind projects in the Atlantic Outer Continental Shelf (OCS) and all development and operational phases. A PSMMP will be developed for each project.

1.1.1 PSMMP Format

General Project standard conditions are presented in **Sections 1** and **2** of the PSMMP; while Project-specific activities will be reflected in the **Section 3** and beyond as applicable. The Project-specific sections consider the range of activities and potential impacts; the biological and ecological information about species likely to occur within each project area; and permit conditions under which the work is being performed.

The protocols described herein are designed to:

- minimize impacts to protected species resulting from Project activities.

record the occurrence of protected species in proximity to the Project Area. The described monitoring and mitigation methods primarily target marine mammals potentially exposed to underwater sound levels that could constitute "take" under the Marine Mammal Protection Act (MMPA).

Subsequent sections of the PSMMP provide Project-specific details regarding the protocols that will be implemented during:

- HRG surveys, and
- construction

Each activity section is designed to be used as a reference to the required measures that will be implemented during the corresponding activity including:

- designating mitigation and monitoring zones,

- defining measures related to sound impacts, and
- vessel strike avoidance measures as applicable for each activity.

Users should reference the PSMMP to confirm that all agreed and regulatory measures are being implemented using the accepted methods and practices. Additionally, sections are included that address longer term and ecological monitoring initiatives that are associated with specific projects or are in development through broader Orsted and Orsted partnership activities.

The ***Standard Conditions for Mitigation and Monitoring*** (**Section 2**) that follows, outlines standard protocols and definitions that are common between all Orsted projects. This section should be considered the base conditions, or standard practices that can expected for any Orsted or Orsted partnership project. Project-specific details or modifications to these practices are provided in subsequent PSMMP sections which provides the agreed upon and regulatory frameworks for implementing Orsted and Orsted partnerships mitigation and monitoring programs.

2 Standard Conditions for Mitigation and Monitoring

2.1 Defining Mitigation and Monitoring

For purposes of the PSMMP, mitigation and monitoring are defined as follows:

- **Mitigation** – defined as the set of personnel, equipment, and protocols that are in place to minimize the risk of any potential impacts to marine mammals that could result from Project activities.

- **Monitoring** – defined in two ways:

  1) Mitigation monitoring associated with ***mitigation activities***. Mitigation monitoring is typically comprised of protected species observers (PSOs) who visually and acoustically monitor specified zones (**Section 2.1.1**), during Project activities; and
  2) Ecological Monitoring to ***assess the effectiveness of mitigation measures***. Ecological monitoring is used within the context of long-term or ecosystem-based assessments outside of any mitigation requirements. While the same or similar methods and equipment as mitigation monitoring may be used, ecological monitoring typically addresses different questions or actions than mitigation monitoring. In this context, we use the term ecological monitoring in the PSMMP to differentiate the two monitoring regimes.

2.1.1 Zone Definitions

Throughout the PSMMP, zones are described that identify either an impact range, or areas within which mitigation and/or monitoring occurs. The size of the zones and the actions (if necessary) taken within each zone will be project-, species-, and activity-specific and are identified in each Project activity section for marine mammals and in the applicable Appendices for other species. Not all zones may be incorporated for all projects or activities. If additional zones are necessary for a project outside of the standard conditions, they will be defined in the associated activity sections of that project's PSMMP and in applicable Appendices for other species. The zones applicable to this Project are defined below.

- **Level A[1] Zone** – the area encompassing the waters from a sound source to an isopleth that meets a threshold at which the **onset of a permanent threshold shift (PTS)** can occur. Level A zones may result from an instantaneous exposure, exposure over a 24-hour period, exposure to a single-strike or pulse, or other defined metric. Level A zones may be calculated or modeled, and their extent

[1] Level A refers to marine mammal harassment defined in the Marine Mammal Protection Act (MMPA) that could potentially cause PTS onset.

can be defined by acoustic ranges[2] or by exposure ranges[3]. Entry by an animal into the Level A zone may or may not require mitigation measures be taken. Marine mammals detected between the sound source and the outer range limit of the Level A zone under the specified exposure conditions may constitute Level A exposure. Unless otherwise stated, the Level A zones for marine mammals use the following metrics:
  - Cumulative sound exposure level (SEL_{cum}) and peak sound pressure level (SPL_{pk}) PTS thresholds as defined by the National Marine Fisheries Service (NMFS), (2018).

- **Level B[4] Zone** – the area encompassing the waters from a sound source to an isopleth that meets a threshold at which **onset of a behavioral disturbance can occur**. Level B zones may result from an instantaneous exposure, exposure to a single-strike or pulse, or other defined metric. Level B zones may be calculated or modeled, and their extent can be defined by acoustic ranges or by exposure ranges. Entry by an animal into the Level B zone may or may not require mitigation measures be taken. Marine mammals detected within this zone under the specified exposure conditions may constitute Level B exposure. Unless otherwise stated, the Level B zones for marine mammals use the following metrics:
  - Level B zone encompasses the distance from the sound source to an unweighted received root-mean-square sound pressure level (SPL_{rms}) of 160 decibels (dB) referenced to (re) 1 micropascal (μPa) when impulsive or sweep sources are considered; and an unweighted SPL_{rms} of 120 dB re 1 μPa when non-impulsive sources are considered (NMFS, 2019).

- **Pre-start Clearance Zone** – the area that must be visually clear of protected species **prior to starting an activity** that produces sound at frequencies and amplitudes that could result in Level A or Level B exposures. Clearance zones may also be implemented after a shutdown in sound-producing activities prior to restarting the source. The size of the clearance zone is dependent on the activity and permit conditions. The clearance zone will be specific to species and/or faunal groups and may be larger than the species/faunal group-specific exclusion zone (described below).

- **Exclusion Zone (EZ)** – the area in which shutdown or other active mitigation measures must be implemented **once a source is active**. The size of the EZ is dependent on the activity and permit conditions. The EZ may or may not encompass other zones. EZs will be specific to species and/or faunal groups.

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[2] Acoustic range: Range to acoustic thresholds calculated using only propagation modeling which assumes a stationary receiver
[3] Exposure range: Ranges to acoustic thresholds calculated using acoustic modeling which considers animal movement and behavior
[4] Level B refers to marine mammal harassment defined in the Marine Mammal Protection Act (MMPA) that could potentially cause behavioral disturbance.

- **Monitoring Zone** – encompasses the **waters around an activity to be visually and/or acoustically monitored** for the presence of marine protected species. The monitoring zone represents the farthest extent practicable that can be monitored for marine mammals. There are no mitigation or visibility requirements associated with the monitoring zone; however, all species detected within the monitoring will be recorded. The minimum size of the monitoring zone will help inform the appropriate monitoring methods that will be employed during activities. Monitoring zones can be considered an area of situational awareness for the project that carry no specific regulatory requirements.

- **Buffer Zone** – an area added to any existing zone, usually prior to specific operations, to enhance the effectiveness of mitigation such that there is a buffer in space and time within which marine mammals may monitored and appropriate mitigation can be applied. If an animal enters the buffer zone, mitigation measures may be required, or it may initiate a period of heightened awareness such that mitigation measures should be made ready.

- **Zone of Influence (ZOI)** – this is not a defined area for mitigation or monitoring purposes; rather, it is the area within which potential impacts to species are assessed and estimated. The ZOI would not be greater than the maximum Level B zone. While the ZOI provides the needed information to establish the other zones, it does not play an additional role in mitigation and monitoring during Project activities.

2.2 Permits and Agreements

Permits and agreements pertaining to the Project will define and modify the mitigation and monitoring requirements through the various stages of the permitting process. The permits and agreements in place for the Project are detailed in the individual Project activity sections.

2.3 Personnel

Dedicated personnel may be required for carrying out mitigation and monitoring efforts onboard Project vessels. These roles are generally required to be filled by NMFS-approved and BOEM-accepted PSOs and passive acoustic monitoring (PAM) operators.

All personnel in the field have a responsibility to support these activities and will receive Project-specific training. A Permits and Environmental Compliance Plan (PECP) manual which will include the PSMMP will be prepared to describe species expected to occur in the Project Area, monitoring and mitigation measures, data collection and reporting measures, equipment specifications, etc.

The Project will conduct standardized pre-activity environmental awareness training for all crew members (e.g., PECP training). The training will summarize the PECP and other relevant topics including:

- The responsibilities of each party;
- Definition of the chains of command;
- Communication procedures;
- An overview of monitoring purposes;
- Review of operational procedures;
- Procedures for sighting, reporting, and protection of marine mammals and other protected species;
- General review of protected species anticipated in the region; and
- Review of additional environmental requirements and awareness elements relevant to the Project.

2.3.1 Protected Species Observers

Protected species observers will, at a minimum, meet the observer standards outlined in Baker et al. (2013) and will have the appropriate approvals from NMFS for conducting PSO duties during wind farm activities. The Project will deploy a PSO team consisting of PSOs with appropriate skills and in sufficient numbers to meet all mitigation and monitoring requirements.

The PSO field team will have a lead monitor (Lead PSO) who will have experience in the northwestern Atlantic Ocean on similar projects. The PSO team will also have one PSO supervisor who may work in the field or shore side for the duration of the mitigation activities. The remaining PSOs will have previous PSO experience on similar projects and the ability to work with the relevant software and equipment.

In addition to the PECP training indicated above, PSOs will also complete a two-day training and refresher session with the PSO provider and Project compliance representatives to review in detail the protected species expected in the Project Area and associated regulatory requirements to be conducted shortly before the anticipated start of Project-related activities.

2.3.2 Passive Acoustic Monitoring Operators

If real-time PAM is employed as a mitigation monitoring protocol, a PAM operator or PAM team will be deployed. PAM operators will have the qualifications and relevant experience to meet the needs of the PAM program including safe deployment and retrieval of equipment as necessary, set-up and monitoring of acoustic processing software, and knowledge in detecting and localizing marine mammal vocalizations. Like the PSO team, the PAM team will have a lead monitor (PAM Lead) who will have experience in the Northwestern Atlantic Ocean on similar projects. The remaining PAM operators will have previous PAM experience on similar projects and the ability to work with the relevant software and equipment. Resumes for all PAM team members will be submitted to NMFS for review prior to the start of mitigation monitoring activities.

In addition to the PECP training indicated above, PAM operators will also complete a 2-day training and refresher session with the PSO provide and Project compliance representatives to review in detail the protected species expected in the Project Area and associated regulatory requirements to be conducted shortly before the anticipated start of Project-related activities.

2.3.3 Environmental Compliance Monitor

PSOs will be employed by a third-party provider. However, non-third-party observers who act as environmental compliance monitors in support of a Lead PSO may be approved by NMFS on a case-by-case basis for limited, specific duties in support of approved, independent PSOs.

2.3.4 PSO & PAM Operator Responsibilities

Prior to Project commencement, senior-level Lead PSOs will be designated for each team of PSOs on each asset (i.e., Project vessel or platform). These individuals shall have the experience and skill set to manage the team of PSOs on that asset and to make decisions related to monitoring, including potential exposure assessments for each sighting as needed. This person will be the single point-of-contact (POC) for PSO activities on that specific asset. The Lead PSO for each asset will report to the PSO Project Manager or Vessel Project Manager. The Lead PSOs shall provide daily sightings and mitigation summary reports to the designated Project Manager which is reported through to Project representatives for the previous day's operations. Any subsequent changes made to any reports submitted by the Lead PSO shall be documented in a change log and the review and acceptance by the lead PSO noted. The Lead PSO is also responsible for quality assurance (QA)/quality control (QC) and management of data collection utilizing electronic data collection and embedded QA/QC processes with software such as Mysticetus in the field on their asset. They are the primary representative of observations, reports, and mitigation actions taken by the PSO team.

The PSO supervisor will oversee data collection at the highest level of all the PSO and PAM teams. The Lead PSOs and PAM Leads will be responsible for communicating to the vessel and client POCs directly or through agreed upon Project Management intermediaries and will ensure that the communication protocols established for the Project are maintained at all times and that all personnel are trained on the communication protocols. These communication duties shall include the final responsibility for calling for a mitigation action.

Prior to the start of Project-related activities, the Lead PSO will work with the vessel captain and crew (i.e., operations team) on the vessel (the latter as applicable) to achieve compliance with all applicable regulatory documents and provide training when necessary to the vessel captain and crew.

Following established BOEM and NMFS standards, the PSO/PAM team(s) will work in designated shifts during monitoring. For PSOs, shifts will be set up such that no individual will work more than 4 consecutive hours without a 2-hour break, or longer than 12 hours during any 24-hour period. The Project will provide each PSO with one 8-hour break per 24-hour period to sleep or rest, depending on onsite conditions (e.g., weather). An example rotation is provided in **Attachment 1**. Actual rotations will be Project-, activity-, and vessel-specific, and implemented rotations will be documented with the Project's final PSO report.

For PAM operators, minimum standard shifts are typically restricted to no more than 3 hours, but can be reduced if NMFS or BOEM directs a shorter shift. Typically, there is a "floater" PAM operator on the vessel who can rotate in to allow the PAM operator on shift to rest or eat. In some cases where vessels work under 24-hour operations, 4-hour PAM operator rotations may be scheduled. In the cases where PAM systems are monitored remotely (i.e., shore side) alternative rotations to the above may be requested on a case-by-case basis.

The combined PSO and PAM team will conduct monitoring efforts onboard Project vessels and, in some cases, shore side for remote and autonomously monitored systems. At all times during monitoring efforts, at least one dedicated vessel will be used to monitor for marine mammals relative to the activity being conducted. Autonomous, remotely operated systems may also be deployed to support the monitoring program. It is expected that during most activities, monitoring will take place from more than one platform.

The PSOs will watch for marine mammals from the best available vantage point on the vessels. Ideally this vantage point is a stable, elevated platform from which the PSOs have an unobstructed 360° view of the water. The PSOs will systematically scan with the naked eye and 7x50 reticle binoculars, supplemented with night-vision equipment when needed (see below). During activities with large monitoring zones, 25X 150 millimeter (mm) "big eye" binoculars may be used. New or inexperienced PSOs will be paired with an experienced PSO qualified to mentor new PSOs so that the quality of marine mammal observations and data recording is kept consistent. All vessel personnel are provided the guidance "*If you see something, say something*" and are responsible for reporting to the PSO team any opportunistic sightings made as soon as able and safe to do so.

2.4 Equipment

The PSOs will be equipped with reticle binoculars and will have the ability to estimate distances to marine mammals located in proximity to their respective zones using range finders. Digital single-lens reflex camera equipment will be used to record sightings and verify species identification. During night operations, night-vision equipment (night-vision goggles with thermal clip-ons) and infrared technology will be used. Position data will be recorded using hand-held or vessel global positioning system (GPS) units for each sighting. Recent studies have also concluded that the use of infrared (IR) thermal imaging technology may allow for the detection of marine mammals at night as well as improve the detection during all periods with automated detection algorithms (Weissenberger, 2011; Smith et al., 2020; Zitterbart et al., 2020).

