Appendix II-L1

Hydroacoustic Modeling Report

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Atlantic Shores South Acoustic and Exposure Modeling

JASCO Applied Sciences (USA) Inc.

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The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Acronyms and Abbreviations

AMAPPS	Atlantic Marine Assessment Program for Protected Species
ANSI	American National Standards Institute
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
CeTAP	Cetacean and Turtle Assessment Program
COP	Construction and Operations Plan
CPA	closest point of approach
dB	decibels
DP	Dynamic positioning
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ESP	electrical service platform
FD	Finite difference
FHWG	Fisheries Hydroacoustic Working Group
ft	feet
FWRAM	Full Wave Range Dependent Acoustic Model
GARFO	Greater Atlantic Regional Fisheries Office
GDEM	Global Digital Elevation Model
GEBCO	The General Bathymetric Chart of the Oceans
G&G	Geophysical and Geotechnical
h	hour
ISO	International Organization for Standardisation
HF	high frequency (cetacean hearing group)
HFC	high-frequency cetaceans
Hz	Hertz
IHA	Incidental Harassment Authorization
in	inch
IWC	International Whaling Commission
JASMINE	JASCO Animal Simulation Model Including Noise Exposure
kg	kilogram
kHz	kilohertz
kJ	kilojoule
km	kilometer
LE	cumulative sound exposure level
LF	low frequency (cetacean hearing group)
LFC	low-frequency cetacean
LLC	Limited Liability Company
Lp	sound pressure level
Lpk	peak pressure level
m	meter
MA	Massachusetts
MA WEA	Massachusetts Wind Energy Area
MF	mid-frequency (cetacean hearing group)
MFC	mid-frequency cetaceans
mi	mile
MMPA	Marine Mammal Protection Act
MONM	Marine Operations Noise Model
µPa	micro-Pascal
m/s	meters per second
MW	megawatt
NARW	North Atlantic right whale
NAS	Noise Abatement System
NEFSC	Northeast Fisheries Science Center
NLPSC	Northeast Large Pelagic Survey Collaborative
NOAA	National Oceanic and Atmospheric Administration
NM	nautical mile
NMFS	National Marine Fisheries Service
NYSERDA	New York State Energy Research and Development Authority
OCS	Outer Continental Shelf
OECC	Offshore Export Cable Corridor
OPA	offshore planning area
OSP	Optimum Sustainable Population
OSS	Offshore Substations
PAM	passive acoustic monitoring
PBR	Potential Biological Removal
PDF	probability distribution function
PDSM	Pile Driving Source Model
PSMESP	Protected Species Management and Equipment Specification Plan

Executive Summary

Atlantic Shores Offshore Wind, LLC (Atlantic Shores), a 50/50 joint venture between EDF-RE Offshore Development, LLC (a wholly owned subsidiary of EDF Renewables, Inc. [EDF Renewables]) and Shell New Energies US LLC (Shell), is proposing to develop two offshore wind energy generation projects (the Projects) within Lease Area OCS-A 0499 (the Lease Area). The Lease Area is located on the Outer Continental Shelf (OCS) within the New Jersey Wind Energy Area, which was identified as suitable for offshore renewable energy development by the Bureau of Ocean Energy Management (BOEM) through a multi-year, public environmental review process.

Atlantic Shores' proposed offshore wind energy generation facilities will be located in an approximately 102,124 acre (413.3 square kilometer [km^2]) Wind Turbine Area (WTA) located in the Lease Area. Project 1 is located in the western 54,175 acres (219.2 km^2) of the WTA and Project 2 is located in the eastern 31,847 acres (128.9 km^2) of the WTA, with a 16,102 acre (65.2 km^2) Overlap Area that could be used by either Project. At its closest point, the WTA is approximately 8.7 miles (mi) (14 km) from the New Jersey shoreline. In addition to the WTA, the Projects will include two offshore Export Cable Corridors (ECCs) within federal and New Jersey state waters as well as two onshore interconnection cable routes, two onshore substation and/or converter station sites, and a proposed operations and maintenance (O&M) facility in New Jersey.

Within the WTA, the Projects will include:

- A combined maximum of up to 200 wind turbine generators (WTGs), inclusive of the Overlap Area[1]:
  - Project 1: A minimum of 105 WTGs and up to a maximum of 136 WTGs
  - Project 2: A minimum of 64 WTGs and up to a maximum of 95 WTGs
- Up to 10 offshore substations (OSSs):
  - Up to five for Project 1
  - Up to five for Project 2
- Up to one permanent meteorological (met) tower, to be installed during Project 1 construction
- Up to four temporary meteorological and oceanographic (metocean) buoys:
  - Up to three for Project 1
  - Up to one for Project 2

This hydroacoustic assessment considered the proposed development for the Projects within the WTA in its entirety and thus evaluated the installation of up to 200 wind turbine generators (WTGs), up to 10 offshore substations (OSSs), and up to one permanent met tower.

The Projects include three options for WTG and OSS foundations: piled (monopile or jacket), suction bucket, or gravity foundations. Atlantic Shores is considering three sizes for the OSSs: small, medium, and large. Depending on the final OSS design, there will be up to 10 small OSSs (five for Project 1 and five for Project 2), up to five medium size OSSs (two for Project 1 and three for Project 2), or up to four large OSSs (two for Project 1 and two for Project 2). If jacket foundations are used, a small OSS may require up to four piles (four legs with one pile each), a medium OSS may require up to 12 piles (six legs

[1] The number of WTGs in Project 1, Project 2, and the associated Overlap Area will not exceed 200 WTG locations. For example, if Project 1 includes 105 WTGs (the minimum) then the Overlap Area would be incorporated into Project 2 which would include the remaining 95 WTGs; and conversely if the Overlap Area is incorporated into Project 1 such that it includes 136 WTGs, then Project 2 would be limited to 64 WTGs. Each Project may also use only part of the Overlap Area.

with up to two piles each), and a large OSS may require up to 24 piles (eight legs with up to three piles each). We evaluated both a maximum design scenario, and a realistic base case scenario. For both the WTG and OSS piled foundation types, the maximum design monopiles will have a diameter of up to 49.2 feet (ft) (15.0 meters [m]), though a more realistic base-case using a diameter of 39.4 ft (12.0 m) is also assessed. The jacket piles will have a diameter of up to 16.4 ft (5.0 m).

The WTGs will be aligned in a uniform grid with east-northeast to west-southwest rows spaced 1 nautical mile (nm) (1.9 km) apart and north to south rows spaced 0.6 nm (1.1 km) apart. The OSS positions will be located between the WTGs along the same east-northeast to west-southwest rows as the proposed WTGs. The WTGs and OSSs will be connected by a system of 66 kV to 150 kV inter-array cables. OSSs within the WTA may be connected to each other by 66 kV to 275 kV inter-link cables.

Energy from the OSSs will be delivered to shore via 230 kV to 525 kV high voltage alternating current (HVAC) and/or high voltage direct current (HVDC) export cables. Export cables will be installed within each of the two ECCs (the Atlantic ECC and the Monmouth ECC), with a maximum of up to eight export cables. The export cables will traverse federal and state waters to deliver energy from the OSSs to landfall sites in New Jersey. The Atlantic ECC travels from the western tip of the WTA westward to the Atlantic Landfall Site in Atlantic City, NJ and has a total length of approximately 12 mi (19 km). The approximately 61 mi (98 km) long Monmouth ECC travels from the eastern corner of the WTA along the eastern edge of Lease Area OCS-A 0549 to the Monmouth Landfall Site in Sea Girt, NJ. The offshore cables (i.e., the export cables, any inter-link cables, and the inter-array cables) will be buried to a target depth of approximately 5 to 6.6 ft (1.5 to 2 m); cable protection may be necessary in limited areas if sufficient burial depth cannot be achieved. Installation of offshore Project components, including inter-array and export cables, may require the use of dynamically positioned (DP) vessels.

Construction of the Projects' onshore and offshore facilities will occur over a period of up to 3 years; offshore construction is expected to last approximately two years.

The primary sound source associated with the Projects is impact (impulsive) pile driving during construction. Several secondary sound sources are expected to occur during construction or over the lifecycle of the Projects. These may include vibratory pile driving, installation of suction and gravity-based structures, and vessel activities associated with cable-laying, dredging, and construction. Operations, maintenance, and decommissioning are also considered to be secondary sound sources. Vessels associated with any of these activities contribute non-impulsive sound to the environment via DP thrusters and vessel propulsion. Secondary sound sources are discussed but not quantitatively modeled as part of this analysis.

WTG and OSS monopile and jacket foundations were modeled at two representative locations in the southern portion of the Lease Area. Forcing functions for impact pile driving were computed for each pile type using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). The resulting forcing functions were used as inputs to JASCO's impact pile driving source models to estimate equivalent acoustic source characteristics. Acoustic sound fields were estimated using JASCO's Marine Operations Noise Model (MONM) and Full Wave Range Dependent Acoustic Model (FWRAM). To account for the likely minimum sound reduction resulting from noise abatement systems (NAS) such as bubble curtains, the modeling study included hypothetical broadband attenuation levels of 0, 6, 10, and 15 dB for all impact pile driving.

Results of the acoustic modeling of piling activities are presented as single-strike acoustic ranges to a series of nominal sound pressure levels (SPL), sound exposure levels (SEL), and zero-to-peak pressure levels (PK) in addition to the SEL accumulated over the installation of each foundation type. Acoustic radial distance tables are provided for the modeled hammer energies for each pile diameter with an average summer sound speed profile and reported for different species' hearing group frequency weighting functions. JASCO's Animal Simulation Model Including Noise Exposure (JASMINE) was used to

estimate the radial distances (exposure ranges) within which 95% of simulated animals (animats) may be exposed above the relevant regulatory-defined thresholds for injury and behavioral response for marine species that may be in the vicinity of the proposed piling operations. The exposure ranges were estimated for permitting, monitoring and mitigation purposes.

The potential risk from acoustic exposure for marine species was estimated by finding the accumulated sound energy (SEL) and maximum SPL and PK pressure level each animat received over the course of the simulation. Exposure criteria associated with injury and behavioral response are based on relevant regulatory-defined thresholds and best available science for marine mammals, fish and sea turtles (NOAA 2005, Andersson et al. 2007, Wysocki et al. 2007, Stadler and Woodbury 2009, Mueller-Blenkle et al. 2010, Purser and Radford 2011, NMFS 2018), and available relevant scientific understanding of marine mammal and sea turtle behavior. The projected number of animals exposed to sound levels above threshold values was determined by scaling the number of animats exposed above threshold criteria in the model using the local animal densities from the Duke University Habitat-based Cetacean Density Models (2015, Roberts et al. 2016a, 2017, 2018, 2020) for marine mammals, and the New York State Energy Research and Development Authority aerial survey reports for sea turtles (NYSERDA; Normandeau Associates and APEM 2018, 2019a, 2019b, 2019, 2020).

The analysis for all pile types predicted the number of individual animals potentially exposed to sound levels above SEL and PK injury threshold criteria using only noise mitigation. The exposures summarized here assume 10 dB of attenuation was achieved using a noise abatement system (NAS) although results at 0, 6, 10, and 15 dB were also assessed to provide context. For critically endangered North Atlantic right whale (NARW), a simulation with conservative assumptions and no mitigation other than NAS resulted in fewer than two potential injurious exposures. The foundation type with the longest exposure ranges for marine mammals was the post-piled jacket foundation, with an exposure range of 1.06 km to the SEL injury criteria threshold for NARW. The only species with exposures exceeding PK injury threshold criteria at 10 dB attenuation were harbor porpoise, humpback whales, NARW, and offshore bottlenose dolphins. Exposure modeling results for behavioral thresholds were assessed using both NOAA (2005) and Wood et al. (2012) for marine mammals. The model results predicted that fewer than 23 individual NARWs would be exposed to sound levels that could elicit a behavioral response using the Wood et al. (2012) criteria. Exposure ranges to behavioral thresholds were longest for post-piled jacket foundations, at 10.7 km from the pile for NARW.