The exact equipment complement used by the PSO/PAM team will vary by the activity, mitigation and monitoring requirements, and observation platform constraints. Additional equipment may be added as necessary. The PSO/PAM team will typically use some combination of the following equipment for observation efforts:

- 7x50 reticle binoculars;
- 25x150 "big eye" binoculars;
- Handheld GPS units;
- High-definition digital single-lens reflex cameras with a minimum 300-mm zoom lens;
- Hard drives to back up data;
- Laser rangefinder;
- Rangefinder stick;
- Night vision devices (NVDs);
- Mounted IR thermal imaging cameras;
- Hand-held IR thermal imaging cameras;
- PAM hydrophone arrays and/or corresponding monitoring stations;
- PCs/laptops/tablets; and
- Computer-based PSO data recording system (e.g., Mysticetus).

Specific equipment requirements for individual Project-related activities are provided in **Sections 4** through **8**. Descriptions of the primary hardware used during mitigation and monitoring activities for all phases of wind farm development are provided below in **Sections 2.4.1** through **2.4.3**.

2.4.1 IR Thermal Camera Systems

Studies have indicated that IR thermal camera performance is independent of daylight and has demonstrated effectiveness ranges exceeding 3 kilometers (km). Results of studies demonstrate that IR thermal imaging can be used for reliable and continuous marine mammal protection (Zitterbart, 2013; Zitterbart et al., 2020; Smith et al., 2020). For this reason, the Project finds that use of IR thermal camera systems for mitigation purposes warrants additional application in the field as both a stand-alone tool and in conjunction with other alternative monitoring methods (e.g., night vision binoculars, PAM, visual monitoring).

2.4.2 Night Vision Devices

NVDs work on a different principle than IR thermal cameras. NVDs enhance available light to provide an image of what is being viewed through the device in such a way that it resembles viewing during higher light conditions. In this way, NVDs are less dependent on temperature differentials necessary for the IR thermal camera systems. Their drawback, however, are their narrow fields of view and short effective ranges.

Equipment selected will be tailored to the size of the zones being monitored for the Project. Specifications for representative NVD and IR thermal camera will be provided for individual projects as needed. Specific NVD and IR thermal camera equipment models will be subject to availability.

2.4.3 PAM Systems

A PAM system is defined as any system or device that uses hydrophones or arrays of hydrophones, or other sensors (e.g., vector sensors such as Directional Frequency Analysis and Recording devices [DIFAR] capable sonobuoys), to detect sounds produced by marine mammals. A review of PAM systems that are under consideration are provided in **Attachment 2** which gives a general overview of the different types of applicable PAM systems including some of their advantages and disadvantages.

Within environmental impact statements and mitigation guidelines, there is often a general presumption that animal vocalizations will be consistently detected regardless of operator experience or background noise conditions encountered (Barkaszi and Kelly, 2019; Ludwig et al., 2016; Verfuss et al., 2018). Impact estimates and risk assessments also rely on the assumption that animals within an EZ will be detected and localized immediately, so that sound exposures over certain criteria thresholds can either be avoided or enumerated (Barkaszi and Kelly, 2019; Verfuss et al., 2018). In reality, detection performance at a given distance can be highly variable due to variability in the frequency, amplitude, directionality, and repetition rate of marine mammal vocalizations; as well as the continually changing background noise levels that effectively reduce the ability to detect signals generated within a monitoring zone (Andriolo et al., 2018; Clausen et al., 2019; Parks et al, 2009; Thode and Guan, 2019; Van Parijs et al., 2009). Furthermore, localization, when required, often relies on the detection of multiple high-quality signals. When the detection performance of signals is diminished, the actual time required to localize an animal or group of animals might be prolonged or impossible (Abadi et al., 2017; Barkley et al., 2016; Thode and Guan, 2019). The types and configurations of PAM systems considered for all monitoring on Orsted and Orsted Partnership projects are discussed in **Sections 2.4.3.1** through **2.4.3.2** and in **Attachment 2**.

2.4.3.1 PAM Systems for Real-Time Mitigation Monitoring

PAM is widely used to monitor mitigation zones around vessels and other platforms during survey and installation activities that could negatively impact marine mammals. The priority of mitigation monitoring is the ability for compliance personnel to detect and spatially localize marine mammals such that a mitigation decision can be made in a matter of minutes. The complexity of acoustic detection and localization is further hindered by practical operational conditions that are common for mitigation monitoring, described further below.

The real-time requirement limits the types of PAM technologies that can be used to those systems that are either cabled, satellite, or radio-linked. The system chosen will dictate the design and protocols of the PAM operations. Seafloor cabled PAM systems are not considered here, due to high installation and maintenance costs, environmental issues related to cable laying, permitting, and other reasons.

Towed PAM systems are cabled hydrophone arrays that are deployed from a vessel and typically monitor directly from the tow vessel. By and large, towed PAM systems are the mainstay of mitigation PAM applications due to the relatively low cost, high mobility, and ease and reliability of operation. However, the main challenge of a towed PAM system is the fact that it is usually towed from a vessel that may not be fit-for-purpose that may also be towing other equipment, operating sound sources, and is working in patterns that are permit and Project-driven rather than driven by acoustic monitoring needs; all of which can result in less than optimal conditions in which to employ PAM systems. In particular, detection and localization of low-frequency signals (e.g., baleen whale calls) can be challenging in many commercial deployment configurations. One significant value of towed PAM systems, however, is their ability to work in unison with visual monitoring efforts along transects. The ability to coordinate call types and call rates with visually detected species and group sizes provides important information for analyzing data from non-towed systems. While towed PAM systems have a place in mitigation monitoring (e.g., in support of visual observation), alternative PAM systems are required for long-range and low frequency signal monitoring.

Mobile and hybrid PAM systems utilizing autonomous surface vehicles (ASVs) and radio-linked autonomous acoustic recorders (AARs) shall be considered when they can meet monitoring and mitigation requirements in a cost-effective manner. Mobile systems are defined here as systems that are not fixed (e.g., moored or bottom-mounted) at one location. Examples of mobile systems include autonomous underwater vehicles (AUVs), ASVs, and drifting PAM buoys. Examples of drifting PAM buoys include sonobuoys, the Que-phone, Drifting Autonomous Spar Buoy Recorders (DASBRS), and SonarPoint in the drifter configuration). Due to their drifting nature, these systems are typically deployed in pelagic environments, or for very short periods (e.g., sonobuoys). A review for ASVs and AUVs was recently conducted by Verfuss et al. (2019).

Real-time (e.g., radio-linked) PAM buoys can be used for regional monitoring of large areas and have an advantage over AARs in that they can telemeter data to shore or a monitoring station nearby in real, or near real-time. Examples of real-time PAM buoys are also provided in **Attachment 2**.

2.4.3.1.1 Placement of Mitigation PAM Systems

Ideally, deployment of a mitigation PAM array will be outside the perimeter of the EZ to optimize the PAM system's capability to monitor for the presence of animals potentially entering these zones. The total number of PAM stations and array configuration will depend on the size of the zone to be monitored, the amount of noise expected in the area, and the characteristics of the signals being monitored. There is no single optimal array configuration for all animal call types or noise conditions.

In general, large cetaceans such as baleen whales that produce relatively loud, low-frequency vocalizations can be monitored with a few hydrophones that can be separated by several hundreds of meters or more, whereas smaller cetaceans such as toothed whales and dolphins produce shorter, lower level signals (e.g., whistles, echolocation clicks) that require hydrophones to be spaced more closely, tens of meters to less than a meter apart, and thus may require more hydrophones in an array.

Using closely-spaced clusters of hydrophones (i.e., an array) or vector sensors will allow the direction and, in some cases, the range to vocalizing animals to be estimated. However, this approach adds greater complexity and costs to both the hardware and software, can reduce reliability of the system, and can make real-time monitoring and mitigation difficult for PAM operators. Of course, detection and localization of animals is only possible if they are vocally active.

2.4.3.2 PAM Systems for Ecological Monitoring

The type of system chosen for any ecological monitoring programs will depend on the monitoring priorities (i.e., species and areas to be monitored), the environment (e.g., water depths), bottom fishing (e.g., trawling) in the area to be monitored, and other factors which contribute to detection probabilities.

AARs are a good option for long-term ecological monitoring. AARs are available in a variety of configurations and specifications (**Attachment 2**) (Sousa-Lima et al., 2013). Typically, AARs are deployed on the seafloor for some period of time from several days, weeks, months, up to one year. They are later retrieved from the seafloor, and the data are downloaded. An acoustic release device is typically used to release the recorder from the seafloor, however, grappling methods can also be used in some shallow water environments (usually 50 meters [m] or less). Some shallow water systems can also be retrieved with divers, but this approach is becoming less common due to safety issues and availability of more reliable and low-cost release devices. Once retrieved, the recording devices can be serviced, the data downloaded, and then re-deployed for additional missions. One major disadvantage of AARs over other PAM systems is that the recorders must be periodically retrieved in order to access the data because they record and store data internally and therefore are not capable of real-time monitoring. However, due to their autonomous nature, an advantage of these systems is that an infinite variety of deployment configurations are possible.

Most AARs consist of a single omni-directional hydrophone, and therefore it is not possible to obtain bearings or localizations to sound sources from this type of single device. However, other advanced systems utilize a directional hydrophone/sensor (e.g., DIFAR), or multiple hydrophones connected to a single multi-channel recorder (e.g., a hydrophone array) and thus can localize. In some systems, multiple AAR units can be precisely time-synchronized (e.g., using an acoustic pinger or electronic cable), so that bearings can be obtained and in some deployment configurations localizations of sound sources is thus possible. If an animal or tightly clustered group of animals (e.g., a small pod of dolphins) vocalize consistently through time, it may also be possible to track their movements. In general, the more hydrophones that receive the calls, the higher certainty there will be in the animal locations and tracks, until the increased complexity of processing multiple channels of data in real time becomes an issue.

One downside of AARs is that if a failure occurs (e.g., electronic malfunction, flooding, or a failure to retrieve them) significant volumes of data can be lost. This issue is of particular concern for long-term deployments. Also, the data storage and batteries required for extended deployment periods increase the size and costs of these systems.

Finally, there is a cost associated with deployment and retrieval which typically requires a vessel with a hoist, A-frame, or other heavy machinery. The size of the vessel required depends on size and ease of deployment of the AAR system. Some smaller systems can be deployed from a small boat or rigid-hulled inflatable boat, while others might require a large and costly research or other type of vessel with an A-frame. Finally, the fact that data must be post-processed results in additional analysis expense. However, depending on the level of and type of processing, this approach is usually cheaper (per unit of data collected) than real-time monitoring, which typically requires experienced and relatively costly personnel working on vessels or platforms at sea.

There are also hybrid systems that have some components of both real-time and autonomous systems. For example, many types of real-time systems also record data internally, so they can function both as a real-time system, and as autonomous recorders in case the radio or satellite link is not reliable. Some hybrid systems only send status reports or whale-call detection summaries to shore or a vessel nearby via the radio or satellite-link.

The optimal system will depend on cost considerations, the target species, the length of deployment desired, and a variety of other factors. It is important to realize that there is no single system that is capable of mitigation and monitoring of all species of marine mammals for all areas and noise conditions, so it is possible that several systems, or combinations of systems will be needed.

2.5 Software & Informational Tools

During Project-related activities when a marine mammal is detected (either visually or acoustically), data will be collected using software designed for such collection. Software systems exist or are being developed that allow for real-time or near real-time uploads into internet-based cloud storage systems, enabling that information to be downloaded by other vessels or PSOs/PAM operators in the area. This regular and ongoing sharing of sighting data and acoustic detections across platforms will integrate into a Project-wide *Situational Awareness System* that will also include, as feasible, a Marine Operation Centers vessel monitoring system, external sources of information such as WhaleAlert and the NMFS Sight Advisory System (SAS), detections from external sources of sighting information such as any existing North Atlantic right whale (NARW) Listening Network detections, 3rd party sightings, and any designated and overlapping designated seasonal and dynamic management areas (SMA and DMA).

The overall goal will be to create a Common Operating Picture (i.e., the ability to describe current conditions or species presence in real time or near real time) viewable by project personnel across multiple project assets and provide a mechanism to manage multiple assets or activities throughout the Project Area in a systematic way. The system as named supports increased situational awareness of marine mammals and facilitates active whale avoidance (Gende et al., 2019) which is an *active and adaptive* mitigation approach for marine mammal monitoring and supports quick decision making for vessel operators, Project crew, or PSO/PAM operators during Project activities. The software selected for this Project is described further in **Section 2.5.1**.

As a secondary measure, PSOs will check at least once per 4 hours (or as otherwise requested by the Project) additional available information sources including WhaleAlert and the NMFS SAS.

2.5.1 Mysticetus Software

Mysticetus is field-tested technology specifically designed to facilitate PSO operations and enhance protective measures for marine mammals. Mysticetus provides a standardized data collection system customized for data collection protocols specified by the Project across all vessel operators and PSO providers. The standardized data collection includes effort, Project updates, and animal detection data forms and can be updated as needed. Some of the Mysticetus capabilities that enhance Project situational awareness include:

- Real-time graphical display of all relevant information from all boats in the network and 3rd party data feeds defined by the Project.
- Graphically displayed content includes current EZs around work boats, work zones, and survey areas.
- Display that enables instantaneous mitigation decision support features including display of sighting distances and prediction paths of both animals and vessels, enabling informed PSO decisions for survey path adjustment, operational shutdowns, clearance delays, etc.
- Instantaneous sharing of sightings and alerting between all Mysticetus stations in the network (i.e., any animal sighted by any observer shows up on the maps of all nearby Project vessels) creates a multiplying effect of "eyes on water," and is used by vessel crews to actively avoid animals.
- Automatic display of NMFS NARW DMAs on heads-up display map.

- Standardized QA and reporting processes and tools for all PSOs, regardless of which PSO provider or vessel sub-contractor they work for.
- Email and text message instant alerts in the case of sightings of dead, injured, or entangled animals, as well as all NARW sightings.
- Automatic, accurate localization of sighted animals based on reticle binoculars or inclinometer readouts, including deck and PSO eye height, taking into account curvature of the earth.
- IR thermal camera integration of video recording, animal localization support, effort, etc.
- PAM integration and the recording of PAM effort and acoustic detections to Project-specified data collection standards.

2.6 Recording

As part of all monitoring programs, PSOs, PAM operators, and crew members (as applicable) will record all sightings of marine mammals sighted anywhere within the monitoring zone. For mitigation monitoring, data on all PSO observations will be recorded based on standard PSO data collection requirements and specific permit conditions. A data collection software system (e.g., Mysticetus) will be used to record and collate data obtained from visual and acoustic observations during mitigation monitoring. The PSOs and PAM operators will enter the data into the selected data entry program (e.g. Mysticetus) installed on field laptops/tablets. PSO data records will include:

- The presence and location (if determinable) of any marine mammal detected by PSOs, PAM operators, or crew members.
- Identification of marine mammal species, numbers of individuals, and behaviors as able. PAM detections are rarely suitable for enumeration or behavior of animals unless verified by visual detections.
- Detections will be annotated with information regarding vessel activity, environmental conditions, and by other operational parameters (e.g., number of vessels in areas, equipment start and stop times, operational duration, etc.).
- Size of all regulatory and monitoring zones.
- Implementation of vessel strike avoidance measures.
- Implementation of clearance, ramp-up, and shutdown measures as applicable for exclusion and monitoring zones.
- Implementation of specific NARW mitigation measures.

- Observations of any potential injured or dead protected species (e.g., stranding events).

- The following information about each marine mammal detection will be carefully and accurately recorded:
  - Species, group size, age/size/sex categories (if determinable), and physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals;
  - Behavior when first sighted and during any subsequent sightings;
  - Heading (if consistent), bearing, and distance from observer;
  - Location of confirmed acoustic detections within Project Area (if PAM operator is able to localize the animal);
  - Tracks of marine mammals derived from PAM systems if accurate localization is attainable;
  - Entry of animal into any regulatory or monitoring zones and duration in those zones;
  - Closest point of approach to the applicable activities and/or vessels and assets;
  - Apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.) with annotations regarding animal headings, pace, or other information that could help assess changes in behavior;
  - Time, location, speed, and Project activity/active sound sources in operation;
  - How the animal was detection (i.e., with what monitoring method) and if the animal was detected by any other monitoring method; and
  - Mitigation measures requested and implemented (if any).

- At regular intervals and at each detection the following information will be recorded by PSOs and PAM operators when the information is determinable:
  - Sea state, visibility, and sun glare;
  - Noise performance of PAM systems and effective detection ranges for species;
  - Vessel or Project activities and location (if mobile);
  - PSO shift changes;
  - Monitoring equipment being used; and
  - Any NARW SMA or DMAs place during that particular watch.

2.7 Reporting

The following situations would require immediate reporting to appropriate POCs:

- In the event of a sighting of a stranded, entangled, injured, or dead protected species, the sighting shall be reported within 24 hours to the NMFS SAS hotline as stipulated in **Attachment 3**.

- In the event a protected species is injured or killed as a result of Project activities, the vessel captain or PSO on board shall report immediately to NMFS Office of Protected Resources and Greater Atlantic Regional Fisheries Office no later than within 24 hours as stipulated in **Attachment 3**.

- Any NARW sightings should be reported as soon as feasible and no later than within 24 hours to the NMFS SAS hotline or via the WhaleAlert App.

Data and Final Reports will be prepared using the following protocols:

- All vessels will utilize a standardized data entry format.

- A QA/QC'd database of all sightings and associated details (e.g., distance from vessel, behavior, species, group size/composition) within and outside of the designated Exclusion Zones, monitoring effort, environmental conditions, and Project-related activity will be provided after field operations and reporting are complete.

- Final reports will follow a standardized format for PSO reporting from activities requiring marine mammal mitigation and monitoring.

- An annual report will be provided to NMFS and to BOEM on April 1 every calendar year summarizing the prior year's activities.

2.8 Noise Mitigation Systems

Noise mitigation systems (NMS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

There are two categories of NMS, primary and secondary. A primary NMS is used to reduce the level of noise produced by the pile driving activities at the source, typically by adjusting parameters related to the pile driving methods or the impulse produced by a hammer strike. However, primary NMS are not fully effective at eliminating all harmful noise levels that can propagate from construction activities (e.g., $\geq$1 km), so a secondary NMS is typically employed to further mitigate pile driving noise. A secondary NMS is a device or devices employed to reduce the noise as it is transmitted through the water (and through the seabed) from the pile. The noise is typically reduced by some sort of physical barrier that either reflects or absorbs sound waves and therefore decreases the distance over which higher energy sound is propagated through the water column.

Primary NMS are still evolving and will be considered for mitigation when mature with demonstrated efficacy in commercial projects. There are generally three types of secondary NMS considered for impact pile driving within the PSMMP. The final selection of the single or suite of technologies that comprise the NMS will be dependent upon the pile and environmental characteristics of the piling location. The demonstrated effectiveness of these systems is described in Bellmann et al., (2020). The three NMS technologies considered for the Project include:

1) Big bubble curtain (BBC):
   A BBC consists of a flexible tube fitted with special nozzle openings and installed on the seabed around the pile. Compressed air is forced through the nozzles producing a curtain of rising, expanding bubbles. These bubbles effectively attenuate noise by scattering sound on the air bubbles, absorbing sound, or reflecting sound off the air bubbles.
2) Hydro-Sound Damper (HSD):
   An HSD system consists of a fisher net with different sized elements are laid out at various distances from each other which encapsulates the pile. HSD elements can be foam plastic or gas-filled balloons. Noise is reduced as it crosses the HSD due to reflection and absorption.
3) AdBm, Helmholz resonator:
   The AdBm system consists of large arrays of Helmholtz resonators, or air fill containers with an opening on one side that can be set to vibrate at specific frequencies to absorb noise, deployed as a "fence" around pile driving activities.

There are other available systems, however, these may not be technically feasible for the Project (e.g., noise mitigation screen), are either in early stages of development, or have yet to demonstrate their expected performance during field tests and are therefore not being currently considered for use during construction. The Project is committed to achieving the modeled ranges associated with 10dB of noise attenuation.

The configuration of any secondary NMS will optimize its efficacy based on the location, operations, and environmental and oceanographic parameters of the project. For the context of this report, the ***standard*** BBC configuration is defined as a BBC that has been professionally deployed and further optimized after initial deployment based on local conditions and *in-situ* measurement results.

2.9 Vessel Strike Avoidance Policy

The project will implement a vessel strike avoidance policy for all vessels under contract to reduce the risk of vessel strikes, and the likelihood of death and/or serious injury to marine mammals that may result from collisions with vessels. In addition to vessels transiting and working (e.g., HRG surveys, construction, O&M) within the Project Area, there will be vessels transiting to and from the Project Area transporting materials, equipment, and personnel. A project-specific vessel strike avoidance plan is provided in **Attachment 5**.

Marine mammals may not be able to avoid vessels, especially fast-moving ones, and may have difficulty identifying the direction of the source of the vessel noise due to sound propagation characteristics in the marine environment.

All vessels will comply with the vessel strike avoidance measures as specified below, except under extraordinary circumstances when complying with these requirements would put the safety of the vessel or crew at risk.

1) Vessel operators and crews shall receive protected species identification training. This training will cover sightings of marine mammals and other protected species known to occur or which have the potential to occur in the Project Area. It will include training on making observations in both good weather conditions (i.e., clear visibility, low wind, low sea state) and bad weather conditions (i.e., fog, high winds, high sea states, glare). Training will include not only identification skills but information and resources available regarding applicable federal laws and regulations for protected species. It will also cover any Critical Habitat requirements, migratory routes, seasonal variations, behavior identification, etc.

2) Vessel operators and crews will maintain a vigilant watch for marine mammals and other protected species and change course, respond with the appropriate action (e.g., slow down, steer away from the animal) to avoid striking marine mammals.

3) Vessel operators will monitor the Project's *Situational Awareness System* and as necessary, WhaleAlert and the NMFS SAS for the presence of NARWs once every 4-hour shift during Project-related activities.

4) All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW.

5) All vessels 65 ft (20 m) or longer subject to the jurisdiction of the U.S. will comply with the 10-knot speed restriction when entering or departing a port or place subject to U.S. jurisdiction, and in any SMA[5] during NARW migratory and calving periods from November 1 to April 30; also in the following feeding areas as follows: from January 1 – May 15 in Cape Cod Bay; from March 1 – April 30 off Race Point and from April 1 – July 31 in the Great South Channel.

6) When whales are sighted, the vessel shall maintain a distance of 91 m (100 yards) or greater between the whale(s) and the vessel; for smaller cetaceans or sea turtles, a distance of 45 m (50 yards) or greater is best; for right whales this distance is 457 m (500 yards).

[5] Compliance Guide for Right Whale Ship Strike Reduction Rule (50 CFR 224.105), available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales#seasonal-management-areas---mid-atlantic

7) All attempts shall be made to remain parallel to the animal's course when a travelling marine mammal is sighted in proximity to the vessel in transit. All attempts shall be made to reduce any abrupt changes in vessel direction until the marine mammal has moved beyond its associated separation distance (as described above).

8) If an animal or group of animals is sighted in the vessel's path or in close proximity to it, or if the animals are behaving in an unpredictable manner, all attempts shall be made to divert away from the animals or, if unable due to restricted movements, reduce speed and shift gears into neutral until the animal(s) have moved beyond the associated separation distance (with the exception of voluntary bow riding dolphin species).

Additionally, all vessel operators will be briefed to ensure they are familiar with the measures listed above and discussed throughout this Plan. The Project will continue to support external initiatives to further mitigate marine traffic impacts and currently is a supporter of the WhaleAlert system and is investing in development and advancement of whale listening network.

2.9.1 Vessel Types Expected During Construction

Vessels associated with construction (i.e., HRG surveys, pile driving, cable laying), are described in **Table 1**.

Table 1. General vessel types expected during construction.

Vessel Type	Installation Foundations	Installation Export Cable
Survey Vessel (offshore)	❍	
Survey Vessel (nearshore)		❍
Heavy Lift Crane Vessel	❍	
Derrick Barge Crane Vessel	❍	
Jack-up Installation Vessel	❍	
Jack-up Material Feeder Barge	❍	❍
Floating Material Barge	❍	❍
Jack-up Crane Work Vessel	❍	❍
Floating Crane Work Vessel	❍	❍
Towing Tug	❍	❍
Anchor Handling Tug	❍	❍
Rock Dumping/Fallpipe Vessel (FPV)	❍	
Fuel Bunkering Vessel	❍	❍
Cable Laying Vessel	❍	❍
Crew Transport Vessel	❍	❍
Support Vessel/Inflatable Boat	❍	❍
Cable Installation Equipment	❍	❍

3 South Fork Wind Farm Project Area

3.1 Applicable Project Area

The area covered by the PSMMP includes Lease Area OCS-A 0517, some ports of mobilization, transit corridors and the SFEC. Subject to Construction and Operations Plan (COP) conditions. All operations occurring in coordinate with the COP. For the purpose of this PSMMP, the Project Area is defined as the state and federal waters in the vicinity of the SFWF and the SFEC (**Figure 1**).

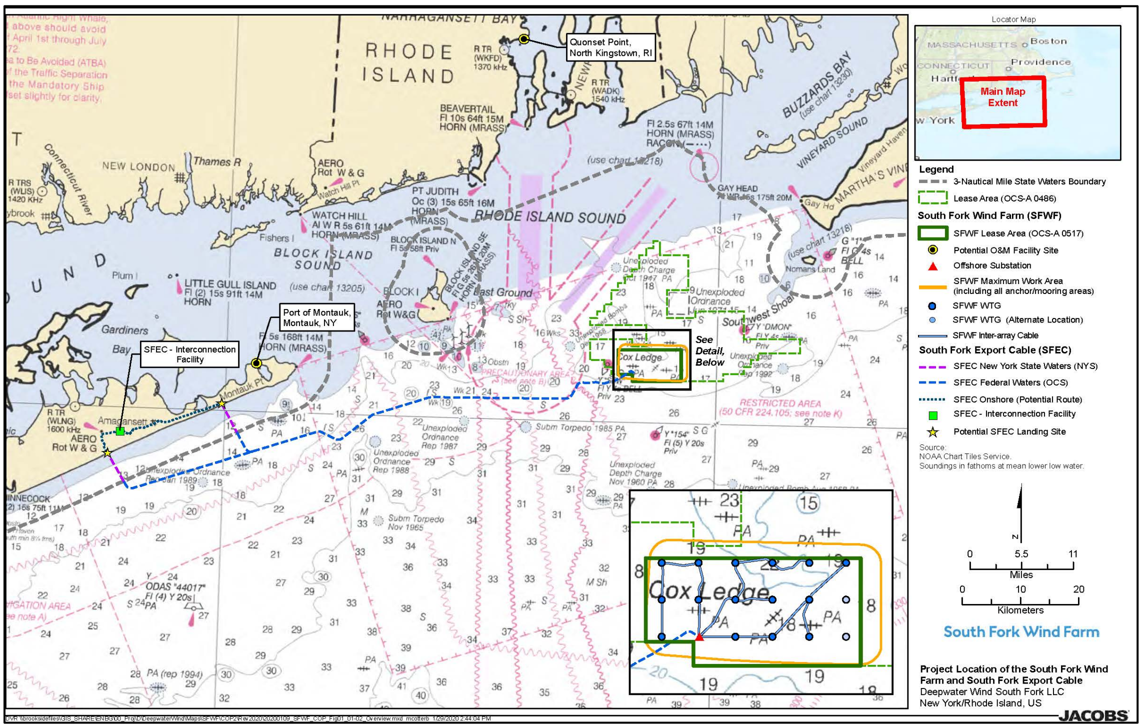


Figure 1. Map of Project Area.

4 HRG Survey Monitoring and Mitigation

HRG survey activities may be required during construction and O&M phases of the Project. During such surveys, activities would include, but are not limited to the following:

- Depth sounding (multibeam depth sounders) to determine water depths and general bottom topography (currently estimated to range from approximately 1 to 55 m, in depth below mean lower low water);
- Magnetic intensity measurements for detecting local variations in regional magnetic field from geological strata and potential ferrous objects on and below the seabed;
- Seafloor imaging (side-scan sonar surveys) for seabed sediment classification purposes to identify natural and man-made acoustic targets resting on the bottom as well as any anomalous features;
- Sub-bottom profiler surveys to map the near surface stratigraphy; and
- Ultra-High Resolution Seismic (UHRS) equipment to map deeper sub-surface stratigraphy as needed.

HRG survey operations will be conducted over 24-hour periods. To provide survey flexibility, specific locations and vessel numbers to be utilized for such surveys will be determined at the time of contractor selection.