Using criteria described by Finneran et al. (2017) fewer than two Kemp's ridley, leatherback, or green sea turtles and up to 14 leatherback sea turtles are predicted to be exposed above the regulatory-defined threshold for injury, with a maximum exposure range of 220 m from the maximum design 15 m monopile. The criteria described by McCauley et al. (2000) and Finneran et al. (2017) that is potentially associated with behavioral response results in less than 51 exposures for Kemp's ridley, leatherback, or green sea turtles. However, the density for loggerhead turtles is predicted to be an order of magnitude higher than any of the other sea turtle species, and this is reflected in the higher behavioral exposures with up to 914 exceedances at 10 dB attenuation. For turtles, exposure ranges to behavioral criteria thresholds are longest for the 15 m monopile, at up to 1.4 km from the source. Exposure ranges to behavioral thresholds for jacketed foundations are substantially lower at less than 800 m for all turtle species.

Atlantic Shores is committed to implement monitoring and mitigation measures specified in the BOEM lease documentation for the lease area, including seasonal restrictions on construction activity, piling energy ramp up, Protected Species Observers (PSOs), Passive Acoustic Monitoring (PAM), and species-specific exclusion zones. After mitigation measures are implemented, the residual risk of impacts is expected to be significantly reduced.

1. Introduction

1.1. Overview of Assessed Activity

Atlantic Shores Offshore Wind, LLC (Atlantic Shores), a 50/50 joint venture between EDF-RE Offshore Development, LLC (a wholly owned subsidiary of EDF Renewables, Inc. [EDF Renewables]) and Shell New Energies US LLC (Shell), is proposing to develop two offshore wind energy generation projects (the Projects) within Lease Area OCS-A 0499 (the Lease Area). The Lease Area is located on the Outer Continental Shelf (OCS) within the New Jersey Wind Energy Area, which was identified as suitable for offshore renewable energy development by the Bureau of Ocean Energy Management (BOEM) through a multi-year, public environmental review process.

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Offshore construction will occur over a period of approximately two years.

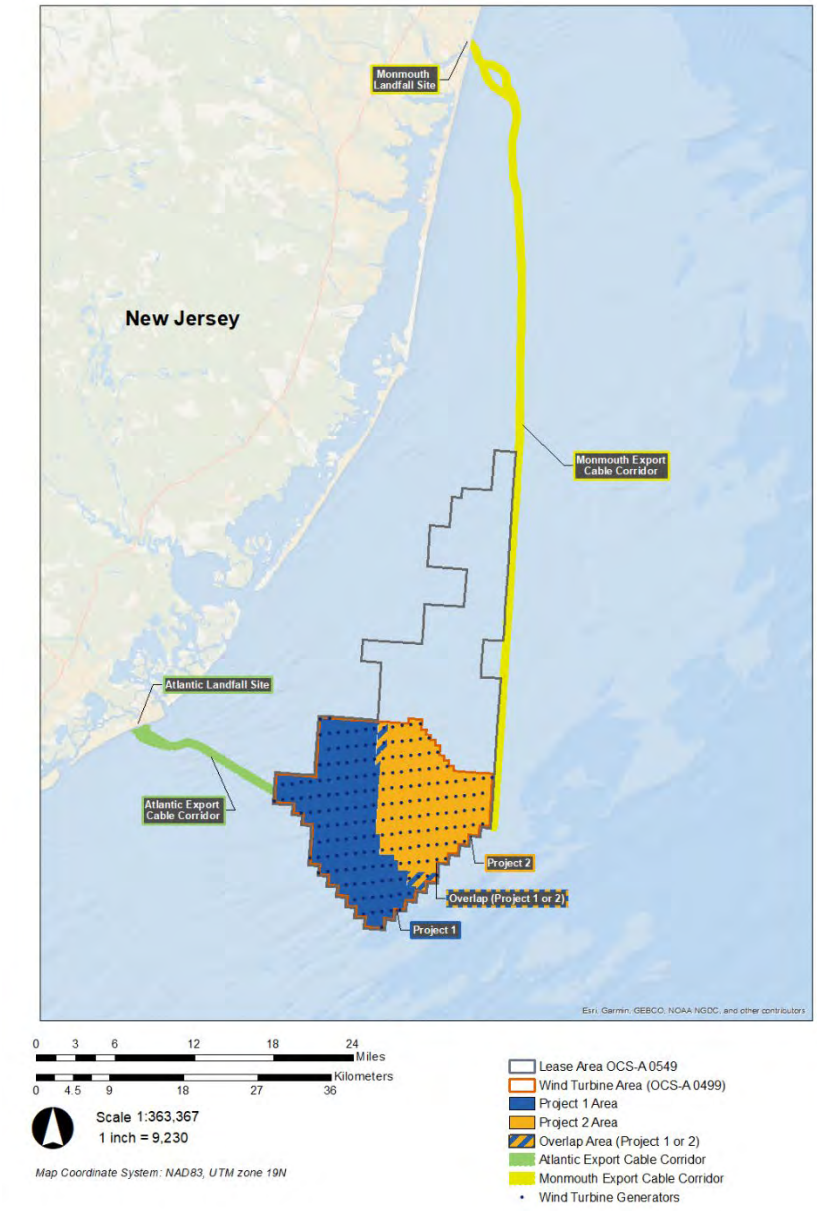

Figure 1. Site of the proposed Project Area.

The primary sound source associated with the Project Area is impact (impulsive) pile driving during foundation installation in the construction phase. Secondary sound sources expected to occur during construction or over the lifecycle of the Projects include potential vibratory and suction pile installation, vessel activities associated with cable-laying, dredging and construction, potential installation of gravity-based structures, operations and maintenance, and decommissioning. Vessel noise levels during the operations, maintenance, and decommissioning phases of the Projects are expected to be similar to, or less than during construction. The sound level that results from turbine operation is of low intensity (Madsen et al. 2006), with energy concentrated at low frequencies (below a few kilohertz) (Tougaard et al. 2008).

Acoustic modeling of impact pile driving was conducted for two representative locations in lease area OCS-A 0499. The locations were selected to span the depth range within the ProjectArea. The results in this report are presented as sound pressure levels (SPL), zero-to-peak sound pressure (PK), and single-strike (i.e., per-impulse) and accumulated sound exposure levels (SEL). Section 2.1 describes the specifications of the impact pile driving source used in the modeling process and all environmental parameters the propagation models require. Sections 2.2 and 2.3 detail the methods used to predict sound source levels and model the sound propagation and potential exposure. Sound attenuation methods are discussed in Section 2.4. Sections 2.5 and 2.6 describe the metrics used to represent underwater acoustic fields and the impact criteria considered. JASCO's Animal Simulation Model Including Noise Exposure (JASMINE) model is described in Section 2.7. Marine fauna included in the acoustic and exposure assessment are summarized in Section 3. Acoustic and exposure modeling results are provided in Section 4 and discussed in Section 5.

1.2. Modeling Scope and Assumptions

The primary expected source of sound during construction of the Projects is from impact pile driving of monopiles and jacket foundation piles during installation in the construction phase of the Projects. The objectives of this modeling study were to predict the acoustic and exposure-based radial distances to regulatory-defined acoustic thresholds associated with injury and behavioral disturbance for various marine fauna including fish, marine mammals, and sea turtles that may occur in, or near, the Project Area during pile driving. JASCO also used the results of animal movement and exposure modeling to estimate potential exposure numbers for marine mammals and sea turtles.

1.2.1. Foundation Types

Project foundation types considered for the WTGs and OSSs include monopiles and jackets. A monopile is a single, hollow cylinder fabricated from steel that is secured in the seabed. Monopile foundations consisting of a single 12 or 15 m diameter pile, were modeled assuming a penetration depth of 60 m (197 ft). The jacket foundation design concept typically consists of a large lattice jacket structure, and a transition piece (TP). The jacket foundation structure is typically supported/secured by three or four pre-installed ("pre-piled") driven piles (one per leg). Alternatively, the jacket is secured to the sea floor via piles that are driven through "sleeves" or guides mounted to the base of each leg of the jacket structure. This is described as "post-piling". Jacket foundations were modeled with piles being either pre- or post-piled and driven to a penetration depth of 70 m (230 ft). The pile diameter modeled in the acoustic assessment for all WTG and OSS jacket foundations was 5 m; WTG jacket foundations may include up to four piles and OSS jacket foundations may include up to 24 piles.

1.2.2. Modeling Inputs for Impact Pile Installation

The amount of sound generated during pile driving during foundation installation varies with the energy required to drive the piles to the desired depth, which depends on the sediment resistance encountered. Sediment types with greater resistance require hammers that deliver higher energy strikes and/or more hammer strikes compared to installations in softer sediment. Maximum sound levels from foundation installation usually occur during the last stage of impact pile driving (Betke 2008), where the greatest resistance is encountered. The representative make and model of impact hammers and the hammer energy schedule used in the acoustic modeling effort to assess various scenarios were provided by Atlantic Shores. Jacket foundation piles were assumed to be pre- and post-piled. Pre-piling means that

the jacket structure will be set on pre-installed piles. Post-piling means that the jacket structure is placed on the seafloor and piles are subsequently driven through guides at the base of each leg. These jacket foundations will also radiate sound as the piles are driven. To account for the larger radiating area including the jacket structure, the broadband sound level estimated for the piles was increased by 2 dB for post-piling scenarios. Key modeling assumptions and a representative hammering schedule for each pile type are shown in Table 1. Modeled wall thickness along the length of the 12 m pile is 13 cm, whereas the wall thickness for the 15 m pile is 16 cm. Further modeling details for the monopile and jacket foundation scenarios are provided in Appendix B.

Table 1. Hammer energy schedule and number of strikes for the monopile and jacket foundations.

Modeled maximum scenario	Hammer model	Energy level (kJ)	Strike count	Pile penetration range (m)	Strike rate (strikes/min)
12 m monopile foundation	Menck MHU 4400S	1,400	750	5	30
		1,800	1,250	5	
		2,000	4,650	15	
		3,000	4,200	15	
		4,400	1,500	5	
	Total		**12,350**	**45**	
15 m monopile foundation	Menck MHU 4400S	480	1,438	8	30
		800	1,217	3	
		1,600	1,472	4	
		2,500	2,200	5	
		3,000	4,200	10	
		4,000	2,880	9	
		4,400	1,980	6	
	Total		**15,387**	**45**	
5 m piles for jacket foundation	IHC S-2500	1,200	700	10	30
		1,400	2,200	20	
		1,800	2,100	15	
		2,500	1,750	10	
	Total		**6,750**	**55**	

* Assume self-penetration of 15 m for all piles.

1.2.3. Modeling Locations

Acoustic propagation modeling was conducted for 12 m and 15 m diameter monopiles, and 5 m diameter jacket foundations at two locations: L01 in 36.1 m water depth, and L02 in 28.1 m water depth (Figure 2; Table 2). The water depth at the site locations were extracted from the bathymetry file obtained from the General Bathymetric Chart of the Oceans (GEBCO Bathymetric Compilation Group 2019).

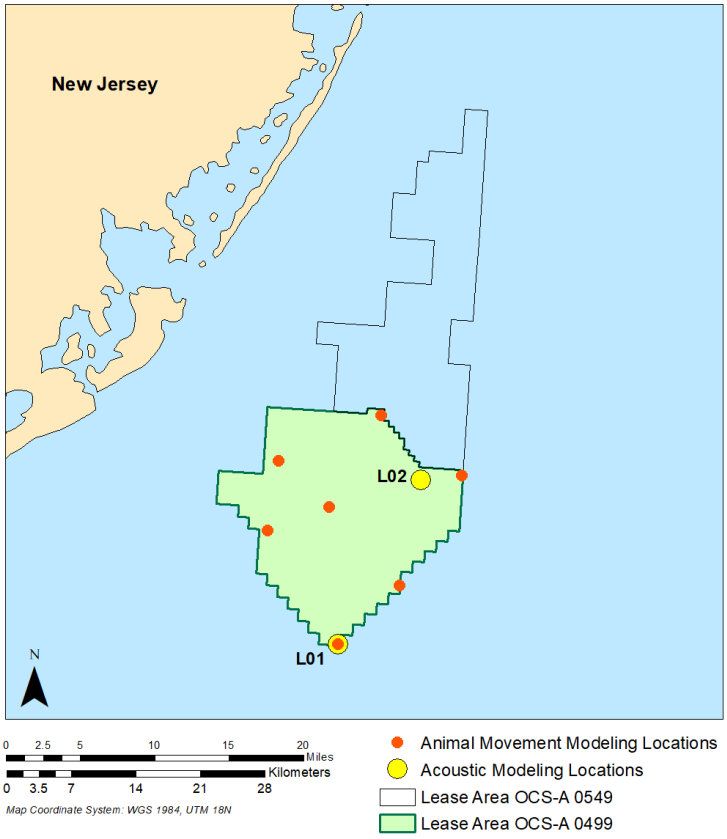

Figure 2. Acoustic propagation and animal movement modeling locations in the Atlantic Shores Project Area.

Table 2. Locations for acoustic modeling of WTG and OSS foundations.

Location name	Location (UTM Zone 18N)		Water depth (m)	Position within Project area	Source type
	Easting	Northing			
L01	578,893.1	4,333,357	36.1	South	Impulsive
L02	586,723.1	4,351,663	28.1	North	

1.2.4. Modeling Scenario and Pile Construction Schedules

In assessing potential pile driving impacts, three construction schedules were modeled for each of three cases:

1. Full buildout of Project 1 and Project 2 (Table 3):
    - 200 WTGs, one met tower, and four large OSSs
2. Buildout of Project 1 plus the overlap area (Table 4):
    - 105 WTG foundations, one met tower, two large OSSs, plus the overlap area (6 WTG foundations)
3. Buildout of Project 2 plus the overlap area (Table 5):
    - 89 WTG foundations, two large OSSs, plus the overlap area (6 WTG foundations)

Construction schedules 1 and 2 are based on a 2-year buildout, and construction schedule 3 assumed a 1-year buildout. In all cases, the met tower was modeled to be installed on the same foundation type as the WTGs (201 total foundations).

Construction schedule 1 assumed that the 201 foundations would be monopiles and installed at a rate of one monopile per day (201 days). Construction schedule 2 assumed that the 201 foundations would include 112 monopiles installed at a rate of one monopile per day (112 days), and four-legged WTG jacket foundations with one pin pile per leg, for a total of 356 pin piles, and that the pin piles would be installed at a rate of four per day (which equates to 189 days of piling). Construction schedule 3 assumed that the 201 foundations would all be monopiles and installed at a rate of up to two monopiles per day (total of 201 foundations and 123 days).

All three construction schedules used in the modeling assumed that four large OSSs foundations would be installed, which is the maximum number of OSS foundations for the Project. Each OSS foundation is on an eight-legged jacket foundation, with 3 pin piles per leg, all installed at a rate of four pin piles per day. This results in 24 pin piles per OSS, for a total of 96 pin piles, and 6 days of piling per OSS foundation. Although other sizes of OSS foundation are being considered, the modeling conservatively assumed four large OSSs as this represents the highest number of pin piles and the greatest number of piling days for the OSSs.

For construction schedules separated by year, please see Appendix G.2.

Table 3. Construction schedule options - Full buildout of the Project: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores.

Construction month	Schedule 1: WTG Monopile Two Year Duration		Schedule 2: WTG Monopile and Jacket Two Year Duration			Schedule 3: WTG Monopile One Year Duration		
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	WTG Monopile 15 m diameter IHCS2500 (2 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	13	0	8	5	0	9	3	0
Jun	35	12	20	15	12	8	16	6
Jul	45	0	25	20	0	10	15	6
Aug	37	12	19	18	12	0	25	6
Sep	32	0	18	14	0	1	12	6
Oct	29	0	16	13	0	13	6	0
Nov	9	0	5	4	0	3	1	0
Dec	1	0	1	0	0	1	0	0
Total Piling Days	**201**	**24**	**112**	**89**	**24**	**45**	**78**	**24**
Total Piles	**201**	**96**	**112**	**356**	**96**	**45**	**156**	**96**
Total Foundations	**201**	**4**	**112**	**89**	**4**	**45**	**156**	**4**

Table 4. Construction schedule options – Project 1 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores.

Construction month	Schedule 1: WTG Monopile Two Year Duration		Schedule 2: WTG Monopile and Jacket Two Year Duration			Schedule 3: WTG Monopile One Year Duration		
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	WTG Monopile 15 m diameter IHCS2500 (2 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	8	0	8	0	0	9	3	0
Jun	20	6	20	0	6	8	16	6
Jul	25	0	25	0	0	10	15	6
Aug	19	6	19	0	6	1	8	0
Sep	18	0	18	0	0	0	0	0
Oct	16	0	16	0	0	0	0	0
Nov	5	0	5	0	0	0	0	0
Dec	1	0	1	0	0	0	0	0
Total Piling Days	**112**	**12**	**112**	**0**	**12**	**28**	**42**	**12**
Total Piles	**112**	**48**	**112**	**0**	**48**	**28**	**84**	**48**
Total Foundations	**112**	**2**	**112**	**0**	**2**	**28**	**84**	**2**

Table 5. Construction schedule options – Project 2 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores.

Construction month	Schedule 1: WTG Monopile Two Year Duration		Schedule 2: WTG Monopile and Jacket Two Year Duration		Schedule 3: WTG Monopile One Year Duration		
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	WTG Monopile 15 m diameter IHCS2500 (2 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	5	0	5	0	0	0	0
Jun	15	6	15	6	0	0	0
Jul	20	0	20	0	0	0	0
Aug	18	6	18	6	1	19	6
Sep	14	0	14	0	1	12	6
Oct	13	0	13	0	13	6	0
Nov	9	0	9	0	3	1	0
Dec	1	0	1	0	1	0	0
Total Piling Days	**95**	**12**	**95**	**12**	**19**	**38**	**12**
Total Piles	**95**	**48**	**380**	**48**	**19**	**76**	**48**
Total Foundations	**95**	**2**	**95**	**2**	**19**	**76**	**2**

1.3. Secondary Sound Sources

There are several other potential anthropogenic sound sources associated with the Projects during offshore construction, operation and maintenance, and decommissioning. These sources were not quantitatively modeled because the potential acoustic effects of these sound sources are expected to be much less than the impact pile driving sound source associated with hammer-installed foundations. A qualitative consideration of secondary sound sources is discussed in this section.

Anthropogenic sounds from vessels associated with the Project Area are likely to be similar in frequency characteristics and sound levels to existing commercial traffic in the region. Vessel sound would be associated with cable installation vessels and operations, piling installation vessels, and general transit to and from the foundation locations during construction, operations, and maintenance. Potential sound effects from cable installation are expected to derive primarily from the cable laying vessel(s).

For example, during a similar type of underwater construction activity, Robinson et al. (2011) measured sound levels radiated from marine aggregate dredgers, mainly trailing suction hopper dredges during normal operation. Robinson et al. (2011) concluded that because of the operation of the propulsion system, noise radiated at less than 500 Hertz (Hz) is similar to that of a merchant vessel "travelling at modest speed (i.e., between 8 and 16 knots)" for self-propelled dredges. During dredging operations, additional sound energy generated by the impact and abrasion of the sediment passing through the draghead, suction pipe, and pump is radiated in the 1–2 kHz frequency band. These acoustic components would not be present during cable lay operations, so these higher frequency sounds are not anticipated. Additionally, field studies conducted offshore New Jersey, Virginia, and Alaska show that noise generated

by using vibracores and drilling boreholes diminishes below the National Marine Fisheries Service (NMFS) Level B harassment thresholds (120 dB for continuous sound sources) relatively quickly and is unlikely to cause harassment to marine mammals (NMFS 2009, Reiser et al. 2010, 2011, TetraTech 2014). Based on these studies, sounds from cable laying activities are anticipated to be comparable to potential Project vessel noise impacts from offshore construction activities.

During construction, it is estimated that multiple vessels may operate concurrently in the vicinity of the Project Area. Some of these vessels may maintain their position using DP thrusters during pile driving or other construction activities. The dominant underwater sound source on DP vessels arises from cavitation on the propeller blades of the thrusters (Leggat et al. 1981). The noise power from the propellers is proportional to the number of blades, propeller diameter, and propeller tip speed. Sound levels generated by vessels under DP are dependent on the operational state and weather conditions. Zykov et al. (2013) and McPherson et al. (2019) report a maximum broadband SPL for numerous vessels with varying propulsion power under DP of up to 192 decibel (dB) re 1 micropascal (µPa) (for a pipe-laying vessel in deep water). All vessels emit sound from propulsion systems while in transit. Non-Project vessel traffic in the vicinity of the Project Area includes recreational vessels, fishing vessels, cargo vessels, tankers, passenger vessels, and others. As such, marine mammals, fish, and sea turtles in the general region are regularly subjected to vessel activity and would potentially be habituated to the associated underwater noise as a result of this exposure (BOEM 2014a). Because noise from vessel traffic associated with construction activities is likely to be the same, or similar to, background vessel traffic noise, the potential risk of impacts from vessel noise to marine mammals is expected to be low relative to the risk of impact from pile-driving sound.

2. Methods

The basic modeling approach used in this acoustic assessment was to characterize the sounds produced by the source, determine how the sounds propagate within the surrounding water column, and then estimate species-specific exposure probability by combining the computed sound fields with animal movement in simulated representative scenarios.

For impact pile driving sounds, time-domain representations of the acoustic pressure waves generated in the water are required for calculating the SPL, SEL, and PK. The source signatures associated with installation of each of the modeled foundation types are predicted using a finite-difference model that determined the physical vibration of the pile caused by pile driving equipment. The sound field radiating from the pile was simulated as a vertical array of point sources. For this study, synthetic pressure waveforms were computed using a Full Waveform Range-dependent Acoustic Model (FWRAM), which is JASCO's acoustic propagation model capable of producing time-domain waveforms. The sound propagation modeling incorporated site-specific environmental data including bathymetry, sound speed in the water column, and seabed geoacoustics in the proposed construction area. Animal movement modeling integrated the estimated sound fields with species-typical behavioral parameters (e.g., dive patterns) in JASMINE to estimate received sound levels for the modeled animals (animats) that may occur in the construction area. Animats that exceeded pre-defined acoustic thresholds/criteria (e.g., NMFS 2018) were identified and the range for the exceedances determined.

2.1. Acoustic Environment

The Project Area is located on the continental shelf, an environment characterized by predominantly sandy seabed sediments. Water depths in the Project Area vary between 19 to 37 m (62 to 121 ft). From July through September, the average temperature of the upper 10 to 15 m of the water column is higher, resulting in an increased surface layer sound speed. This creates a downward refracting environment in which propagating sound interacts with the seafloor more than in a well-mixed environment. Increased wind mixing combined with a decrease in solar energy during the winter months (January to March) results in a sound speed profile that is more uniform with depth. The average summer sound speed profile for the area was chosen because it is the most realistic sound propagation environment for the proposed activities. See Appendix E.2 for more details on the environmental parameters used in acoustic propagation and exposure modeling.

2.2. Source Modeling: Impact Pile Driving

Piles deform when driven with impulsive impact hammers, creating a bulge that travels down the pile and radiates sound into the surrounding air, water, and seabed. This sound may be received as a direct transmission from the sound source to biological receivers (such as marine mammals, sea turtles, and fish) through the water or as the result of reflected paths from the surface or re-radiated into the water from the seabed (Figure 3). Sound transmission depends on many environmental parameters, such as the sound speeds in water and substrates. It also depends on the sound production parameters of the pile and how it is driven, including the pile material, size (length, diameter, and thickness) and the make and energy of the hammer. Post-piling has been shown to increase sound levels by 2 dB relative to pre-piling (Bellmann et al. 2020). To account for this, post-piled jacket foundations were modeled with a 2 dB increase in received levels.