The mitigation procedures outlined in this section have evolved from protocols and procedures that have been previously implemented for similar offshore wind projects HRG surveys within the Lease Area and approved by NMFS. Unless otherwise specified, the following mitigation measures apply to HRG survey activities for this Project.

NOTE: The mitigation and monitoring for HRG surveys apply only to sound sources with operating frequencies below 200 kHz. There are no mitigation or monitoring protocols required for sources operating >200 kHz.

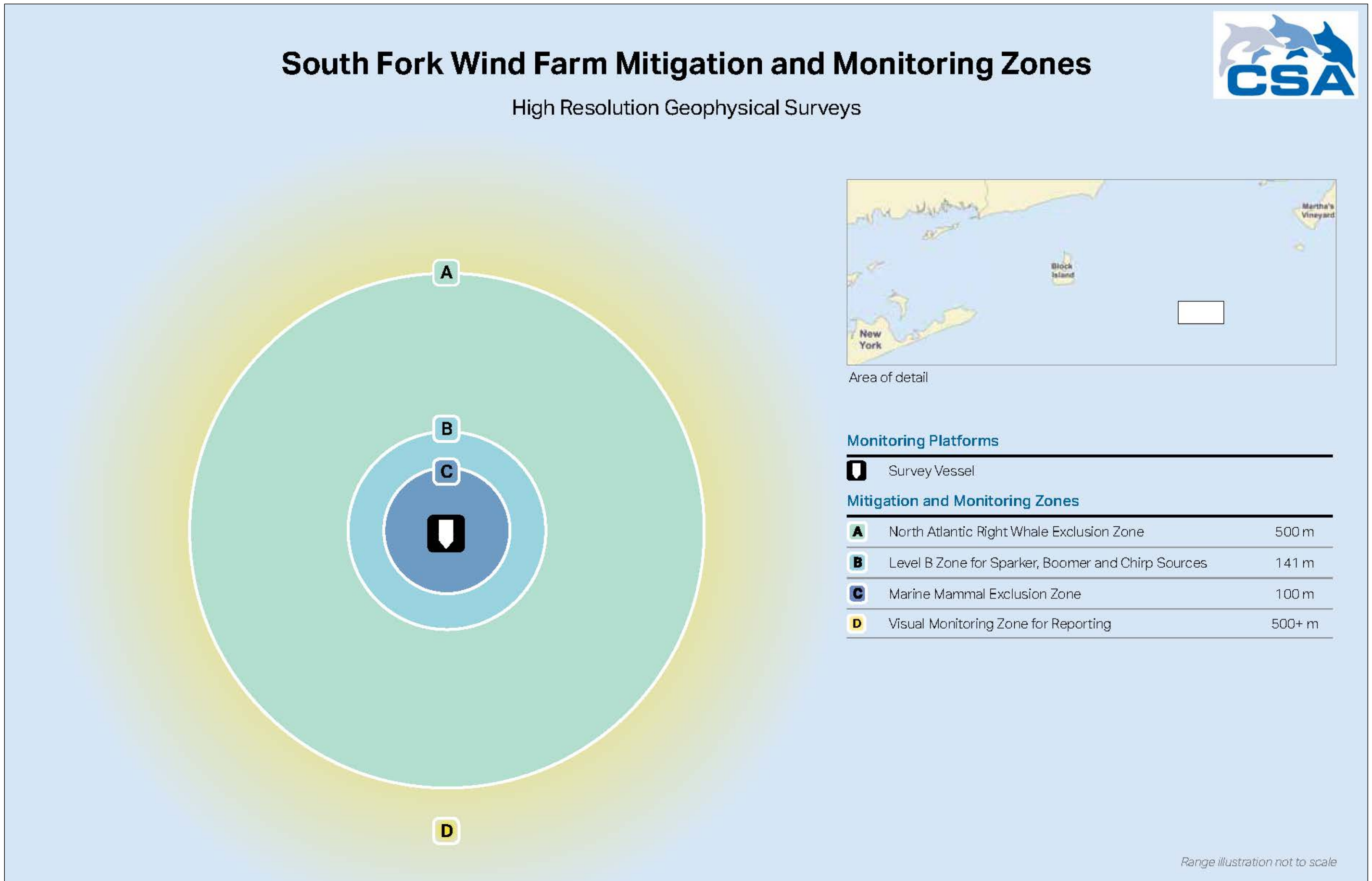
4.1 Monitoring and Mitigation Zones

The monitoring and mitigation zones established in IHAs, lease conditions, and best practices are provided in **Table 2** and displayed in **Figure 2**.

Table 2. Standard monitoring and mitigation zones established for HRG survey activities.

Species	Level A Zone (SEL_{cum})	Level A Zone (SPL_{pk})	Maximum extent of Zone in meters (m) from all potential HRG sound sources					Vessel Separation Distance
			Level B Zones		Monitoring Zone[a]	Pre-Start Clearance Zone	Exclusion Zone	
			Innomar	All Other Equipment				
Low-frequency Cetaceans								
Fin whale*	<1	<1	50	141	500	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	500	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	36.5	4.7	50	141	500	100	100	50
Phocid Pinnipeds in Water								
Gray seal	<1	<1	50	141	500	100	-	50
Harbor seal	<1	<1	50	141		100	-	50

* = denotes species listed under the Endangered Species Act; SEL_{cum} = cumulative sound exposure level in units of decibels referenced to 1 micropascal squared second; SPL_{pk} = peak sound pressure level in units of decibels referenced to 1 micropascal.
- = No exclusion zone mitigation measures will be applied.
[a] 500 m is the minimal monitoring zone applicable. Monitoring zone extends to maximum visible distance.
[b] Dolphin and pinniped species have a required 100-m exclusion zone; however, shut down requirements are waived for these species.



Mitigation Activities

	Standard Daytime Visual			Nighttime and Low Visibility	
	PSOs on watch	Reticle binoculars	Mysticetus data collection software system	Mounted thermal / IR camera system	Hand-held or wearable night vision devices
# On Construction Vessel	2	2	1	1	2

Figure 2. Marine mammal mitigation and monitoring zones for high-resolution geophysical surveys.

Note to Figure: The 100-m marine mammal exclusion zone is also the clearance zone for all species except North Atlantic right whales (NARW) and is an exclusion zone (shutdown zone) for only large whales except the NARW which has a 500-m exclusion zone.

4.2 Project Monitoring and Mitigation Protocols

HRG surveys using sound sources with operating frequencies below 200 kHz are subject to the mitigation and monitoring protocols described in the following subsections.

There will be four to six visual PSOs on all 24-hr survey vessels, and two to three visual PSOs on all 12-hour survey vessels[6]. **Table 3** provides the list of the personnel on watch and monitoring equipment available onboard each HRG survey vessel.

Table 3. Personnel and equipment compliment for monitoring vessels during HRG surveys.

Item	# on Survey Vessel
PSOs on watch	1
Reticle binoculars	2
Mounted thermal/IR camera system	1
Hand-held or wearable NVD	2
IR spotlights	2
Mysticetus data collection software system	1
PSO-dedicated VHF radios	2
Digital single-lens reflex camera equipped with 300-mm lens	1

IR = infrared; NVD = night vision devices; PSO = protected species observer; VHF = very high frequency.

4.2.1 Visual Observation Protocols and Methods

The following visual observation protocols will be implemented by all PSOs employed on Project vessels:

- Visual monitoring of the established EZs and monitoring zone will be performed by PSO teams on each survey vessel.
- Observations will take place from the highest available vantage point on all the survey vessels. General 360° scanning will occur during the monitoring periods, and target scanning by the PSO will occur if cued to a marine mammal. PSOs will adjust their positions appropriately to ensure adequate coverage of the entire exclusion and monitoring zones around the respective sound sources.
- PSOs will work in shifts such that no one PSO will work more than 4 consecutive hours without a 2-hour break or longer than 12 hours during any 24-hour period.
- The PSOs will begin observation of the EZs prior to initiation of HRG survey operations and will continue throughout the survey activity and/or while equipment operating below 200 kHz are in use.

[6]A 24-hour vessel is considered any vessel expected to conduct operations after daylight hours; a 12-hour vessel is considered a vessel that conducts operations during daylight hours only.

- The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities.

- It will be the responsibility of the Lead PSO on duty to communicate the presence of marine mammals as well as to communicate and enforce the action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.

4.2.1.1 Daytime Visual

The following protocols will be applied to visual monitoring during daytime surveys:

- One PSO on watch during pre-clearance periods and all source operations.

- PSOs will use reticle binoculars and naked eye to scan the monitoring zone for marine mammals.

4.2.1.2 Nighttime and Low Visibility Visual Observations

Visual monitoring during nighttime surveys or periods of low visibility will utilize the following protocols:

- The lead PSO will determine if conditions warrant implementing reduced visibility protocols.

- Two PSOs on watch during pre-clearance periods and all operations.

- Each PSO should use the most appropriate available technology (e.g., IR camera and NVD) and viewing locations to monitor the EZs and maintain vessel separation distances.

4.2.1.3 ASV Operations

Should an ASV be utilized during surveys, the following procedures will be implemented:

- PSOs will be stationed aboard the mother vessel to monitor the ASV in a location which will offer a clear, unobstructed view of the ASV's exclusion and monitoring zones.

- When in use, the ASV will be within 800 m of the primary vessel while conducting survey operations.

- For monitoring around an ASV, if utilized, a dual thermal/high definition (HD) camera will be installed on the mother vessel facing forward and angled in a direction so as to provide a field of view ahead of the vessel and around the ASV.

- PSOs will be able to monitor the real-time output of the camera on hand-held iPads. Images from the cameras can be captured for review and to assist it verifying species identification.

- A monitor will also be installed on the bridge displaying the real-time picture from the thermal/HD camera installed on the front of the ASV itself, providing an additional forward field of view of the craft.

- Night-vision goggles with thermal clip-ons, as mentioned above, and a hand-held spotlight will be provided such that PSOs can focus observations in any direction around the mother vessel and/or the ASV.

4.2.2 Pre-Start Clearance

- PSOs will implement a 30-minute clearance period of the EZs prior to the initiation of equipment ramp-up (**Section 4.2.3**).

- The EZ's must be visible using the naked eye or appropriate visual technology during the entire clearance period for operations to start. If the EZs are not visible, source operations <200 kHz may not commence.

- Ramp-up may not be initiated if any marine mammal(s) is detected within its respective EZ.

- If a marine mammal is observed within its respective EZ during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting its respective EZ or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).

4.2.3 Ramp-up

- Where technically feasible, a ramp-up procedure will be used for HRG survey equipment capable of adjusting energy levels at the start or re-start of HRG survey activities. Ramp-up procedures provide additional protection to marine mammals near the Project Area by allowing them to vacate the area prior to the commencement of survey equipment use.

- The ramp-up procedure will not be initiated during periods of inclement conditions or if the EZs cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 30-minute period.

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

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

4.2.4 Operations Monitoring

- PSOs will monitor Mysticetus and/or appropriate data systems for DMAs established within their survey area.

- PSOs will also monitor the NMFS NARW reporting systems including WhaleAlert and SAS once every 4-hour shift during Project-related activities within, or adjacent to, SMAs and/or DMAs.

4.2.5 Shutdown Protocols

- An immediate shutdown of the HRG survey equipment operating at frequencies <200 kHz will be required if a marine mammal is sighted at or within its respective EZ.

- 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 EZ within 30 minutes of the shutdown or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).

4.2.6 Pauses And Silent Periods

- If the acoustic source is shutdown 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 EZs.

- If the acoustic source is shutdown for a period longer than 30 minutes or PSOs were unable to maintain constant observation, then ramp-up procedures will be initiated as described in **Section 4.2.3**.

4.2.7 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

4.2.7.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

4.2.8 Data Recording

- All data recording will be conducted using Mysticetus or similar software.

- Operations, monitoring conditions, observation effort, all marine mammal detections, and any mitigation actions.

- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area as previously described.

4.3 Reporting

- The Project will follow reporting measures as stipulated in **Section 2.7**.

4.3.1 DMAs

- DMAs will be reported across all vessels.

4.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as stipulated in **Section 2.7**.

5 Construction – Impact Pile Driving Monitoring and Mitigation

Up to 15 wind turbine generators (WTG) and one offshore substation (OSS) will be installed on either monopile or jacket foundations using impact pile driving. Impact pile driving will take up to 4 hours to install each monopile foundation and 16 hours for each jacket foundation. After completion of the pile-driving activities for each foundation, the installation vessel will move to the next position and a secondary vessel will complete installation (i.e., attachment of external and internal platforms, commissioning, etc.).

5.1 Monitoring and Mitigation Zones

The Level A exposure ranges and Level B acoustic ranges along with the mitigation zones are provided in **Table 4** and displayed in **Figure 3**. These zones and ranges are based on the modeled piling scenario with inclusion of a difficult pile and with an NMS that assumes 10 dB broadband noise attenuation. Monitoring zones implemented during the project may be modified, with NMFS approval, based on measurements of the received sound levels during piling operations. The sound field measurement plan is described in detail in **Attachment 4**.

Table 4. Table of mitigation and monitoring zones[1] during impact pile driving with a noise mitigation system.

Species	Level A Zone (m) (SEL_{cum})[3]	Level A Zone (m) (SPL_{pk})	Monitoring and mitigation zones in meters (m)[2]				Vessel Separation Distance (m)
			Level B Zone	Monitoring Zone (situational awareness zone)	Pre-start Clearance Zone[4]	Exclusion Zone[5]	
Low-frequency Cetaceans							
Fin whale*	1,769	≤10	4,684	>4,684	2,200	2,000	100
Minke whale	1,571	≤10	4,684	>4,684	2,200	2,000	100
Sei whale*	1,756	≤10	4,684	>4,684	2,200	2,000	100
Humpback whale	3,642	≤10	4,684	>4,684	2,200	2,000	100
North Atlantic right whale*	1,621	≤10	4,684	>4,684	4,684	2,000	500
Blue whale*[6]	1,769	≤10	4,684	>4,684	2,200	2,000	100
Mid-frequency Cetaceans							
Sperm whale*	-	≤10	4,684	>4,684	2,200	2,000	100
Atlantic spotted dolphin	-	≤10	4,684	>4,684	100	50	50
Atlantic white-sided dolphin	-	≤10	4,684	>4,684	100	50	50
Common dolphin	-	≤10	4,684	>4,684	100	50	50
Risso's dolphin	-	≤10	4,684	>4,684	100	50	50
Bottlenose dolphin	-	≤10	4,684	>4,684	100	50	50
Long-finned pilot whale	-	≤10	4,684	>4,684	100	50	50
High-frequency Cetaceans							
Harbor porpoise	365	301	4,684	>4,684	450	450	50
Phocid Pinnipeds in Water							
Gray seal	117	≤10	4,684	>4,684	150	150	50
Harbor seal	85	≤10	4,684	>4,684	150	150	50

* = denotes species listed under the Endangered Species Act; dB = decibel; SEL_{cum} = cumulative sound exposure level SPL_{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 with10 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.