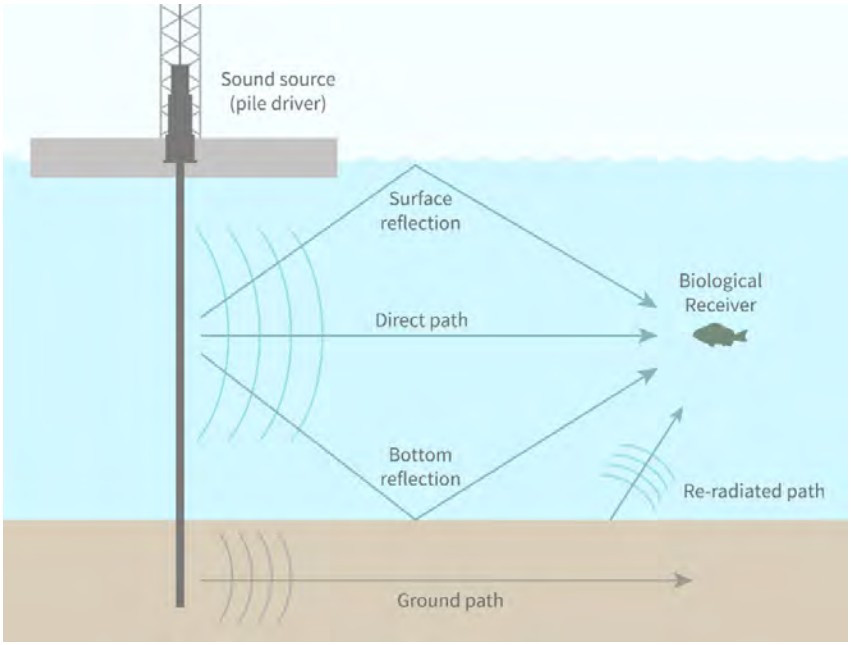

Figure 3. Sound propagation paths associated with pile driving (adapted from Buehler et al. 2015).

JASCO's physical model of pile vibration and near-field sound radiation (MacGillivray 2014) was used in conjunction with the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010) to predict source levels associated with impact pile driving activities. The sound radiating from the pile itself was simulated using a vertical array of discrete point sources. These models account for several parameters that describe the operation (pile type, material, size, and length), the pile driving equipment, the number of hammer strikes to install the pile, and the approximate pile penetration depth. See Appendix E.1 for a more detailed description.

Forcing functions were computed for 5 m diameter jacket foundation piles and the 12 and 15 m monopile foundations, using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). The model assumed direct contact between the representative hammers, helmets, and piles (i.e., no cushion material). The forcing functions serve as the inputs to JASCO's pile driving source models (PDSM) used to estimate equivalent acoustic source characteristics detailed in Appendix E.1. Decidecade spectral source levels for each pile type, hammer energy and modeled location, using an average summer sound speed profile are provided in Section 4.1.

2.3. Modeling Sound Propagation

Acoustic propagation modeling used JASCO's Marine Operations Noise Model (MONM) and Full Wave Range Dependent Acoustic Model (FWRAM) that combine the outputs of the source model with the spatial and temporal environmental context (e.g., location, oceanographic conditions, and seabed type) to estimate sound fields. The lower frequency bands were modeled using MONM-RAM, which is based on the parabolic equation method of acoustic propagation modeling. For higher frequencies, additional losses resulting from absorption were added to the propagation loss model. See Appendix E for a more detailed description.

2.4. Sound Attenuation Methods

One way to mitigate potential impacts from pile driving sound on marine fauna is to minimize, as much as possible, the sound levels from the pile driving source. Doing so reduces the zone of potential effect, thus reducing the number of animals exposed and the sound levels to which they would be exposed. These reductions may be achieved with various technologies.

Noise abatement systems (NASs) are often used to decrease the sound levels in the water near a source by inserting a local impedance change that acts as a barrier to sound transmission. Attenuation by impedance change can be achieved through a variety of technologies, including bubble curtains, evacuated sleeve systems (e.g., IHC-Noise Mitigation System (NMS)), encapsulated bubble systems (e.g., HydroSound Dampers (HSD)), or Helmholtz resonators (AdBm NMS). The effectiveness of each system is frequency dependent and may be influenced by local environmental conditions such as current and depth. For example, the size of the bubbles determines the effective frequency band of an air bubble curtain, with larger bubbles needed for lower frequencies.

Small bubble curtains have been measured to reduce sound levels by ~10 dB to more than 20 dB but are highly dependent on water depth and current and how the curtain is configured and operated (Koschinski and Lüdemann 2013, Bellmann 2014, Austin and Li 2016). Larger bubble curtains tend to perform better and more reliably, particularly when deployed with two rings (Koschinski and Lüdemann 2013, Bellmann 2014, Nehls et al. 2016). A California Department of Transportation (CalTrans) study tested several small, single, bubble-curtain systems and found that the best attenuation systems resulted in 10–15 dB of attenuation. Buehler et al. (2015) concluded that attenuation greater than 10 dB could not be reliably predicted from small, single, bubble curtains because sound transmitted through the seabed and re-radiated into the water column is the dominant source of sound in the water for bubble curtains deployed immediately around (within 32 ft [10 m] of) the pile (Buehler et al. 2015).

A recent analysis by Bellmann et al. (2020) of NAS performance measured during impact pile driving for wind farm foundation installation provides expected performance for common NAS configurations. Measurements with a single bubble curtain and an air supply of 0.3 m^3/min resulted in 7 to 11 dB of broadband attenuation for optimized systems in up to 131.25 ft (40 m) water depth. Increased air flow (0.5 m^3/min) may improve the attenuation levels up to 11 to 13 dB (M. Bellmann, personal communication, 2019). Double bubble curtains add another local impedance change and, for optimized systems, can achieve 15 to 16 dB of broadband attenuation (measured in up to 131.25 ft [40 m] water depth). The IHC-NMS can provide 15 to 17 dB of attenuation but is currently limited to piles <8 m in diameter. Other NASs such as the AdBm NMS achieved 6 to 8 dB (M. Bellmann, personal communication, 2019), but HSDs were measured at 10–12 dB attenuation and are independent of depth (Bellmann et al. 2020). Systems may be deployed in series to achieve higher levels of attenuation.

The NAS must be chosen, tailored, and optimized for site-specific conditions. NAS performance of 10 dB broadband attenuation was chosen for this study as an achievable reduction of sound levels produced during pile driving when one NAS is in use, noting that a 10 dB decrease means the sound energy level is reduced by 90 %. For exposure modeling, several levels of attenuation (0, 6, 10, and 15 dB) were included for comparison purposes. A Protected Species Management and Equipment Specification Plan (PSMESP) is included as an appendix to the Letter of Authorization application for this Project. The PSMESP contains details about the mitigation and monitoring measures during construction of the Projects.

2.5. Acoustic Thresholds Used to Evaluate Potential Impacts to Marine Mammals

The MMPA prohibits the take of marine mammals. The term "take" is defined as: to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. MMPA regulations define harassment in two categories relevant to the Project operations. These are:

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

To assess the potential impacts of Project-associated sound sources, it is necessary to first establish the acoustic exposure criteria used by United States (U.S.) regulators to estimate marine mammal takes. In 2016, the National Oceanographic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) issued a Technical Guidance document that provides acoustic thresholds for onset of a permanent threshold shift (PTS) in marine mammal hearing for most sound sources, which was updated in 2018 (NMFS 2016, 2018). The Technical Guidance document also recognizes two main types of sound sources: impulsive and non-impulsive. Non-impulsive sources are further broken down into continuous or intermittent categories.

NMFS also provided guidance on the use of weighting functions when applying Level A harassment criteria. The Guidance recommends the use of a dual criterion for assessing Level A exposures, including a PK (unweighted/flat) sound level metric and a cumulative SEL metric with frequency weighting. Both acoustic criteria and weighting function application are divided into functional hearing groups (low-, mid-, and high-frequency) that species are assigned to, based on their respective hearing ranges. The acoustic analysis applies the most recent sound exposure criteria utilized by NMFS to estimate acoustic harassment (NMFS 2018).

Sound levels thought to elicit disruptive behavioral response are described using the SPL metric (NMFS and NOAA 2005). NMFS currently uses behavioral response thresholds of 160 dB re 1 µPa for impulsive sounds and 120 dB re 1 µPa for non-impulsive sounds for all marine mammal species (NMFS 2018), based on observations of mysticetes (Malme et al. 1983, 1984, Richardson et al. 1986, 1990). Alternative thresholds used in acoustic assessments include a graded probability of response approach and take into account the frequency-dependence of animal hearing sensitivity (Wood et al. 2012). This assessment uses both the NOAA (2005) and the Wood et al. (2012) criteria to estimate Level B exposures to impulsive piling sounds.

The publication of ISO 18405 Underwater Acoustics–Terminology (ISO 2017) provided a dictionary of underwater bioacoustics (the previous standard was [ANSI] American National Standards Institute and [ASA] Acoustical Society of America S1.1-2013). In the remainder of this report, we follow the definitions and conventions of ISO (2017) except where stated otherwise (Table 6).

Table 6. Summary of relevant acoustic terminology used by US regulators and in the modeling report.

Metric	NMFS (2018)	ISO (2017)	
		Main text	Equations/Tables
Sound pressure level	Not applicable	SPL	L_p
Peak pressure level	PK	PK	L_{pk}
Cumulative sound exposure level	SEL_{cum}	SEL	L_E

The SEL_{cum} metric used by the NMFS describes the sound energy received by a receptor over a period of 24 h. Accordingly, following the ISO standard, this will be denoted as SEL in this report, except for in tables and equations where L_E will be used.

2.5.1. Marine Mammal Hearing Groups

Current data and predictions show that marine mammal species differ in their hearing capabilities, in absolute hearing sensitivity as well as frequency band of hearing (Richardson et al. 1995, Wartzok and Ketten 1999, Southall et al. 2007, Au and Hastings 2008). While hearing measurements are available for a small number of species based on captive animal studies, there are no direct measurements of many odontocetes or any mysticetes. As a result, hearing ranges for many odontocetes are grouped with similar species, and predictions for mysticetes are based on other methods including: anatomical studies and modeling (Houser et al. 2001, Parks et al. 2007, Tubelli et al. 2012, Cranford and Krysl 2015); vocalizations (see reviews in Richardson et al. 1995, Wartzok and Ketten 1999, Au and Hastings 2008); taxonomy; and behavioral responses to sound (Dahlheim and Ljungblad 1990, see review in Reichmuth et al. 2007). In 2007, Southall et al. proposed that marine mammals be divided into hearing groups. This division was updated in 2016 and 2018 by the NMFS using more recent best available science (Table 7).

Southall et al. (2019) published an updated set of Level A sound exposure criteria (i.e., for onset of temporary threshold shift (TTS) and PTS in marine mammals). While the authors propose a new nomenclature and classification for the marine mammal functional hearing groups, the proposed thresholds and weighting functions do not differ in effect from those proposed by NMFS (2018). The new hearing groups proposed by Southall et al. (2019) have not yet been adopted by NOAA. The NMFS (2018) hearing groups presented in Table 7 are used in this analysis.

Table 7. Marine mammal hearing groups and their hearing range (Sills et al. 2014, NMFS 2018).

Faunal group	Generalized hearing range[a]
Low-frequency (LF) cetaceans (mysticetes or baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (odontocetes: delphinids, beaked whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (other odontocetes)	275 Hz to 160 kHz
Phocid pinnipeds in water (PPW)	50 Hz to 86 kHz
Phocid pinnipeds in air (PPA)b	50 Hz to 36 kHz

[a] The generalized hearing range is for all species within a group. Individual hearing will vary.
[b] Sound from piling will not reach NMFS thresholds for behavioral disturbance of seals in air (90 dB [rms] re 20 µPa for harbor seals and 100 dB [rms] re 20 µPa for all other seal species) at the closest-located sites where seals may spend time out of the water. Thus in-air hearing is not considered further.

2.5.2. Marine Mammal Auditory Weighting Functions

The potential for anthropogenic sound to impact marine mammals is largely dependent on whether the sound occurs at frequencies that an animal can hear well, unless the sound pressure level is so high that it can cause physical tissue damage regardless of frequency. Auditory (frequency) weighting functions reflect an animal's ability to hear a sound (Nedwell and Turnpenny 1998, Nedwell et al. 2007). Auditory weighting functions have been proposed for marine mammals, specifically associated with PTS thresholds expressed in metrics that consider what is known about marine mammal hearing (e.g., SEL) (Southall et al. 2007, Erbe et al. 2016, Finneran 2016). Marine mammal auditory weighting functions for all hearing groups (Table 7) published by Finneran (2016) are included in the NMFS (2018) Technical Guidance for use in conjunction with corresponding PTS (Level A) onset acoustic criteria (Table 8, Appendix D).

The application of marine mammal auditory weighting functions emphasizes the importance of taking measurements and characterizing sound sources in terms of their overlap with biologically important frequencies (e.g., frequencies used for environmental awareness, communication, and the detection of predators or prey), and not only the frequencies that are relevant to achieving the objectives of the sound producing activity (i.e., context of sound source; NMFS 2018).

2.5.3. Marine Mammal Auditory Injury Exposure Criteria

Injury to the hearing apparatus of a marine mammal may result from a fatiguing stimulus measured in terms of SEL, which considers the sound level and duration of the exposure signal. Intense sounds may also damage hearing independent of duration, so an additional metric of peak pressure (PK) is also used to assess the risk of injury from acoustic exposure. A PTS in hearing may be considered injurious, but there are no published data on the sound levels that cause PTS in marine mammals. There are data that indicate the received sound levels at which TTS occurs, and PTS onset may be extrapolated from TTS onset level using an assumed growth function (Southall et al. 2007). The NMFS (2018) criteria incorporate the best available science to estimate PTS onset in marine mammals from sound energy accumulated over 24 h (SEL), or very loud, instantaneous PK levels. These dual threshold criteria of SEL and PK are used to calculate marine mammal exposures (Table 8). If a non-impulsive sound has the potential to exceed the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Table 8. Summary of relevant permanent threshold shift (PTS) onset acoustic thresholds for marine mammal hearing groups (NMFS 2018).

Faunal group	Impulsive signals[a]		Non impulsive signals
	Unweighted L_{pk} (dB re 1 µPa)	Frequency weighted $L_{E,\,24hr}$ (dB re 1 µPa^{2}s)	Frequency weighted $L_{E,\,24hr}$ (dB re 1 µPa^{2}s)
Low-frequency (LF) cetaceans	219	183	199
Mid-frequency (MF) cetaceans	230	185	198
High-frequency (HF) cetaceans	202	155	173
Phocid seals in water (PW)	218	185	201

[a] Dual metric acoustic thresholds for impulsive sounds: The largest isopleth result of the two criteria is used for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds have also been considered.

2.5.4. Marine Mammal Behavioral Response Exposure Criteria

Numerous studies on marine mammal behavioral responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioral reactions. It is recognized that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison et al. 2012). Due to the complexity and variability of marine mammal behavioral responses to acoustic exposure, the NMFS has not yet released technical guidance on behavioral thresholds for calculating animal exposures (NMFS 2018). The NMFS currently uses a step function to assess behavioral effects (NOAA 2005). A 50% probability of inducing behavioral responses at an SPL of 160 dB re 1 µPa was derived from the HESS (1999) report, which was based on the responses of migrating mysticete whales to airgun sounds (Malme et al. 1983, 1984). The HESS team recognized that behavioral responses to sound may occur at lower levels, but substantial responses were only likely to occur above an SPL of 140 dB re 1 µPa.

An extensive review of behavioral responses to sound was undertaken by Southall et al. (2007, their Appendix B). Southall et al. (2007) found varying responses for most marine mammals between an SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions. In 2012, Wood et al. proposed a graded probability of response for impulsive sounds using a frequency weighted SPL metric. Wood et al. (2012) also designated behavioral response categories for sensitive species (harbor porpoises and beaked whales) and for migrating mysticetes. Both the unweighted NOAA (2005) and the frequency-weighted Wood et al. (2012) criteria are used in this study to estimate Level B exposures to impulsive piling sounds (Table 9).

Table 9. Acoustic thresholds used in this assessment to evaluate potential behavioral impacts to marine mammals. Units are sound pressure level (L_p). Probabilities are not additive.

Marine mammal group	Species	Frequency weighted probabilistic response[a] (L_p; dB re 1 µPa)				Unweighted threshold[b] (L_p; dB re 1 µPa)
		120	140	160	180	160
Sensitive odontocetes	Harbor porpoise	50%	90%	—	—	100%
Migrating mysticete whales	North Atlantic right whale	10%	50%	90%	—	100%
All other species		—	10%	50%	90%	100%

[a] Wood et al. (2012).
[b] NMFS recommended threshold.

2.6. Acoustic Thresholds Used to Evaluate Potential Impacts to Sea Turtles and Fish

In a cooperative effort between Federal and State transportation and resource agencies, interim criteria were developed to assess the potential for injury to fish exposed to pile driving sounds (Stadler and Woodbury 2009) and described by the Fisheries Hydroacoustic Working Group (FHWG 2008). Injury and behavioral response levels for fish were based on past literature that was compiled and listed in the NOAA Fisheries Greater Atlantic Regional Fisheries Office acoustics tool (GARFO 2020) for assessing the potential effects to Endangered Species Act (ESA) listed animals exposed to elevated levels of underwater sound from pile driving. Dual acoustic thresholds for physiological injury to fish included in the tool are 206 dB re 1 µPa PK and either 187 dB re 1 µPa^2·s SEL (>2 grams [g] fish weight) or 183 dB SEL (<2 g fish weight) (FHWG 2008, Stadler and Woodbury 2009) (Table 10). The behavioral threshold for fish is ≥150 dB SPL (Andersson et al. 2007, Wysocki et al. 2007, Mueller-Blenkle et al. 2010, Purser and Radford 2011).

A technical report by an American National Standards Institute (ANSI) registered committee (Popper et al. 2014) reviewed available data and suggested metrics and methods for estimating acoustic impacts for fish and sea turtles. Table 10 shows threshold levels suggested by Popper et al. (2014) for PTS for impulsive and continuous sounds. Their report does not define sound levels that may result in behavioral response, but does indicate a high likelihood of response near impact pile driving (tens of meters), moderate response at intermediate ranges (hundreds of meters), and low response far (thousands of meters) from the pile (Popper et al. 2014).

Injury and behavioral thresholds for sea turtles were developed for use by the US Navy (Finneran et al. 2017) based on exposure studies (e.g., McCauley et al. 2000). For sea turtles, dual acoustic thresholds (PK and SEL) have been suggested for PTS and TTS. Sea turtle auditory weighting functions published by Finneran et al. (2017) are used in conjunction with SEL thresholds for PTS and TTS (Appendix D). The behavioral threshold recommended in the GARFO acoustic tool (GARFO 2020) is an SPL of 175 dB re 1 µPa (McCauley et al. 2000, Finneran et al. 2017) (Table 10).

Table 10. Interim sea turtle and fish injury and behavioral acoustic thresholds currently used by NMFS GARFO and Bureau of Ocean Energy Management (BOEM) for impulsive pile driving.

Faunal group	Injury		TTS		Behavior
	L_{PK}	L_E	L_{PK}	L_E	L_p
Fish ≥2 g[a,b]	206	187	—	—	150
Fish <2 g[a,b]		183	—	—	
Fish without swim bladder[c]	>213	>216	--	>>186	--
Fish with swim bladder not involved in hearing[c]	>207	203	---	>186	--
Fish with swim bladder involved in hearing[c]	>207	203	--	186	--
Sea turtles[d,e]	232	204	226	189	175

L_{PK} – peak sound pressure (dB re µPa).
L_E – sound exposure level (dB re 1 µPa^2·s).
L_p – root mean square sound pressure (dB re 1 µPa).
TTS – temporary, recoverable hearing effects.
[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
[b] Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007).
[c] Popper et al. (2014)
[d] Finneran et al. (2017).
[e] McCauley et al. (2000).

2.7. Animal Movement Modeling and Exposure Estimation

JASMINE was used to estimate the probability of exposure of animals to sound arising from pile driving operations during construction of the Project. Sound exposure models such as JASMINE use simulated animals (animats) to sample the predicted 3-D sound fields with movement rules derived from animal observations (Appendix G.1). An overview of the exposure modeling process using JASMINE is shown in Figure 4.

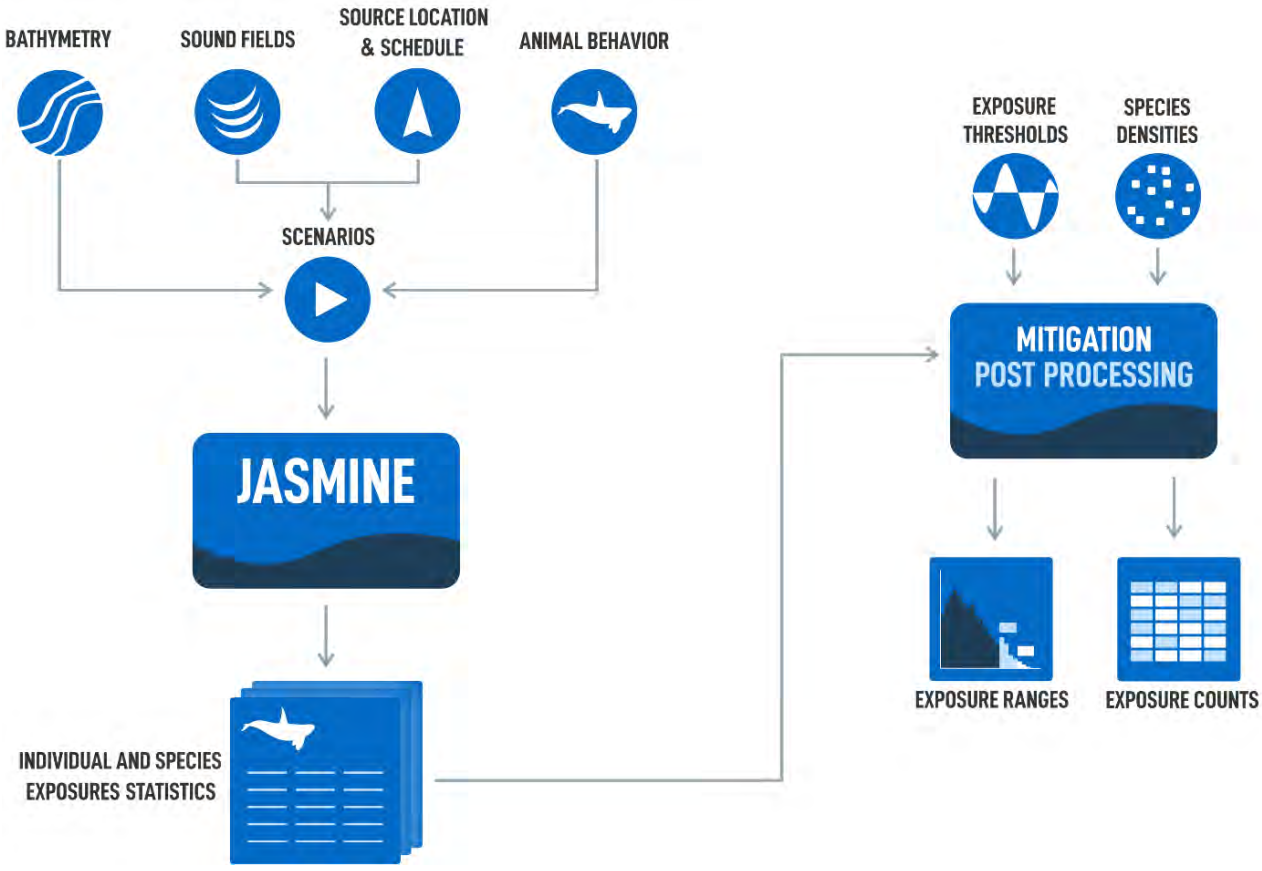

Figure 4. Exposure modeling process overview.