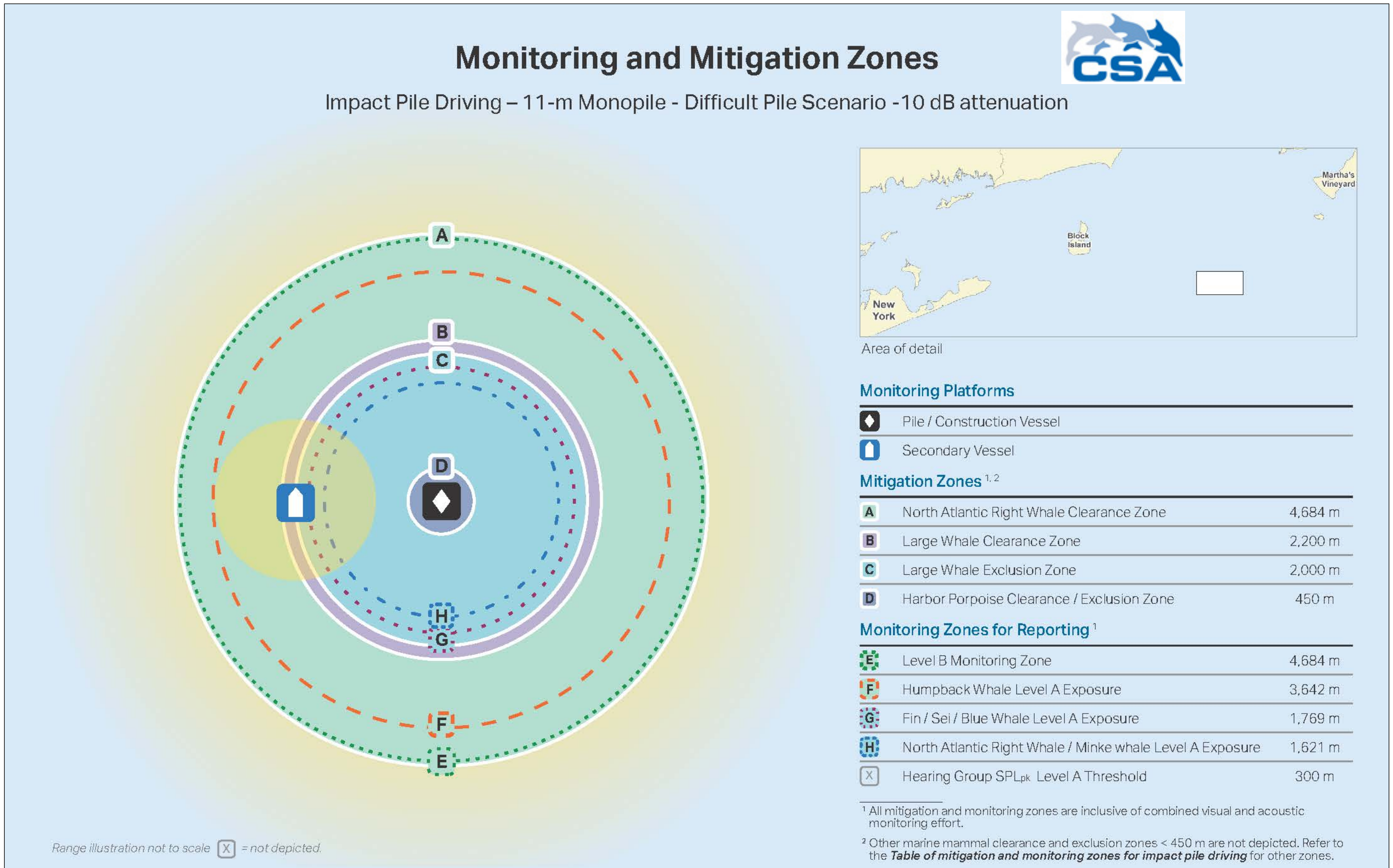
[2] Zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation.

[3] The Level A zone represents the exposure ranges of species derived from animal movement modeling.

[4] The pre-start clearance zone for large whales, porpoise, and seals is based upon the maximum non-humpback whale Level A zone plus 20% buffer and rounded up for PSO clarity. The North Atlantic right whale zone was set equal to the Level B zone to avoid any unnecessary take; Mid-frequency cetacean zones were set using precautionary distances and will extend to the distances listed or just beyond the noise mitigation system, whichever is further.

[5] The exclusion zone for large whales (including North Atlantic right whale), porpoise, and seals is based upon the maximum Level A zone plus 10% buffer and rounded up for PSO clarity. Mid-frequency cetacean zones were set using precautionary distances and will extend to the distances listed or just beyond the noise mitigation system, whichever is further.

[6]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.



Mitigation Activities

	DAYTIME MONITORING							NIGHTTIME MONITORING					
	PERSONNEL		EQUIPMENT					PERSONNEL		EQUIPMENT			
	PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted "big eye" binoculars	Mounted Thermal Camera System	Monitoring station for real time PAM	Mysticetus data software	PSOs on hand-held NVD/IR	PAM operators on duty	Handheld NVD / IR	Mounted Thermal Camera System	Monitoring station for real time PAM	Mysticetus data software
# on Construction Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1
# on Secondary Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1

Figure 3. Marine mammal mitigation and monitoring zones during impact pile driving with a noise mitigation system.

5.2 Project Monitoring and Mitigation Protocols

There are four primary mitigation and monitoring efforts associated with impact pile driving:

1) Vessel-based visual PSOs and associated visual monitoring tools stationed on the construction vessel and on any secondary marine mammal monitoring vessels;

2) PAM operators and an associated mitigation PAM array in support of the visual PSOs;

3) Noise attenuation systems; and

4) Acoustic measurement data collection to verify distances to regulatory or mitigation zones.

Monitoring and mitigation protocols applicable to impact pile driving activities during SFWF construction are described further in the following subsections. Impact pile driving may be initiated after dark or during reduced visibility periods following the protocols in **Sections 5.2.1** through **5.2.4** and include utilization of alternative monitoring methods.

There will be a team of six to eight visual and acoustic PSOs on the pile driving vessel, and a team of four to eight visual and acoustic PSOs on any secondary marine mammal monitoring vessel (secondary vessel). PAM operators may be located remotely/onshore. **Table 5** provides the list of the personnel on watch and the PSO and PAM monitoring equipment available onboard the construction vessel and the secondary vessel.

Table 5. Personnel and equipment use for all marine mammal monitoring vessels during pre-start clearance, impact pile driving, and post piling monitoring.

Item	Standard Daytime		Monitoring for Nighttime and Low Visibility	
	# on Construction Vessel	# on Secondary Vessel	# on Construction Vessel	# on Secondary Vessel
Visual PSOs on watch	2	2	2	2
PAM operators on duty[1]	1	1	1	1
Reticle binoculars	2	2	0	0
Mounted thermal/IR camera system[2]	1	1	1	1
Mounted "big-eye" binocular	1	1	0	0
Monitoring station for real time PAM system[3]	1	1	1	1
Hand-held or wearable NVDs	0	0	2	2

Table 5. (Continued)

Item	Standard Daytime		Monitoring for Nighttime and Low Visibility	
	# on Construction Vessel	# on Secondary Vessel	# on Construction Vessel	# on Secondary Vessel
IR spotlights	0	0	2	2
Mysticetus data collection software system	1	1	1	1
PSO-dedicated VHF radios	2	2	2	2
Digital single-lens reflex camera equipped with 300-mm lens	1	1	0	0

IR = infrared; NVD = night vision device; PSO = protected species observer; VHF=very high frequency.
[1]PAM operator may be stationed on the vessel or at an alternative monitoring location.
[2] The camera systems will be automated with detection alerts that will be checked by a PSO on duty; however, cameras will not be manned by a dedicated observer.
[3]The selected PAM system will transmit real time data to PAM monitoring stations on the vessels and/or a shore side monitoring station.

5.2.1 Daytime Visual Monitoring

Visual monitoring will occur from the construction vessel and a secondary vessel. Daytime visual monitoring is defined by the period between nautical twilight rise and set for the region. The intent of the visual monitoring program is to provide complete visual coverage of the EZs during impact pile driving using the following protocols:

- During the pre-start clearance period, throughout pile driving, and 30-minutes after piling is completed, two PSOs will maintain watch at all times on the construction vessel; likewise, two PSOs will also maintain watch during the same time periods from the secondary vessel.

- The total number of observers will be dictated by the personnel necessary to adhere to standard shift schedule and rest requirements while still meeting mitigation monitoring requirements for the Project. A sample crew rotation is provided in **Attachment 1**.

- It is expected the full complement of PSOs will not always be required (i.e., full coverage will be in place during piling activities, however, in between piling events, the PSO team can consist of only one PSO on duty). Piling is anticipated to take a maximum of 4 hours per piling event (i.e., 4 hours at a given foundation location) after which the construction vessel moves away to a new location for the next piling event. PSOs will monitor for 30 minutes before and after each piling event.

- During daytime observations, two PSOs on each vessel will monitor the EZ with the naked eye and reticle binoculars. One PSO will periodically scan outside the EZ using the mounted big eye binoculars.

- Visual monitoring zones are as follows:
  - PSOs will visually monitor, the maximum (non-humpback) Level A zone plus an additional 20% buffer (**Table 3**) which constitutes the pre-start clearance zone. This zone encompasses the maximum Level A exposure ranges for all marine mammal species except the humpback whale.
  - PSOs will visually monitor the harbor porpoise, pinniped, and dolphin EZs. (**Table 3**)
  - The secondary vessel will be positioned and circling at the outer limit of the Large Whale EZ (**Figure 3**).
  - PSOs stationed on the secondary vessel will ensure the outer portion of the EZs and pre-start clearance zone are visually monitored.
  - There will be a PAM operator on duty (see **Section 5.2.4**) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods, piling, and post-piling monitoring periods. Acoustic monitoring, as described in **Section 5.2.4,** will include extend beyond the Large Whale Pre-Start Clearance Zone.

5.2.2 Daytime Periods of Reduced Visibility

- If the monitoring zone is obscured, the two PSOs on watch on each vessel will continue to monitor the EZ utilizing thermal camera systems and handheld night vision devices as able.

- There will be a PAM operator on duty (see **Section 5.2.4**) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods, piling, and post-piling monitoring periods.

- All on-duty PSOs will be in contact with the PAM operator on-duty who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.

5.2.3 Nighttime Visual: Construction and Secondary Vessel

- During nighttime operations, visual PSOs on-watch will rotate in pairs: one observing with an NVD and one monitoring the IR thermal imaging camera system.

- The mounted thermal cameras may have automated detection systems or require manual monitoring by a PSO.

- PSOs will focus their observation effort during nighttime watch periods within the EZs and waters immediately adjacent to the vessel.

- If possible, deck lights will be extinguished or dimmed during night observations when using the NVDs (strong lights compromise the NVD detection abilities); alternatively, if the deck lights must remain on for safety reasons, the PSO will attempt to use the NVDs in areas away from potential interference by these lights.

- There will be a PAM operator on duty (see **Section 5.2.4**) conducting acoustic monitoring in coordination with the visual PSOs. All on-duty PSOs will be in contact with the PAM operator on-duty who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.

5.2.4 Passive Acoustic Monitoring

Visual monitoring will be supplemented by PAM during all pre-start clearance, piling operations and post monitoring periods. A PAM Operator will be on duty and will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area. A combination of alternative monitoring measures, including PAM has been demonstrated to have comparable detection rates to daytime visual detections for several species (Smith et al., 2020).

PAM devices proposed for monitoring during Project impact pile driving activities are not likely to be towed from the vessel, but rather will be independent (e.g., autonomous or moored remote) stations located around the area to be monitored. The specific placement of PAM devices or systems will be determined based on the final mitigation zones determined in the regulatory review process. As detailed in **Attachment 2** there are multiple available PAM systems with demonstrated capability for monitoring and localizing marine mammal calls, including large whales, within the proposed monitoring and mitigation zones (e.g. sonobuoy arrays or similar retrievable buoy systems).

PAM will be used to monitor the following zones during piling:

- PSOs will acoustically monitor a zone that encompasses the Level B zone for all marine mammals, which also encompasses the Level A zones for all marine mammal species (**Table 3**).

In general, the following monitoring protocols related to PAM will be followed for this Project:

- It is expected there will be a PAM operator stationed on at least one of the dedicated monitoring vessels in addition to the PSOs; or located remotely/onshore.

- PAM operators must complete specialized training for operating PAM systems prior to the start of monitoring activities.

- All on-duty PSOs will be in contact with the PAM operator on-duty. who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.

- For real-time PAM systems, at least one PAM operator will be designated to monitor each system by viewing data or data products that are streamed in real-time or near real-time to a computer workstation and monitor located on a Project vessel or onshore.

- The PAM operator will inform the Lead PSO on duty of animal detections approaching or within applicable ranges of interest to the pile-driving activity via the data collection software system (i.e., Mystcetus) who will be responsible for requesting that the designated crewmember implement the necessary mitigation procedures.

- Acoustic monitoring will complement visual monitoring (e.g., visual PSOs and thermal cameras) and will cover an area of at least the EZ around each foundation.

- PAM monitoring will follow a similar shift schedule as PSO monitoring unless otherwise requested and approved.

5.2.5 Mitigation Measures During Impact Pile Driving

Mitigation measures implemented during a piling event include pre-start clearance by the PSOs, ramp up or soft start of the pile strikes, post-piling monitoring, shutdowns, and delays in soft start. The parameters of these mitigation measures are summarized in **Table 6** and detailed in the subsequent sections.

- Mitigation zones established for all species including the NARW will be applied during all months of the year.

Table 6. Summary of mitigation measures during impact pile driving with a noise mitigation system.

	Piling with an NMS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance Zone[1]	4,684 m	2,200 m	100 m	450 m	150 m
Clearance Duration	60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min				
Soft Start	All Piles				
Post-piling monitoring	30 min				
Exclusion (Shutdown) Zone[2]	2,000 m	2,000 m	50 m	450 m	150 m

m=meters; min=minutes; NARW=North Atlantic right whale; NMS=Noise Mitigation System
[1] Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods.
[2] Shutdowns may be initiated by either visual or acoustic detection. Only acoustic detections that meet criteria (e.g. localization) for determining that the call originated inside the given zone will be considered for mitigation.