The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, and surface times) were determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. Time-varying, three-dimensional sound fields were sampled by the model receivers in a way that real animals are expected to by programming animats to behave like marine species that may be present near the Project Area. The output of the simulation is the exposure history for each animat within the simulation. An individual animat's sound exposure levels are summed over a specific duration, i.e., 24 h (Appendix G.1), to determine its total received acoustic energy (SEL) and maximum received PK and SPL. These received levels are then compared to the threshold criteria described in Sections 2.5 and 2.6 within each analysis period. Appendix G.1 provides fuller description of animal movement modeling and the parameters used in the JASMINE simulations. Due to shifts in animal density and seasonal sound propagation effects, the number of animals predicted to be impacted by the pile driving operations is sensitive to the number of foundations installed during each month.

JASMINE can be used to simulate aversive behaviors, where animals respond to sound. A subset of scenarios were run with aversion for comparison purposes only (see Section 4.2.1.1.1). All other animal movement modeling results are presented without aversion applied. For this study, the effect of aversion is demonstrated using NARW and harbor porpoise. The NARW species used the same behavioral definitions as the non-aversive scenarios, which included both migratory and foraging behaviors at 75% and 25%, respectively (see Section 3.1 for additional details).

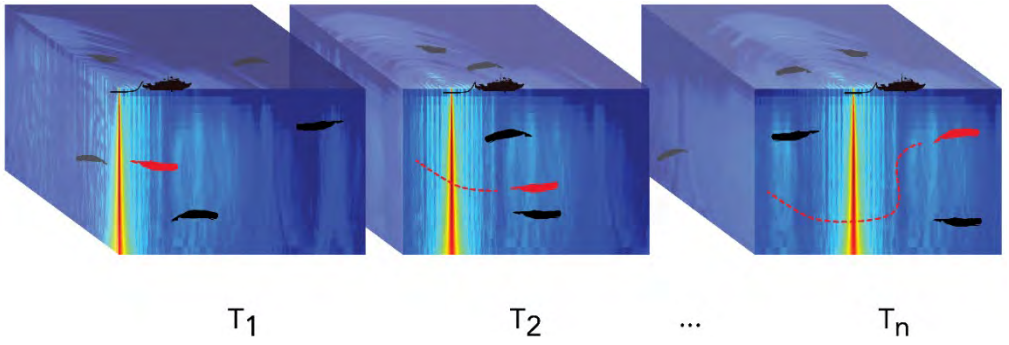

Figure 5. Depiction of animats in an environment with a moving sound field. Example animat (red) shown moving with each time step. The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

2.8. Estimating Monitoring Zones for Mitigation

Monitoring zones for mitigation purposes have traditionally been estimated by determining the acoustic range to injury and behavioral thresholds based only on acoustic information (see Appendix E.6). The traditional method tacitly assumes that all receivers (animals) in the area remain stationary for the duration of the sound event. Where an animal is in a sound field and the pathway it takes through the sound field as it evolves over time determines the received level for each animal, and so treating animals as stationary may not produce realistic estimates for the monitoring zones.

Animal movement and exposure modeling can be used to account for the movement of receivers when estimating distances for monitoring zones. The closest point of approach (CPA) for each of the species-specific animats during a simulation is recorded and then the CPA range that accounts for 95% of the animats that exceed an acoustic impact threshold is determined (Figure 6). The $ER_{95\%}$ (95% Exposure Range) is the horizontal distance that includes 95% of the CPAs of animats exceeding a given impact

threshold. $ER_{95\%}$ is reported for marine mammal and sea turtle species, and for each metric (PK, SEL, and SPL). If used as an exclusion zone, keeping animals farther away from the source than the $ER_{95\%}$ will reduce exposure estimates by 95%.

Unlike marine mammals and sea turtles for which animal movement modeling was performed, fish were considered static (not moving) receivers, so exposure ranges were not calculated. Instead, the acoustic ranges to fish impact criteria thresholds were calculated by determining the isopleth at which thresholds could be exceeded (see Section 4.4).

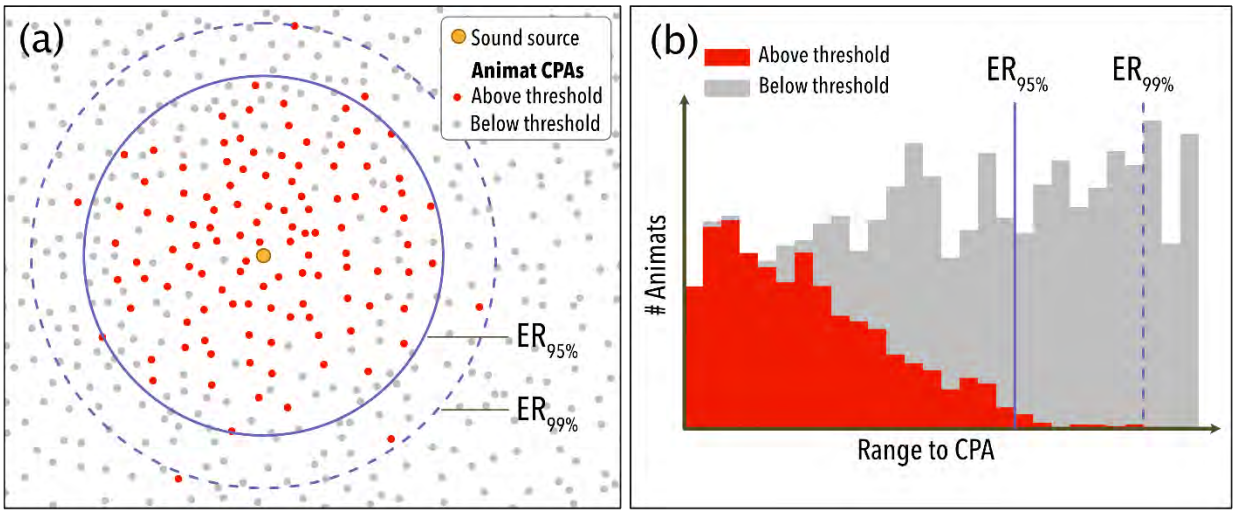

Figure 6. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animats near a sound source. Panel (b) shows the distribution of ranges to animat CPAs. The 95% and 99% Exposure Ranges ($ER_{95\%}$ and $ER_{95\%}$) are indicated in both panels.

3. Marine Fauna Included in the Acoustic Assessment

Marine fauna included in the acoustic assessment are marine mammals (cetaceans and pinnipeds), sea turtles, fish, and invertebrates.

All marine mammal species are protected under the MMPA. Some marine mammal stocks may be designated as Strategic under the MMPA (2015), which requires the jurisdictional agency (NMFS for the Atlantic offshore species considered in this application) 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 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 or threatened species under the Endangered Species Act (2002). Some species are further protected under the ESA (2002).

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" (ESE 2002).

3.1. Marine Mammals that may Occur in the Area

Thirty-eight marine mammal species (whales, dolphins, porpoise, seals, and manatees) comprising 38 stocks have been documented as present (some year–round, some seasonally, and some as occasional visitors) in the Northwest Atlantic Outer Continental Shelf region (CeTAP 1982, USFWS 2014, Roberts et al. 2016a, Hayes et al. 2018). All 38 marine mammal species identified in Table 11 are protected by the MMPA and some are also listed under the ESA. The five ESA-listed marine mammal species known to be present year-round, seasonally, or occasionally in the Project Area waters are the sperm whale (*Physeter macrocephalus*), North Atlantic right whale (NARW) (*Eubalaena glacialis*), fin whale (*Balaenoptera physalus physalus*), blue whale (*Balaenoptera musculus*), and sei whale (*Balaenoptera borealis borealis*). The humpback whale (*Megaptera novaeangliae*), which may occur year-round, has been delisted as an endangered species since September 2016.

Mid-Atlantic waters (including the Project Area [Figure 1]) are primarily used as opportunistic feeding areas or habitat during seasonal migration movements that occur between the more northern feeding areas and the more southern breeding areas typically used by some of the large whale species.

There is limited annual research dedicated to marine mammals in mid-Atlantic waters. These waters are within the known migratory route that NARW use as they travel between feeding and calving grounds (Whitt et al. 2013). One study observed obvious skim feeding behavior in New Jersey waters, suggesting feeding may occur in this area, farther south than the main feeding grounds (Whitt et al. 2013). NARW are also thought to be continuous foragers (Stone et al. 2017). Additionally, acoustic detections confirmed occurrence in this area during all seasons, not just during 'typical' migration periods(Whitt et al. 2013, Davis et al. 2017). Other literature suggests that data collected post-2010 shows an increased NARW presence in the mid-Atlantic region (Davis et al. 2017). This area remains relatively understudied, has only been included in broader regional studies, or been compared to detailed research programs in adjacent waters. Therefore, we used a reasonable approximation for behavior probabilities between foraging and migratory states.

We know from this research that NARW are present near the lease area, however, we do not know how much time they spend feeding, or exactly what other functions this habitat area serves for this species. With the lack of specific metrics regarding behavior states, evaluating the potential impacts of pile driving to NARW in nearshore waters of the mid-Atlantic required two simulations. The first simulation had 25% foraging probability and 75% migrating. The second had 50% foraging and 50% migrating. The results of these two simulations were compared to better understand the effect of this parameter on exposure estimates, and to explore the range of potential impacts due to different behavioral patterns. For the remainder of this assessment, the 25% foraging and 75% migrating simulation is assumed when reporting exposure modeling results. Based on recent publications suggesting the area is primarily a migration corridor with occasional opportunistic feeding (Whitt et al. 2013), this configuration is likely more representative of actual NARW behavior within the Project Area.

Along with cetaceans, seals are protected under the MMPA. The four species of phocids (true seals) that have ranges overlapping the Project Area, are harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), harp seals (*Pagophilus groenlandicus*), and hooded seals (*Cystophora cristata*) (Hayes et al. 2019). One species of sirenian, the Florida manatee (*Trichechus manatus latirostris*) 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 marine mammal species in the Project Area is listed in Table 11. Many of the listed marine mammal species do not commonly occur in this region of the Atlantic Ocean. Species categories include:

- 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; and
- Rare-There are limited species records for some years; range includes the proposed Project area but due to habitat preferences and distribution information, species are not expected to occur in the Project area. Records may exist for adjacent waters.

Marine mammals (cetaceans and pinnipeds), sea turtles, and fish that may occur near the Project area were considered in this assessment. C*ommon* and *uncommon* species (Tables 11 -13) were selected for quantitative assessment by acoustic impact analysis and exposure modeling. Quantitative assessment of *rare* species was not conducted because impacts to those species approach zero due to their low densities. The modeled species are identified in Table 11 (marine mammals) and all species in Table 13 (sea turtles) were modeled. The likelihood of incidental exposure for each species based on its presence, density, and overlap of proposed activities is described in Section 4.2.

Table 11. Marine mammals that may occur in the Project Area.