5.2.5.1 Pre-Start Clearance

There is a 60-minute pre-start clearance period that will be implemented for impact pile driving activities. Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods. Visual PSOs will begin surveying the monitoring zone at least 60 minutes prior to the start of pile driving. PAM monitoring will also begin at least 60-minutes prior to the start of piling.

- The large whale EZ must be fully visible for at least 30 minutes prior to commencing ramp-up. (**Table 6**).
- All marine mammals must be confirmed to be out of the clearance zone prior to initiating ramp up.
- If a marine mammal is observed entering or within the relevant clearance zones prior to the initiation of pile driving activity, pile driving activity must be delayed.
- Impact pile driving may commence when either the marine mammal(s) has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, when 30 minutes have elapsed without redetection for mysticetes, sperm whales, Risso's dolphins, and pilot whales; or 15 minutes have elapsed without re-detection of all other marine mammals.

5.2.5.2 Ramp up (Soft Start)

Every monopile installation will begin with a soft start procedure of a minimum of 20-minute duration. The soft start procedure is detailed in **Table 7**.

- Soft start of pile driving will not begin until the Clearance Zone has been cleared by the visual PSO or PAM operators when applicable.
- If any marine mammals are detected within the applicable EZ prior to or during the soft start, activities will be delayed until the animal has been observed exiting the EZ or until an additional time period has elapsed with no further sighting.

Table 7. Generic soft start procedure overview.

% of max hammer blow energy	Soft Start
	10–20%
Monopile blow energy	600–800 kJ
Strike Rate	4–6 strikes/min
Duration	Minimum of 20 minutes or greater until pile verticality/self-stability is secured.

kJ=kilojoule.

5.2.5.3 Post Operations Monitoring

- PSOs will continue to survey the monitoring zone using visual and acoustic protocols throughout the pile installation and for a minimum of 30 minutes after piling has been completed.

5.2.5.4 Shutdown Protocols

For reference, a generic piling procedure has been broken down into five different steps where blows, strike ratio and duration envelopes are defined. The Piling Procedure is summarized in **Table 8** and follows these general criteria:

1) The hammer reaches the max. blows/min rate possible before moving to the next energy level.

2) The piling schedule (and therefore resulting sound field) does not exceed the maximum scenario modelled for regulatory authorizations.
3) Refusal criteria is not exceeded
   (i) 125cl/25 centimeters (cm) over an increment of 6 × 25 cm
   (ii) 200bl/25 cm over an increment of 2 × 25 cm
   (iii) 325bl/25 cm over an increment of 1 × 25 cm.
4) The hammer drives the pile to target penetration.

Table 8. Generic piling procedure and expected net duration (4,000 kJ hammer).

% of Max Hammer Blow Energy	Piling Schedule				
	20%	40%	60%	80%	100%
Monopile blow energy	800 kJ	1,600 kJ	2,400 kJ	3,200 kJ	4,000 kJ
Blow count	500–1,600	600–1,800	1.000–1,800	1,000–1.800	1,000
Strike Rate	10–60 bl/min	20–50 bl/min	30–40 bl/min	35 bl/min	30–32 bl/min
Duration	15–45 min	15–45 min	15–45 min	15–45 min	15–45 min

bl=blow (i.e, strike); kJ=kilojoule.

- If a marine mammal is visually or acoustically detected entering or within the respective EZs after pile driving has commenced, an immediate shutdown of pile driving will be implemented unless SFW and/or its contractor determines shutdown is not feasible 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 (*See Deferred Shutdown Scenarios*).
  (i) If shutdown is called for but SFW and/or its contractor determines shutdown is not feasible due to risk of injury or loss of life, reduced hammer energy must be implemented.
  (ii) After a shutdown, pile driving must only be initiated once all EZs are confirmed by PSOs to be clear of marine mammals for the minimum species-specific time periods.

- **Deferred Shutdown Scenarios:** Scenarios that would prevent shutdown of piling operations typically have a low likelihood of occurrence based on Orsted's extensive pile driving experience and low occurrence of these situations.

  - **Scenario 1**: **Pile Refusal**: The pile driving sensors indicate the pile is approaching refusal, and a shutdown would lead to a stuck pile which then poses an imminent risk of injury or loss of life to an individual, or risk of damage to a vessel that creates risk for individuals.

    - **Risk Likelihood/Mitigation**: Each pile is specifically engineered to manage the sediment conditions at the location at which it is to be driven, and therefore designed to avoid and minimize the potential for piling refusal. Orsted uses these pre-installation engineering assessments and design together with real-time hammer log information during installation to track progress and continuously judge whether a stoppage would cause a risk of injury or loss of life. ***Due to this advanced engineering and planning, circumstances under which piling could not stop if a shutdown is requested are very limited.***

- **Scenario 2: Pile Instability**: For a specified project and installation vessel, weather conditions criteria will be established that determine when a piling vessel would have to "let go" of a pile being installed for safety reasons. A pile may be deemed unstable and unable to stay standing if the piling vessel were to "let go". During these periods of instability, the lead engineer may determine a shutdown is not feasible because the shutdown combined with impending weather conditions may require the piling vessel to "let go" which then poses an imminent risk of injury or loss of life to an individual, or risk of damage to a vessel that creates risk for individuals.

  - **Risk Likelihood/Mitigation**: To reduce the risk that a requested shutdown would not be possible due to weather, Orsted actively assesses weather, using two independent forecasting systems. Initiation of piling also requires a *Certificate of Approval* by the Marine Warranty Supervisor. In addition to ensuring that current weather conditions are suitable for piling, this *Certificate of Approval* process considers forecasted weather for 6 hours out and will evaluate if conditions would limit the ability to shut down and "let go" of the pile. If a shutdown is not feasible due to pile instability and weather, piling would continue only until a penetration depth sufficient to secure the pile is achieved. ***As piling instability is most likely to occur during the soft start period, and soft start cannot commence till the Marine Warranty Supervisor has issued a Certificate of Approval that signals there is a current weather window of at least 6 hours, the likelihood is low for the pile to not achieve stability within the 6 hour window inclusive of stops and starts.***

5.2.5.5 Pauses and Silent Periods

- The EZ must be continuously monitored by PSOs and PAM during any pauses in pile driving.

- If marine mammals are sighted within the EZ during a pause in piling, activities will be delayed until the animal(s) has moved outside the EZ and no marine mammals are sighted for a period of 30 minutes.

5.2.6 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

5.2.6.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

5.2.7 Data Recording

- All data recording will be conducted using Mysticetus software.

- Operations, monitoring conditions, observation effort, all marine mammal detections, and any mitigation actions will be recorded.

- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area.

5.3 Reporting

- The SFW will follow reporting measures as stipulated in **Section 2.7**.

5.3.1 DMAs

- DMAs will be reported across all Project vessels.

5.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as stipulated in **Section 2.7**.

5.4 Noise Attenuation

- The Project will use an NMS for all piling events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation (See **IHA Section 1.2.1**).

5.5 Sound Measurements

Received sound measurements will be collected during driving of at least 1 pile using an NMS. The measurement plan is provided in **Attachment 4**.

- The goals of the of field verification measurements using an NMS include: verification of selected acoustic ranges (e.g., Level B range); and providing sound measurements of impact pile driving using International Organization for Standardization (ISO)-standard methodology to build data that are comparable among projects.

- Potential modification of Clearance and EZs:
    - Based on the sound field measurement results the Project may request a modification of the clearance and/or EZs.

6 Construction – Vibratory Pile Driving Monitoring and Mitigation

The sea-to-shore transition will include a new onshore transition vault, cable installed using horizontal directional drilling under the beach and intertidal water, and may also include a temporary cofferdam located offshore beyond the intertidal zone. If Project conditions require a cofferdam, it will be installed using either sheet pile installed via vibratory pile driving or gravity cell.

6.1 Monitoring and Mitigation Zones

Table 9 provides the ranges to all thresholds and monitoring zones applied during vibratory pile driving for cofferdam installation; no noise attenuation is proposed due to the short time period of the activities. Animal movement modeling resulted in no Level A exposures for any species and no Level A exposures are expected from vibratory pile driving; however acoustic ranges were modeled for reference. The Level A ranges are acoustic ranges and therefore represent the maximum distance at which a stationary receiver (i.e., animal) could exceed SEL_{cum} thresholds over a 24-hour period. Exposure ranges (which were not modeled for vibratory pile driving) are expected to be small enough such that no Level A exposures are anticipated. However, a precautionary approach is being applied with a pre-start clearance zone and an EZ for all large whales that equals the 24-hour acoustic ranges.

Table 9. Threshold ranges, mitigation, and monitoring zones in meters for marine mammal species during Project vibratory pile driving activities.

Species	Level A Acoustic Range Extent (SEL_{cum})	Monitoring and Mitigation Zones in meters (m)				Vessel Separation Distance (m)
		Level B Zone (SPL_{rms})	Monitoring Zone (situational awareness zone)	Pre-start Clearance Zone	Exclusion Zone	
Low-Frequency Cetaceans						
Fin whale*	1,470	36,766	1,500	1,500	1,500	100
Minke whale	1,470	36,766	1,500	1,500	1,500	100
Sei whale*	1,470	36,766	1,500	1,500	1,500	100
Humpback whale	1,470	36,766	1,500	1,500	1,500	100
N.A. right whale*	1,470	36,766	1,500	1,500	1,500	500
Blue whale*	1,470	36,766	1,500	1,500	1,500	100
Mid-Frequency Cetaceans						
Sperm whale*	0	36,766	1,500	1,500	1,500	100
Atlantic spotted dolphin	0	36,766	1,500	100	50	50
Atlantic white-sided dolphin	0	36,766	1,500	100	50	50
Common dolphin	0	36,766	1,500	100	50	50
Risso's dolphin	0	36,766	1,500	100	50	50
Bottlenose dolphin	0	36,766	1,500	100	50	50

Table 9. (Continued).

Species	Level A Acoustic Range Extent (SEL_{cum})	Monitoring and Mitigation Zones in meters (m)				Vessel Separation Distance (m)
		Level B Zone (SPL_{rms})	Monitoring Zone (situational awareness zone)	Pre-start Clearance Zone	Exclusion Zone	
Long-finned pilot whale	0	36,766	1,500	100	50	50
High-Frequency Cetaceans						
Harbor porpoise	63	36,766	1,500	100	100	50
hocid Pinnipeds in Water						
Gray seal	103	36,766	1,500	100	100	50
Harbor seal	103	36,766	1,500	100	100	50

* = denotes species listed under the Endangered Species Act; SEL_{cum} = cumulative sound exposure level in units of decibels referenced to 1 micropascal squared second; SPL_{rms} = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.

6.2 Project Monitoring and Mitigation Protocols

Visual monitoring protocols will be in place for all vibratory piling activities. All observations will take place from one of the construction vessels stationed at or near the vibratory piling location. No PAM operations will be utilized due to the likelihood of masking effects of the vibratory pile driving activities which will result in ineffective acoustic monitoring opportunities. **Table 10** provides the list of the personnel on watch and monitoring equipment available onboard the construction vessel.

Table 10. Personnel and equipment compliment for monitoring vessels during impact pile driving.

Item	# on Construction Vessel
PSOs on watch	2
Reticle binoculars	2
Mounted thermal/IR camera system	1
Mounted "big-eye" binocular	1
Hand-held or wearable NVDs	2
IR spotlights	2
Mysticetus data collection software system	1
PSO-dedicated VHF radios	2
Digital single-lens reflex camera equipped with 300-mm lens	1

IR = infrared; NVD = night vision device; PSO = protected species observer; VHF = very high frequency.

6.2.1 Visual Observation Protocols and Methods

6.2.1.1 Daytime Visual

- Visual monitoring will occur from the construction vessel to provide complete visual coverage of the marine mammal EZs during impact pile driving.

- During the pre-start clearance period (**Section 6.2.2**), throughout vibratory pile driving, and 30-minutes after piling is completed, two PSOs will maintain watch at all times on the construction vessel.

- Two PSOs will conduct observations concurrently. The total number of observers will be dictated by the personnel necessary to adhere to standard schedule and rest requirements while meeting Project mitigation monitoring requirements. A sample crew shift rotation is shown in **Attachment 1**.

- PSOs will visually monitor the EZs.

- During daytime observations one observer will monitor the EZ with the naked eye and reticle binoculars. One PSO will monitor in the same way but will periodically scan outside the EZ using the mounted big eye binoculars.

6.2.1.2 Daytime Visual during Periods of Low Visibility

- During daytime low visibility conditions, one PSO will monitor the EZ with the mounted IR camera while the other maintains visual watch with the naked eye / binoculars.

6.2.1.3 Nighttime Visual

- During nighttime, two PSOs will monitor the EZ with the mounted IR camera and hand-held/wearable NVDs.

6.2.2 Pre-Start Clearance

- PSOs will monitoring the clearance zone for 30 minutes prior to start of vibratory pile driving.

- If a marine mammal is observed entering or within the respective EZs piling cannot commence until the animal has exited the EZ or time has elapsed since the last sighting (30 minutes for large whales, 15 minutes for dolphins, porpoises, and pinnipeds).

6.2.3 Ramp-up

- Ramp-up procedures provide additional mitigation to marine mammals in the Project Area by enabling them to leave the area prior to the start of vibratory pile driving activities.

- Ramp-up procedures will not be initiated if the clearance zone cannot be adequately monitored (i.e., obscured by fog, inclement weather, poor lighting conditions) for a 30-minute period.

6.2.4 Operations Monitoring

- PSOs will continue to survey the EZ using visual protocols throughout the cofferdam installation and for a minimum of 30 minutes after piling has been completed.

6.2.5 Shutdown Protocols

- If a marine mammal is observed entering or within the respective EZs after cofferdam installation has commenced, a shutdown must be implemented.

6.2.6 Pauses and Silent Periods

- The EZ must be continuously monitored by PSOs during any pauses in vibratory pile driving.

- If marine mammals are sighted within the respective EZ during a pause in vibratory pile driving, activities will be delayed until the animal(s) has moved outside the EZ and no marine mammals are sighted for a period of 30 minutes.

6.2.7 Vessel Strike Avoidance

The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

6.2.7.1 Vessel Speed Restrictions

The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 2.9**) and in project-specific Vessel Strike Avoidance Plan provided in **Attachment 5**.

6.2.8 Data Recording

- All data recording will be conducted using Mysticetus software.

- Operations, monitoring conditions, observation effort, all marine mammal detections, and any mitigation actions.

- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area.

6.3 Reporting

The Project will follow reporting measures as stipulated in **Section 2.7**.

6.3.1 DMAs

DMAs will be reported across all vessels.

6.3.2 Injured and Dead Protected Species

The Project will follow reporting measures as stipulated in **Section 2.7**.

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Attachment 1: PSO/PAM operator example team shift schedules

Period a/	Hour	Lead PSO (1)	PSO (2)	PSO (3)	PSO (4)	PAM Lead (1)	PAM (2) /
Daylight	**07:00**	Sleep	Sleep	Visual	IR	PAM	Sleep
	08:00	Sleep	Sleep	IR	Visual	PAM	Sleep
	09:00	Sleep	Sleep	Visual	Off	Sleep	Sleep
	10:00	Visual	Sleep	Off	Sleep	Sleep	Sleep
	11:00	Visual	Sleep	Visual	Sleep	Sleep	Sleep
	12:00	Visual	Sleep	Off	Sleep	Sleep	Sleep
	13:00	Off	Sleep	Visual	Sleep	Sleep	Sleep
	14:00	Off	Sleep	Visual	Sleep	Sleep	Sleep
	15:00	Off	Visual	Off	Sleep	Sleep	Sleep
	16:00	Visual	IR	Sleep	Sleep	Sleep	PAM
Darkness	**17:00**	IR	NVD	Sleep	Sleep	Sleep	PAM
	18:00	NVD	Off	Sleep	IR	Off	PAM
	19:00	Off	IR	Sleep	NVD	PAM	Off
	20:00	IR	NVD	Sleep	Off	PAM	Off
	21:00	NVD	Off	Sleep	IR	PAM	Off
	22:00	Off	NVD	Sleep	Off	PAM	IR
	23:00	Off	IR	Sleep	NVD	Off	PAM
	00:00	Off	NVD	Off	IR	Reporting & PAM Lead Tasks	PAM
	01:00	Reporting & PSO Lead Tasks	Off	IR	NVD	PAM	Off
	02:00	Sleep	IR	NVD	Off	PAM	Off
	03:00	Sleep	Off	Off	NVD	PAM	IR
	04:00	Sleep	Off	NVD	IR	Off	PAM
	05:00	Sleep	NVD	IR	Off	Off	PAM
	06:00	Sleep	IR	Off	Off	NVD	PAM

a/ Periods of daylight and darkness are subject to change based on location and time of year.
b/ The red lines represent a pile-driving event, which is anticipated to include no more than 4 hours of active pile driving per foundation. PSOs/PAMs will be on duty before and after the installation event as appropriate.
c/ PAM rotations in this example are 4-hour periods but actual schedules will likely be reduced to 3-hour shifts.

IR = infrared; NVD = night vision device; PAM = passive acoustic monitoring; PSO = protected species observer.

Attachment 2: Review of PAM systems

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019[1]

Manufacturer/ Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi-Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bit-rate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
WHOI (Baumgartner)	DMON Buoy	AAR,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	3	500 kHz	16 bits	NR	32 GB	up to 18 months	200	NR	NR	Alkaline	>70 ft.
WHOI (Baumgartner)	Robots4whales Waveglider	ASV,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	3	500 kHz	16 bits	NR	32 GB	up to 4 months	1,000	NR	NR	Lithium	Any
Cornell-BRP (Klinck)	Rockhopper (formerly MARU)	AAR	N	custom	Y	UNK	N	NA	380	24-bit	UNK	10.5 TB	6 months (@ 200 Khz sample rate)	3,500	Spherical	UNKN	Lithium	Small Boat (RHIB)
Cornell-BRP (Klinck)	AutoBuoy	AAR, RTB	Y	UNK	UNK	UNK	UNK	NA	UNK	16-bit	UNK	NA	UNK	moored, so limited to shallow water	Large Buoy	UNK	UNK	Large ship
JASCO Applied Sciences	AMARG4	AAR	N	Y: 4	UNK	UNK	Y	4 acoustic, 7 oceanographic sensors	8-512 Khz	24-bit	UNK	10 TB	18 months	6,700	Spherical	43.2 cm3	D-cell	UNK
JASCO Applied Sciences	SPARBuoy	AAR,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	16	512 HHz	24-bit	NR	10 TB	up to 6 months	200	Cylindrical	NR	Alkaline or Lithium?	>70 ft.
JASCO Applied Sciences	3M Observer Buoy	AAR,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	16	512 HHz	24-bit	NR	10 TB	up to 18 months	200	NR	NR	Alkaline or Lithium?	>70 ft.
JASCO Applied Sciences	0.6M Observer Buoy	AAR,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	16	512 HHz	24-bit	NR	10 TB	up to 18 months	200	NR	NR	Alkaline or Lithium?	>70 ft.
JASCO Applied Sciences	Datamaran Observer-Saildrone	USV,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	16	512 HHz	24-bit	NR	6 TB	up to 4 months	1,000	Catamaran	NR	Alkaline or Lithium?	>70 ft.
JASCO Applied Sciences	Waveglider Observer	USV,RTB	Y(near-r-t)	Y(LF,MF,HF)	Can be	NR	Y	16	512 HHz	24-bit	NR	6 TB	up to 4 months	200	Waveglider	NR	Alkaline or Lithium?	>70 ft.
SMRU Consulting	CAB	AAR, RTB	Y	Y	Y	Individual	Y	Up to 3 per CAB Platform	500	UNK	UNK	1 TB	2-3 weeks	45	Cylindrical	110 cm × 56 cm	Lithium	Small Boat
RTSYs	Resea	AAR	N	Y	Y	Individual?	Y	4	3 hz-500 kHz	24-bit	>100 dB	2 TB	UNK	700	Cylindrical	12 cm × 32 cm	alkaline or Li-SOCl2	Small Boat
RTSYs	Multhy	AAR	N	Y	Y	Individual?	Y	16	3 hz-500 kHz	24-bit	>100 dB	2 TB	UNK	700	Cylindrical	55 cm × 12 cm	rechargable battery pack	UNK
RTSYs	Sylence	AAR	N	Y	UNK	UNK	N	1	39 to 1250 kHz	16 or 24-bit	UNK	128 GB	45 days, possibly more	200	Cylindrical	12 cm × 55 cm	18 alkaline or Li-SoCl2 D cell	small boat
Seiche Ltd.	Autonaut PAM	ASV	Y	Y	Y	electro-acoustic (full system)	Y	4 ch	500	16-bit	90	4 TB	months	20 (customizable tow cable length)	Vessel	5 m × 0.8 m	24 V lead-acid	ship / slipway / beach
Seiche Ltd.	Modular buoy system	RTB	Y	Y	Y	electro-acoustic (full system)	Y	4 ch	500	16-bit	90	essentially unlimited as data recorded are at the telemetry receiver station	20 h (lead-acid), 80 h (lithium)	customizable cable length	Buoy		12 V lead-acid or lithium	ship
Seiche Ltd. / ASV Global	ASV PAM	USV (motorized)	Y	Y	Y	electro-acoustic (full system)	Y	4 ch	500	16-bit	UNK	4 TB	several days; limited by fuel capacity of USV	220 (customizable tow cable length)	UNK	models available from 4-12 m LOA	110-240 V invertor	ship / slipway / beach
Greenridge Sciences	ASAR	AAR	N	UNK	UNK	1 omnidirectional, 2 directional	Y	3	1 kHz	16-bit	UNK	60 GB	116 days, continuous recording, no data compression	100	UNK	26" × 26" square base, ~26" high (includes frame)	custom alkaline D-cell battery pack	UNK

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019[1]																		
Manufacturer/ Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi-Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bit-rate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
Greeneridge Sciences	DASAR	AAR	N	UNK	UNK	1 omnidirectional, 2 directional	Y	2	up to 96 kHz	16-bit	UNK	2 TB	200 days for 1-channel continuous recording @ 96 kHz sample rate, assuming 60% data compression; 100 days for 2-channel continuous recording @ 96 kHz sample rate, assuming 60% data compression	750 (2,100 without transponders)	UNK	35" × 8" (60" long with frame)	custom alkaline C-cell battery pack	UNK
Greeneridge Sciences	DASAR-CI	AAR	N	UNK	UNK	3 omnidirectional	Y	3	5 kHz	16-bit	UNK	512 GB	145 days, continuous recording, no data compression	100	UNK	triangular base w/57" sides, 20" high (includes frame)	5 rechargeable batteries	UNK
Wildlife Acoustics	Song Meter 4 (SM4) Series	AAR	N	Y (hydrophones by HTI)	Y	UNK	Y	2	96 kHz	16-bit		1 TB (2x 512 SD cards)	400 days (duty cycled?)	UNK	Cylindrical	UNK	Alkaline or NiHM (4 D cell)	
DBV Technologies	Customized	AAR,RTB	P	UNK	Y	UNK	Y	UNK	User defined	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK
DesertStar Systems	SonarPoint / Multiple models& configurations	AAR, RTB**	Y*	Y	Y	Y	Y (units can be time-synchronized))	UNK	415 kHz	16-bit	95 dB	8 TB (up to 8 SD cards)	For -8 (eight slot/quad battery) version: 115 days @ 25kHz sample rate, 96 days @ 100kHz sample rate, 56 days @ 416 kHz sample rate	300 or 1,000	Cylindrical	6.5"L x 2.5"D (-2 version), 15.7"L x 2.5"D (-8 version)	Rechargeable lithium ion	small boat
Ocean Instruments	SoundTrap ST300	AAR, RTB	N	UNK	Yes	Factory OCR Calibration Certificate, self-calibration check, pistonphone coupler available	UNK	UNK	STD Model: 20 to 60 Hz; HF model: 20 to 150 Hz	16-bit	UNK	256 GB	70 days	500	Cylindrical	200 mm x 60 mm	D-cell batteries	UNK
Ocean Instruments	SoundTrap ST4300	AAR	N	Y	Yes	Self-calibration check	Y	4	288 kHz x 4; 20 Hz-90 kHz ± 3dB	4 x 16-bit SAR	UNK	128 GB	30 Days	500	Cylindrical	200 mm x 60 mm	D-cell batteries	UNK
Ocean Instruments	SoundTrap ST500	AAR	N	UNK	Yes	Factory calibration certificate	UNK	UNK	288 kS/sec; 20 Hz–90 kHz	16-bit	UNK	1 TB	180 Days	500	Cylindrical	350 mm x 100 mm	D-cell batteries	UNK
SIO/UCSD	HARP	AAR	N	Y, custom	Y	UNK	Can Be	UNK	>400 kHz	UNK	UNK	>1 TB	Several months	>1000	Cylindrical	Depends on platform used	Lithium Batteries	Large Vessel with A-frame

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019[1]																		
Manufacturer/ Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi-Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bit-rate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
MTE	AURAL-M2	AAR	N	UNK	UNK	UNK	UNK	UNK	10 to 16,384 kHz	16-bit	UNK	1 TB	365 days	300	Cylindrical	5.75" x 35.375" or 47.375" or 70"	12V Zinc	UNK
MTE	µAURAL	AAR	N	UNK	UNK	UNK	UNK	UNK	UNK	24-bit	UNK	32 GB	300 hours	100	Cylindrical	3" x 18"	Rechargeable NiMH	UNK
Thayer-Mahan	Outpost	ASV	Y		Y	J-9 Projector Calibration	Y	32 / 64 (1)	2.52 kHz	25.2	109	4 TB	>1 year (2)	183 (3)	Linear Array	38.4 / 76.8 m acoustic section	Li-ion	Various
Autonomous Marine Systems Inc. (AMS)	Datamaran	ASV	Yes	Y	Y	N/A	Y	No limit	Whatever the attached PAM equipment is capable of. The DM can transmit 4 channel, 24-bit, 100kHz sampled acoustic waveforms to shore when within 200 kms	24-bit	Depends on specific hydrophone + pre-amp system selected	Practically unlimited. Tens of Terabytes	Unlimited as 1980Watt PV panel name-plate rating and 3072WHr battery capacity available	Can tow array at 100 ft	Catamaran (See website for dimensions of equipment that can be located inside hulls of Datamaran)	1 m x 0.2 m x 0.2 m?	N/A	UNK
RS Aqua	Orca	AAR,RTB	Yes	1 to 5	Y	Multipoint frequency response	Y	5	384	16-bit	95.5	4 TB	155 days (continuous recording)	3,500	cylindrical with cabled hydrophone option	17.8 cm diameter, 28 – 77.5 cm length, 6.7-39 kg	Alkaline or Lithium	UNK
RS Aqua	Porpoise	AAR, RTB	Yes (both real time and autonomous options)	1	N	Single point frequency response	N	1		24 bit	110	4 TB	293 days continuous recording	2,000	cylindrical with cabled hydrophone option	7 cm diameter x 23.3 cm length, 4.5 lb	Alkaline or Lithium	UNK
Liquid Robotics/SMRU Instrumentation/Teledyne-Reson	Blackbeard (AWG)	ASV	Y(only spectral band metrics that are sent in small burst data report; wav audio files not available in real-time)	1	Y(possible to add more hydrophones)	calibration by Reson and SAIL	Yes	4	500 kHz	24-bit	UNK	512 GB	>1 month	10	liquid robotics waveglider towing decimus towbody		lithium-ion	small boat
Ocean Sonics	IcListen AF(L)	AAR	Y*	Y (ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24-bit	106	128 GB	10 hrs	200 or 3,500 (plastic or titanium housing)	Cylindrical	48 x 165 mm	UNK	small boat
Ocean Sonics	IcListen AF	AAR	Y*	Y (ocean Sonics Hydrphones)	Y	UNK	N	1	512 kHz	16 or 24-bit	106	129 GB	10 hrs	201 or 3,500 (plastic or titanium housing)	Cylindrical	49 x 165 mm	UNK	small boat
Ocean Sonics	IcListen HF(L)	AAR	Y*	Y (ocean Sonics Hydrphones)	Y	UNK	N	1	512 kHz	16 or 24-bit	95	130 GB	10 hrs	202 or 3,500 (plastic or titanium housing)	Cylindrical	50 x 165 mm	UNK	small boat
Ocean Sonics	IcListen HF	AAR	Y*	Y (ocean Sonics Hydrphones)	Y	UNK	N	1	512 kHz	16 or 24-bit	95	131 GB	10 hrs	203 or 3,500 (plastic or titanium housing)	Cylindrical	51 x 165 mm	UNK	small boat