Species	Scientific name	Stock	Regulatory status[a]	Project area occurrence	Abundance[b]	Modeled Species?
Baleen whales (Mysticeti)						
Blue whale	*Balaenoptera musculus*	West North Atlantic	ESA-Endangered	Rare	402	N
Fin whale	*Balaenoptera physalus*	West North Atlantic	ESA-Endangered	Common	6,802	Y
Humpback whale	*Megaptera novaeangliae*	Gulf of Maine	MMPA	Common	1,396	Y
Minke whale	*Balaenoptera acutorostrata*	Canadian East Coast	MMPA	Common	21,968	Y
North Atlantic right whale	*Eubalaena glacialis*	West North Atlantic	ESA-Endangered	Common	368[c]	Y
Sei whale	*Balaenoptera borealis*	Nova Scotia	ESA-Endangered	Common	6,292	Y
Toothed whales (Odontoceti)						
Sperm whale (Physeteridae)						
Sperm whale	*Physeter macrocephalus*	North Atlantic	ESA-Endangered	Uncommon	4,349	Y
Dolphin Family (Delphinidae)						
Atlantic spotted dolphin	*Stenella frontalis*	West North Atlantic	MMPA	Uncommon	39,921	Y
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	West North Atlantic	MMPA	Common	93,233	Y
Common bottlenose dolphin[d]	*Tursiops truncatus*	West North Atlantic, Offshore	MMPA	Common	62,851	Y
		West North Atlantic, Coastal	MMPA	Common	6,639	Y
Clymene dolphin	*Stenella clymene*	West North Atlantic	MMPA	Rare	4,237	N
False killer whale	*Pseudorca crassidens*	West North Atlantic	MMPA-Strategic	Rare	1,791	N
Fraser's dolphin	*Lagenodelphis hosei*	West North Atlantic	MMPA	Rare	Unknown	N
Killer whale	*Orcinus orca*	West North Atlantic	MMPA	Rare	Unknown	N
Melon-headed whale	*Peponocephala electra*	West North Atlantic	MMPA	Rare	Unknown	N
Pan-tropical spotted dolphin	*Stenella attenuata*	West North Atlantic	MMPA	Rare	6,593	N
Pilot whale, long-finned	*Globicephala melas*	West North Atlantic	MMPA	Uncommon	39,215	Y
Pilot whale, short-finned	*Globicephala macrorhynchus*	West North Atlantic	MMPA	Uncommon	28,924	Y
Pygmy killer whale	*Feresa attenuata*	West North Atlantic	MMPA	Rare	Unknown	N
Risso's dolphin	*Grampus griseus*	West North Atlantic	MMPA	Uncommon	35,215	Y
Rough-toothed dolphin	*Steno bredanensis*	West North Atlantic	MMPA	Rare	136	N
Short-beaked common dolphin	*Delphinus delphis*	West North Atlantic	MMPA	Common	172,974	Y
Spinner dolphin	*Stenella longirostris*	West North Atlantic	MMPA	Rare	4,102	N

Striped dolphin	*Stenella coeruleoalba*	West North Atlantic	MMPA	Rare	67,036	N
Beaked whales (Ziphiidae)						
Cuvier's beaked whale	*Ziphius cavirostris*	West North Atlantic	MMPA	Rare	5,744	N
Blainville's beaked whale	*Mesoplodon densirostris*	West North Atlantic	MMPA	Rare	10,107[e]	N
Gervais' beaked whale	*Mesoplodon europaeus*	West North Atlantic	MMPA			N
Sowerby's beaked whale	*Mesoplodon bidens*	West North Atlantic	MMPA			N
True's beaked whale	*Mesoplodon mirus*	West North Atlantic	MMPA			N
Northern bottlenose whale	*Hyperoodon ampullatus*	West North Atlantic	MMPA	Rare	Unknown	N
Dwarf and pygmy sperm whales (Kogiidae)						
Dwarf sperm whale	*Kogia sima*	West North Atlantic	MMPA	Rare	7,750[f]	N
Pygmy sperm whale	*Kogia breviceps*	West North Atlantic	MMPA	Rare	7,750[f]	N
Porpoises (Phocoenidae)						
Harbor porpoise	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	MMPA	Common	95,543	Y
Earless seals (Phocidae)						
Gray seal	*Halichoerus grypus*	West North Atlantic	MMPA	Common	27,300[g]	Y
Harbor seal	*Phoca vitulina*	West North Atlantic	MMPA	Regular	61,336	Y
Harp seal	*Pagophilus groenlandicus*	West North Atlantic	MMPA	Rare	Unknown[h]	N
Hooded seal	*Cystophora cristata*	West North Atlantic	MMPA	Rare	Unknown	N
Sirenia						
Florida manatee	*Trichechus manatus latirostris*	Florida	ESA-Threatened	Rare	4,834	N

[a] Denotes the highest Federal regulatory classification. A strategic stock is defined as any marine mammal stock: 1) for which level of direct human-caused mortality exceeds the potential biological removal level; 2) that is declining and likely to be listed as threatened under the ESA; or 3) that is listed as threatened or endangered under the ESA or as depleted under the MMPA (NOAA Fisheries 2019).

[b] Best available population estimate is from NOAA Fisheries Stock Assessment Reports (NOAA Fisheries 2021b).

[c] Best available population estimate is from NOAA Fisheries Stock Assessment Reports (NOAA Fisheries 2021b). NARW consortium has released the 2021 report card results predicting a NARW population of 336 for 2020 (Pettis et al. 2022). However, the consortium "alters" the methods (Pace et al. 2017) to subtract additional mortality. This method is used in order to estimate all mortality, not just the observed mortality, therefore the 2021 draft SAR (NOAA Fisheries 2021b) will be used to report an unaltered output of the (Pace et al. 2017, 2021) model (DoC and NOAA 2020).

[d] Common bottlenose dolphins occurring in the Project Area could belong to the either the Western North Atlantic Offshore stock or the Western North Atlantic Coastal Migratory stock.

[e] This estimate includes all undifferentiated Mesoplodon spp. beaked whales in the Atlantic. Kenney and Vigness-Raposa (2009), Rhode Island Ocean Special Area Management Plan, (2011), Hayes et al. (2011, 2013, 2015), Hayes et al. (2017, 2018, 2019, 2020).

[f] This estimate includes both the dwarf and pygmy sperm whales. Source: NOAA Fisheries (2021b).

[g] Estimate of gray seal population in US waters. Data are derived from pup production estimates. NOAA Fisheries (2021b) notes that uncertainty about the relationship between whelping areas along with a lack of reproductive and mortality data make it difficult to reliably assess the population trend.

[h] NOAA Fisheries (2021b) report insufficient data to estimate the population size of harp seals in US waters; the best estimate for the entire Western North Atlantic population is 7.6 million.

3.2. Mean Monthly Marine Mammal Density Estimates

Mean monthly marine mammal density estimates (animals per 100 square kilometers [animals/100 km^2]) for all species are provided in Table 12. These were obtained using the Duke University Marine Geospatial Ecology Laboratory model results (Roberts et al. 2016a, 2016b, 2017, 2018, 2021a, 2021b) and include recently updated model results for NARW. The 2021 updated model (v11.1) includes new estimates for NARW abundance in Cape Cod Bay in December. Additionally, model predictions are summarized over three eras, 2003–2018, 2003–2009, and 2010–2018, to reflect the apparent shift in NARW distribution around 2010. The modeling conducted in support of this LOA application used the 2010–2018 density predictions.

Densities were calculated within a 3.9 km buffered polygon around the OCS-A 0499 lease area perimeter. The buffer size was selected as the largest 10 dB-attenuated exposure range over all species, scenarios, and threshold criteria, with the exception of the Wood et al. (2012) thresholds. Wood et al. (2012) exposure ranges were not considered in this estimate since they include a small subset of very long ranges for migrating mysticetes and harbor porpoise. The mean density for each month was determined by calculating the unweighted mean of all 10 × 10 km (5 × 5 km for NARW) grid cells partially or fully within the analysis polygon (Figure 7). Densities were computed monthly, annually, and for the May–December period to coincide with proposed pile driving activities. For long- and short-finned pilot whales, monthly densities are unavailable from Roberts et al. (2016a, 2016b, 2017), so annual mean densities were used. Additionally, Roberts et al. (2016a, 2016b, 2017) provide density for pilot whales as a guild that includes both species. To obtain density estimates for long-finned and short-finned pilot whales, the guild density from Roberts et al. (2016a, 2016b, 2017) was scaled by the relative stock sizes based on the best available abundance estimate from NOAA Fisheries SARs (NOAA Fisheries 2021b). Equation 1 shows an example of how abundance scaling is applied to compute density for short-finned pilot whales:

$$d_{short-finned} = d_{both}\left(\frac{a_{short-finned}}{a_{short-finned} + a_{long-finned}}\right), \quad (1)$$

where a represents abundance and d represents density. Similarly, densities are provided for 20 ms as a guild consisting primarily of harbor and gray seals (Roberts et al. 2016a, 2018). Gray and harbor seal densities were scaled by relative NOAA Fisheries SARs (NOAA Fisheries 2021b) abundance.

There are two stocks of bottlenose dolphins near the Project Area, coastal and offshore, but only one density model from Roberts et al. (2016a, 2018). Density for the two stocks was calculated by splitting the buffer area at the 20-m isobath and estimating densities for the buffered area shallower than 20 m for the coastal stock and deeper than 20 m for the offshore stock. Animal movement simulations were run for each stock separately with the same behavior definitions. Exposure ranges, therefore, are very similar for the two stocks, differing only because of different random seeds.

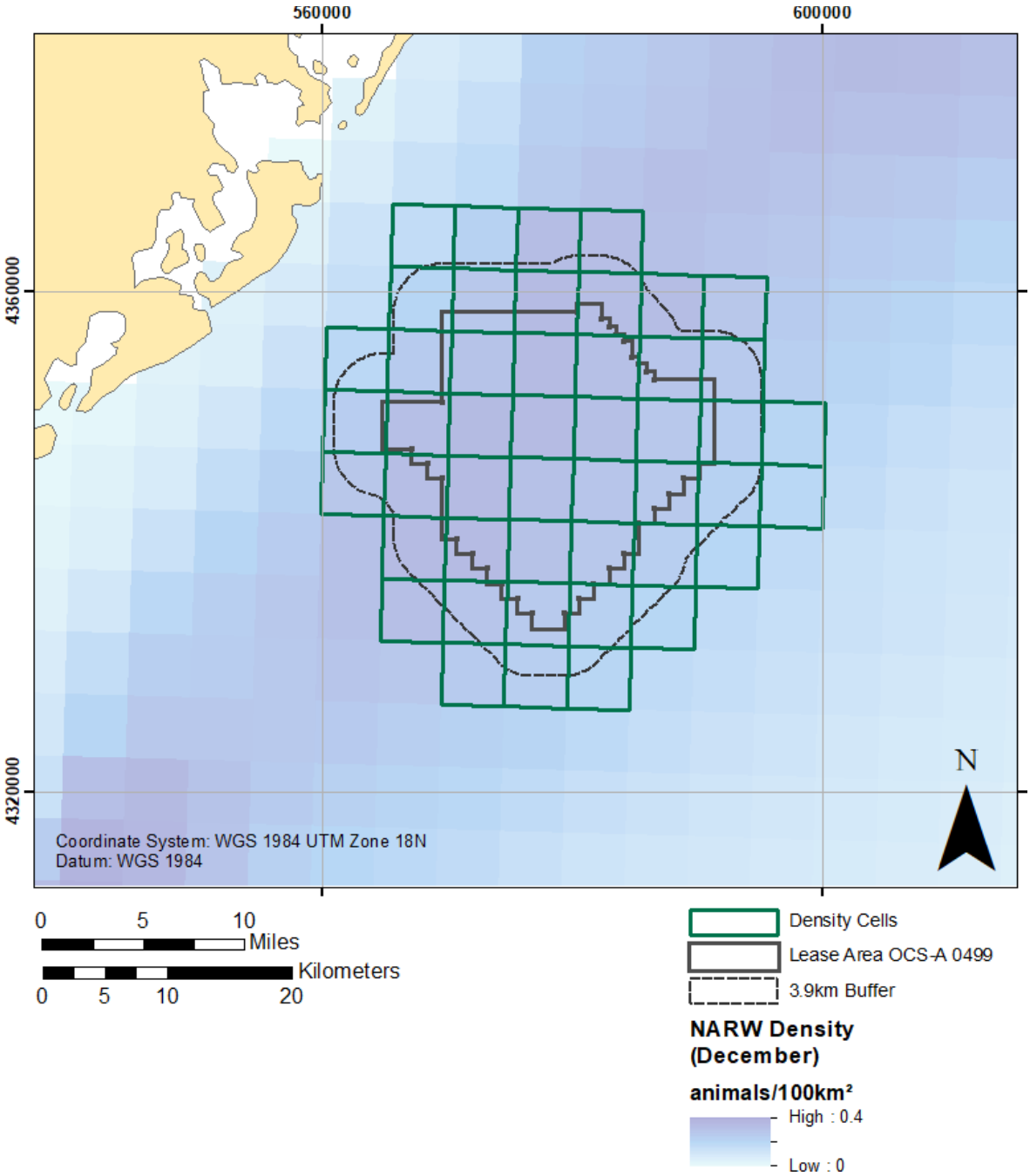

Figure 7. Marine mammal (e.g., NARW) density map showing highlighted grid cells used to calculate mean monthly species estimates within a 3.9 km buffer around the OCS-A 0499 lease area (Roberts et al. 2016a, 2016b, 2017, 2018, 2021a, 2021b).