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019[1]																			
Manufacturer/ Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi-Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bit-rate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
Ocean Sonics	IcListen X2	AAR	Y*	Y (ocean Sonics Hydrphones)	Y	UNK	N	1	512 kHz	16 or 24-bit	95	132 GB	10 hrs	204 or 3,500 (plastic or titanium housing)	Cylindrical	52 x 165 mm	UNK	small boat
Ocean Sonics	IcListen R-Type	AAR	Y*	Y (Reson hydrophone)	UNK	UNK	N	1	512 kHz	16 or 24-bit	90	133 GB	10 hrs	900	Cylindrical	53 x 165 mm	UNK	small boat
Loggerhead Instruments	Snap	AAR	N	Y(3 hydrophone models from HTI)	Y	UNK	N	1	96 kHz	UNK	Depends on gain settings and hydrophones	128 GB	8 days (continuous); 190 days (10min on/off duty cycled)		cylindrical	16 x 2.875"	3 alkaline D-cell batteries	small boat
Loggerhead Instruments	LS1 Multi-Card Recorder	AAR	N	Y (HTI hydrophones)	Y	UNK	Y (Stero possible)	2	97 kHz	UNK	Depends on gain settings and hydrophones	256 GB(expandable)	50 days (continuous)	300	cylindrical	17"x4.5"	12 alkaline D-cell batteries	small boat
Loggerhead Instruments	LS1x Multi-Card Recorder	AAR	N	Y (HTI hydrophones)	Y	UNK	Y (Stero possible)	2	98 kHz	UNK	Depends on gain settings and hydrophones	256 GB (expandable)	100 days? (LS1X has 2x battery capacity of LS1)	3,000 (aluminum housing)	cylindrical	25"x4.5"	24 alkaline D-cell batteries	small boat
Loggerhead Instruments	Medusa	RTB (noise calculations)	Y	UNK	UNK	UNK	N	1	44.1 kHz	UNK	UNK	64 GB	UNK	1 m?	Cylindrical	24" x 3"	lithium ion (8x 5Ah; Rechargeable)	small boat
MSEIS	WISDOM Data	RTB	Y	Y, hi and low sensitivity options	Upon request	Dependant on customer requirement	Y	4	1,000 kHz	16-bit	Dependant on hydrophones used	120 GB (expandable)	40+ hours in darkness, indefinite when solar powered	TBC	Cylindrical buoy	1250mm diameter x 2.5m height above water	2x 12V SLA 22Ah	Deployment by crane

Legend/ Abbreviations:				
	N	No	UNK	unknown or unavailable
	Y	Yes	AAR	Autonomous Acoustic Recorder
	P	Possible	RTB	Radio Telemetered (Moored, Acoustic) Buoy
	NR	N response to request	AUV	Autonomous Underwater Vehicle
	NA	Not applicable or relevant	ASV/USV	Autonomous Surface Vehicle/Unmanned Surface Vehicle (e.g., waveglider)

[1]Information compiled by Tom Norris, Biowaves, Inc.

			Monitoring Type				
			Mitigation		Regional Long-Term	Tracking	
PAM Technology	Vehicle		Pile Driving	Other?		Local	Regional
PAM	Autonomous Recorders and Real-time Systems	Seafloor			X	X	P
		Moored	X	X	X	X	P
	Passively (buoyancy/ wind) powered AV	AUV		X	P		
		ASV	P	X	P	P	P
	Drifter		P	X	P	P	P

X = capable of monitoring.
P = possible under certain conditions or circumstances (e.g. low currents or sea states, or if numerous devices are deployed and data can be integrated).

Attachment 3: Protected Species Reporting Contact Information for the Project

The following contact information may change in the course of the regulatory approval process. Final contact information will be stipulated by the regulatory agencies at the time of issuance of authorizations.

U.S. Coast Guard

USCG District	Phone Numbers for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals and Sea Turtles	
TBD		

National Marine Fisheries Service

NMFS Contact	Phone Number and email for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals and Sea Turtles	
Office of Protected Resources (OPR)	TBD by agency	TBD by agency
Greater Atlantic Regional Fisheries Office (GARFO)	TBD by agency	TBD by agency
Marine Mammal Stranding Program/Regional Stranding Coordinator (New England)	TBD by agency	TBD by agency

BOEM

NMFS Contact	Phone Number and email for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals and Sea Turtles	
BOEM Offshore Wind Division	TBD by agency	TBD by agency

Attachment 4: Acoustic Measurement Plan

Introduction

In connection to the planned foundation installation activities for US offshore wind projects, underwater noise plan for sound field verification is proposed.

Purpose

The aim of the proposed measurement exercise is to obtain dataset that can be used to verify prognosed sound levels submitted in underwater noise assessment and used as input to predict ranges to acoustic thresholds that may result in injury or behavioral disruption of cetaceans, sea turtles and fish near the construction area. It is, therefore, necessary to conduct underwater noise measurements to verify the prognosed sound levels were comparable/lower than those measured in field and any estimated animal exposures were accurate/conservative enough. Impact pile driving is considered as the installation method for the proposed measurement plan. Amendments to the plan for other installation methods are discussed in the end of this document.

Specifics of the measurement plan

All measurements will be performed according to the ISO 18406:2017 standard. The foundation installation noise will be measured using omnidirectional hydrophones capable of measuring frequencies between 20 Hz and 20 kHz. The hydrophone signals will be verified before deployment and after recovery by means of a pistonphone calibrator on deck or similar method. Each measurement position will consist of two hydrophones at approximately mid depth and 2 m above the seafloor. Deployment will be made using a heavy weight as anchor - to prevent equipment drifting (typically total ballast weight exceeding 100 kg) – as depicted in **Figure4-1**. Deployment and retrieving position of each hydrophone will be recorded using hand-held GPS equipment, or alternative precise method. The hydrophones will be placed at various distances from the installation location as depicted in **Figure 4-2**.

The equipment, methodology, placement and analysis will be the same for all pile measurements. Output results will include sound pressure level and frequency context. Measurements will be conducted in a detailed configuration at the beginning of installation. An example of the measurement configuration is provided in **Figure 4-2.**

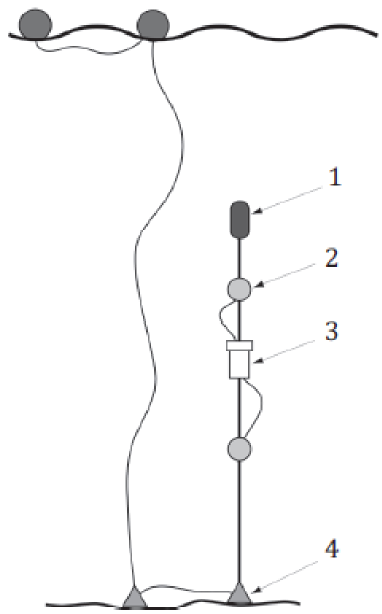

Figure 4-1. Principle sketch of hydrophone deployment. 1 is the float, 2 is the hydrophone, 3 is the recorder and 4 is the bottom weight(s). From ISO 18406:2017.

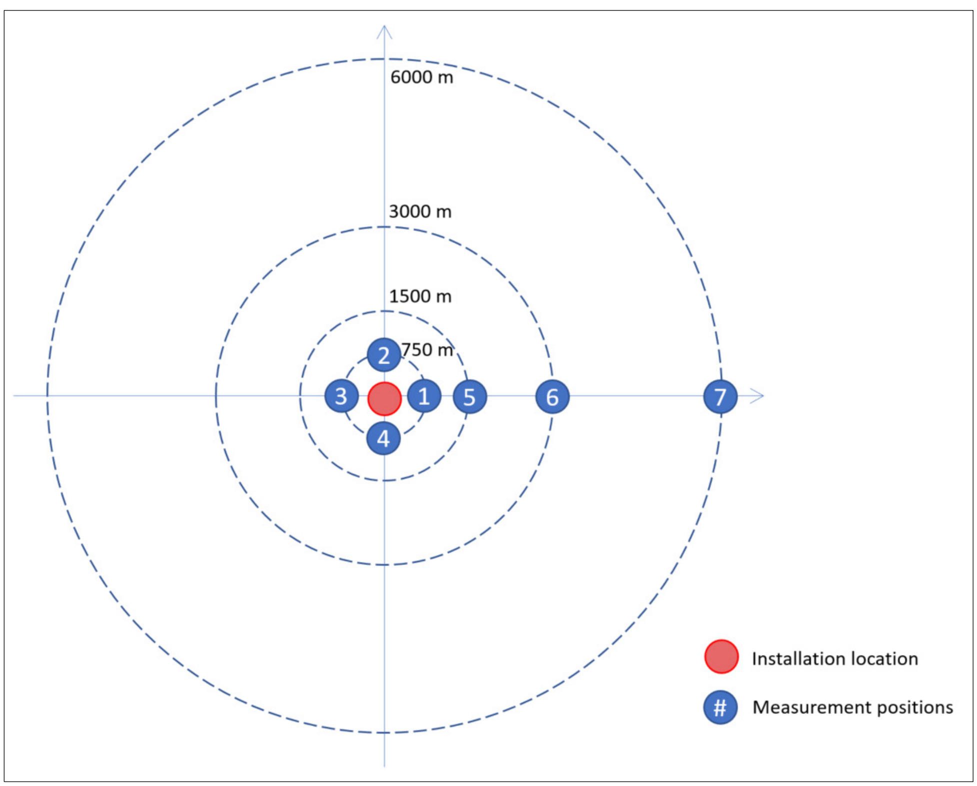

Figure 4-2 Sample sound field verification showing layout of proposed measurement locations. Specific locations are only examples and may change.

Modification of exclusion and monitoring zones

SFW may request a modification to the size of exclusion and monitoring zones based on the results of pile measurements. The zones will be determined as follows:

- The large whale pre-start clearance zone will be calculated as a 20% increase in the radius of the maximum Level A exposure range of any mysticete excluding humpback whales.
- The right whale pre-start clearance zone will be equal to the marine mammal Level B zone.
- The large whale, including right whale, exclusion zone will be calculated as a 10% increase in the radius of the maximum Level A exposure range of any mysticete excluding humpback whales.
- The harbor porpoise and seal pre-start clearance zone and EZ will be determined as the extent of the level A exposure range plus a 20% buffer for the clearance zone and 10% buffer for the EZ.
- For dolphins, no Level A zone is expected as the maximum dolphin exposure range for piling without an NMS is 24 m; and all piles will use an NMS. Therefore, the pre-start clearance zone will be determined as 100 m plus 20% or the exterior edge of the bubble curtain, whichever is greater. The dolphin EZ will be determined as 50 m plus 10% or the exterior edge of the bubble curtain, whichever is greater.

In the case of expanded clearance and EZs, zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation. Based on the results of the sound field verification (SFV) measurements, the secondary vessel will be placed at the outer limit of the subsequent Large Whale Exclusion Zone as described in **Figure 3** of the PSMMP. No additional PSOs or PSO vessels are proposed to visually monitor the expanded zones.

The placement of PAM will sufficiently cover any expanded clearance or exclusion zones. As described in the PSMMP, the total number of PAM stations and array configuration will depend on the size of the zone to be monitored, the amount of noise expected in the area, and the characteristics of the signals being monitored. Acoustic monitoring will include and extend beyond the Large Whale Pre-Start Clearance Zone. Orsted will be prepared to flex the PAM configuration to be capable of monitoring the resulting measured (SFV) zone up to the maximum potential Level B zone.

Attachment 5: Vessel Strike Avoidance Plan

To mitigate potential impacts of vessel strikes, SFW will adhere to the following *Base Conditions*.

Base Conditions:

- **Training***:* All personnel working offshore will receive training on marine mammal, sea turtle, and Atlantic sturgeon awareness.

- **Speed/Approach Constraints**: All vessels will adhere to current NOAA vessel guidelines and regulations in place.

- **Approach Constraints**: Vessels will maintain, to the extent practicable, separation distances of 500 m for North Atlantic right whales, 100 m for other whales, and 50 m for dolphins, porpoises, seals, and sea turtles.

- **Monitoring/Mitigation**: Vessel operators and crew will maintain a vigilant watch for marine mammals and sea turtles, and slow down or maneuver their vessels as appropriate to avoid a potential intersection with a marine mammal or sea turtle.

- **Situational Awareness/Common Operating Picture**: SFW will establish a situational awareness network for marine mammal and sea turtle detections through the integration of sighting communication tools such as Mysticetus, Whale Alert, WhaleMap, etc. Sighting information will be made available to all project vessels through the established network. SFW's Marine Coordination Center will serve to coordinate and maintain a Common Operating Picture. In addition, systems within the Marine Coordination Center, along with field personnel, will:
    - Monitor the NMFS North Atlantic right whale reporting systems daily;
    - Monitor Coast Guard VHF Channel 16 throughout the day to receive notifications of any sighting; and
    - Monitor any existing real-time acoustic networks.

In addition to the above *Base Conditions*, SFW will implement a *Standard Plan* or an *Adaptive Plan* as presented below. SFW intends for these plans to be interchangeable and implemented throughout both the construction and operations phases of the project.

Standard Plan:

- Implement *Base Conditions* described above.

- Vessels of all sizes will operate port to port at 10 knots or less between November 1 and April 30, except for vessels while transiting in Narragansett Bay or Long Island Sound which have not been demonstrated by best available science to provide consistent habitat for North Atlantic right whales.

- Vessels of all sizes will operate at 10 knots or less in any Dynamic Management Areas (DMAs).

<u>Adaptive Plan:</u>

An *Adaptive Plan* will be developed in consultation with NMFS to allow modification of speed restrictions for vessels. Should SFW chose not to implement this *Adaptive Plan* or a component of the *Adaptive Plan* is offline (e.g., equipment technical issues), SFW will default to the *Standard Plan* (described above).

Proposed measures may include:

- Implement *Base Conditions* described above.
- A semi-permanent acoustic network comprising near real-time bottom mounted and/or mobile acoustic monitoring platforms will be installed year-round such that confirmed North Atlantic right whale detections are regularly transmitted to a central information portal and disseminated through the situational awareness network.
- Year-round, if any DMA is established that overlaps with an area where a project vessel would operate, that vessel, regardless of size when entering the DMA, will transit that area at a speed of 10 knots or less unless a trained, dedicated person-on-watch and alternative visual detection system (e.g., thermal cameras) are present.
- If PAM and/or thermal systems are offline, the *Standard Plan* measures will apply for the respective zone (where PAM is offline) or vessel (if thermal systems offline).
- The transit corridor and wind development area (WDA) will be divided into detection action zones.
- Localized detections of North Atlantic right whales in an action zone would trigger a slow-down to 10 knots or less in the respective zone for the following 12 h. Each subsequent detection would trigger a 12-h reset. A zone slow-down expires when there has been no further visual or acoustic detection in the past 12 h within the triggered zone.
- A trained, dedicated person-on-watch and alternative visual detection system (e.g., thermal cameras) will be stationed on all vessels during transits that intend to operate at greater than 10 knots from November 1 through April 30. The primary role of the person-on-watch is to alert the vessel navigation crew to the presence of marine mammals and sea turtles and to report transit activities and protected species sightings to the designated SFW information system.