Table 12. Mean monthly marine mammal density estimates for all modeled species within a 3.9 km buffer around the Atlantic Shores OCS-A 0499 Lease Area.

Species		Monthly density (animals/100 km²)[a]												Annual mean	May to Dec mean
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
LF	Fin whale[b]	0.076	0.071	0.103	0.13	0.13	0.169	0.127	0.077	0.13	0.129	0.071	0.07	0.107	0.113
	Minke whale	0.025	0.03	0.028	0.09	0.105	0.055	0.008	0.004	0.009	0.029	0.012	0.018	0.035	0.03
	Humpback whale	0.072	0.048	0.042	0.025	0.031	0.025	0.008	0.006	0.018	0.04	0.025	0.083	0.035	0.03
	North Atlantic right whale[b]	0.562	0.628	0.685	0.607	0.059	0.004	0.002	0.001	0.002	0.003	0.026	0.275	0.238	0.047
	Sei whale[b]	0.001	0.001	0.000	0.008	0.006	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.001
MF	Atlantic spotted dolphin	0.004	0.002	0.006	0.02	0.028	0.075	0.109	0.2	0.198	0.064	0.051	0.013	0.064	0.092
	Atlantic white-sided dolphin	0.264	0.177	0.314	0.955	0.815	0.549	0.075	0.029	0.092	0.329	0.424	0.464	0.374	0.347
	Short-beaked common dolphin	4.975	1.513	1.118	1.985	2.197	2.133	2.31	2.424	1.924	4.07	4.702	8.674	3.169	3.554
	Bottlenose dolphin, coastal[c]	2.161	0.046	0.295	3.317	10.28	25.867	36.422	48.858	23.321	10.414	10.093	4.309	14.615	21.196
	Bottlenose dolphin, offshore[c]	1.597	0.149	0.271	1.224	2.976	8.075	10.01	13.946	9.101	4.332	3.289	2.007	4.748	6.717
	Risso's dolphin	0.003	0.002	0.001	0.001	0.003	0.004	0.023	0.026	0.009	0.003	0.004	0.007	0.007	0.01
	Long-finned pilot whale[d]	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
	Short-finned pilot whale[d]	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
	Sperm whale[b]	0.000	0.000	0.000	0.001	0.004	0.016	0.02	0.017	0.017	0.008	0.004	0.001	0.007	0.011
HF	Harbor porpoise	2.34	4.438	5.626	2.345	0.501	0.01	0.02	0.026	0.008	0.112	1.539	2.358	1.61	0.572
PPW	Gray seal[d]	1.706	2.285	1.501	0.669	0.185	0.095	0.003	0.001	0.005	0.061	0.079	1.048	0.636	0.185
	Harbor seal[d]	3.833	5.133	3.373	1.504	0.415	0.213	0.008	0.003	0.011	0.136	0.178	2.354	1.43	0.415

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016a, 2016b, 2017, 2018, 2021b).
[b] Listed as Endangered under the ESA.
[c] For bottlenose dolphins, the 3.9 km buffer was split at the 20 m isobath: coastal, < 20 m; offshore >20 m.
[d] Density adjusted by relative abundance.

3.3. Sea Turtles and Fish Species of Concern that May Occur in the Area

Four species of sea turtles may occur in the Project Area that are listed as threatened or endangered: Loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*). Many species of sea turtle prefer coastal waters; however, both the leatherback and loggerhead sea turtles are known to occupy deep-water habitats and are considered common during summer and fall in the Project Area. Kemp's ridley sea turtles are thought to be regular visitors during those seasons. Although uncommon, individual green turtles can be found in the Project Area in the summer and fall when water temperatures are highest.

There are four federally listed threatened or endangered fish species that may occur off the northeast Atlantic coast, including the shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Atlantic salmon (*Salmo salar*), and giant manta ray (*Manta birostris*).

Atlantic sturgeon distribution varies by season, but they are primarily found in shallow coastal waters (bottom depth less than 20 m) during the summer months (May to September) and move to deeper waters (20–50 m) in winter and early spring (December to March) (Dunton et al. 2010). Shortnose sturgeon occur primarily in fresh and estuarine waters and occasionally enter the coastal ocean. Adults ascend rivers to spawn from February to April, and eggs are deposited over hard bottom, in shallow, fast-moving water (Dadswell et al. 1984). Because of their preference for mainland rivers and fresh and estuarine waters, shortnose sturgeon are unlikely to be found in the vicinity of the Project Area. Atlantic salmon is an anadromous species that historically ranged from northern Quebec southeast to Newfoundland and southwest to Long Island Sound. The Gulf of Maine distinct population segment of the Atlantic salmon that spawns within eight coastal watersheds within Maine is federally listed as endangered. In 2009, the distinct population segment was expanded to include all areas of the Gulf of Maine between the Androscoggin River and the Dennys River (NOAA Fisheries 2021a). Only certain Gulf of Maine populations are listed as endangered, and Gulf of Maine salmon are unlikely to be encountered south of Cape Cod (BOEM 2014b). The giant manta ray is found worldwide in tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines. As such, giant manta rays can be found in cool water, as low as 19 °C, although temperature preference appears to vary by region. For example, off the US East Coast, giant manta rays are commonly found in waters from 19 to 22 °C (66.2 to 71.6°F), whereas those offthe Yucatan peninsula and Indonesia are commonly found in waters between 25 to 30 °C (77 to 86°F). Individuals have been observed as far north as New Jersey in the Western Atlantic basin indicating that the Offshore Development Area is located at the northern boundary of the species' range (NOAA Fisheries 2021c).

Table 13. Sea turtle species potentially occurring within the regional waters of the Western North Atlantic Outer Continental Shelf (OCS) and Project Area.

Species	Scientific name	Regulatory status[a]	Relative occurrence in Project Area
Leatherback sea turtle[b]	*Dermochelys coriacea*	ESA Endangered	Common
Loggerhead sea turtle[b]	*Caretta caretta*	ESA Threatened	Common
Kemp's ridley sea turtle[b]	*Lepidochelys kempii*	ESA Endangered	Uncommon
Green sea turtle[b]	*Chelonia mydas*	ESA Threatened	Uncommon

[a] Listing status as stated in NOAA Fisheries n.d., MA NHESP 2019; RI DEM 2011; NYSDEC 2020a
[b] Modeled species.

3.4. Sea Turtle Density Estimates

There are limited density estimates for sea turtles in the Project Area. The Project Area is in the Mid-Atlantic North region defined in NEFSC and SEFSC (2011) for sea turtle distribution. Sea turtles are expected to be present in the Project Area during summer and fall months due to seasonal habitat use, with sea turtles moving to warmer water habitats in the winter months (Hawkes et al. 2007, Dodge et al. 2014, DoN, 2017). Sea turtles were most commonly observed in summer and fall, absent in winter, and nearly absent in spring during the Kraus et al. (2016) aerial surveys of the MA WEA and RI/MA WEAs. Kraus et al. (2016) reported that leatherback and loggerhead sea turtles were the most commonly observed turtle species with an additional six Kemp's ridley sea turtles identified over five years.

South of the MA WEA, in the New York Bight, a multi-year series of seasonal aerial surveys were conducted by Normandeau associates for the New York State Energy Research and Development Authority (NYSERDA; Normandeau Associates Inc. and APEM Inc. 2018, Normandeau Associates Inc. and APEM Inc. 2019a, 2019b, Normandeau Associates Inc. and APEM Ltd. 2019, Normandeau Associates Inc. and APEM Inc. 2020)(Normandeau Associates and APEM 2018, 2019a, 2019b, 2019, 2020) The purpose of the aerial surveys was to gather high resolution data on marine resources within the offshore planning area (OPA) off Long Island, New York. High-resolution digital aerial photographs were collected along specific line transects each season for three consecutive years.

Four turtle species were reported as being present in the area during the NYSERDA surveys: loggerhead turtle, leatherback turtle, Kemp's ridley turtle, and green turtle. To obtain the densities used in the current study, we extracted the maximum seasonal abundance for each species. The abundance was corrected to represent the abundance in the entire OPA then scaled by the full OPA area to obtain a density in units of animals per square kilometer. Two categories listed in the reports included more than one species: one combined loggerhead and Kemp's ridley turtles, and the other included turtles that were observed but not identified to the species level. The counts within the two categories that included more than one species were distributed amongst the relevant species with a weighting that reflected the recorded counts for each species. For example, loggerhead turtles were identified far more frequently than any other species, therefore more of the unidentified counts were assigned to them. The underlying assumption is that a given sample of unidentified turtles would have a distribution of species that was similar to the observed distribution within a given season.

They NYSERDA study (Normandeau Associates and APEM 2018, 2019a, 2019b, 2019, 2020) reported that in the survey area, most of the sea turtles recorded were loggerhead sea turtles, by an order of magnitude. Seasonal sea turtle densities used in animal movement modeling are listed in Table 14 for loggerhead, leatherback, Kemp's ridley, and green sea turtles.

Table 14. Sea turtle density estimates derived from NYSERDA annual reports.

Common name	Density (animals/100 km²)[a]			
	Spring	Summer	Fall	Winter
Kemp's ridley sea turtle[b]	0.050	0.991	0.190	0.000
Leatherback sea turtle[b]	0.000	0.331	0.789	0.000
Loggerhead sea turtle	0.254	26.799	0.190	0.025
Green turtle	0.000	0.038	0.000	0.000

[a] Densities calculated from NYSERDA aerial survey reports (Normandeau Associates and APEM 2018, 2019a, 2019b, 2019, 2020)

[b] Listed as Endangered under the ESA.

4. Results

Acoustic fields produced by impact pile driving for jacket and monopile foundations (WTG and OSS) were modeled at two sites representing the range of water depths within the Project Area (see Table 2 and Figure 2). This section summarizes the source modeling results (see Section 4.1), animal movement modeling results for marine mammals and sea turtles (Sections 4.2 and 4.3), and the acoustic radial distance to threshold for fish (Section 4.4). The report tables indicate whether the Wood step function thresholds for migrating mysticetes were used (NARW only).

4.1. Modeled Source Levels

4.1.1. Impact Pile Driving

Forcing functions were computed for each pile diameter (5, 12, and 15 m) at the two modeling locations, L01 and L02, using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). Resulting forcing functions versus time are shown in Figures 8 to9, and modeling parameters and assumptions are listed in Appendix B.1. The model assumed direct contact between the representative hammers, helmets, and piles (i.e., no cushion material). The forcing functions serve as the inputs to JASCO's pile driving source models used to estimate equivalent acoustic source characteristics detailed in Appendix E.1. Decidecade spectral source levels for each pile diameter, hammer energy, and modeled location for summer sound speed profiles are shown in Figures 11 to 13.

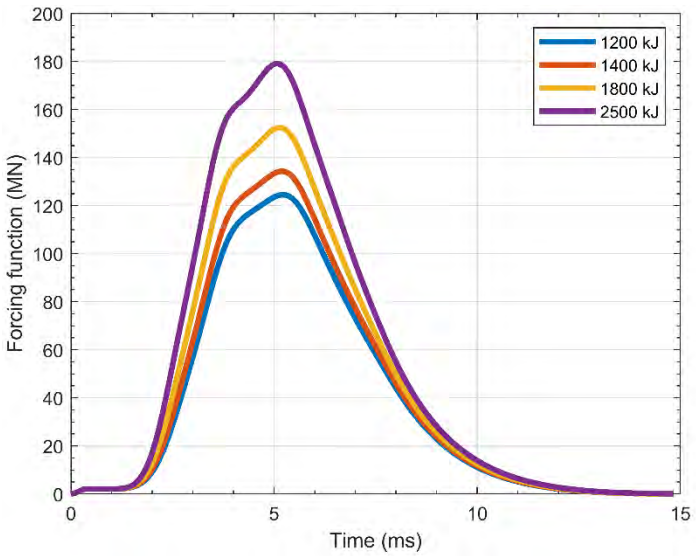

Figure 8. Modeled forcing functions versus time for a 5 m jacket foundation pile as a function of hammer energy.

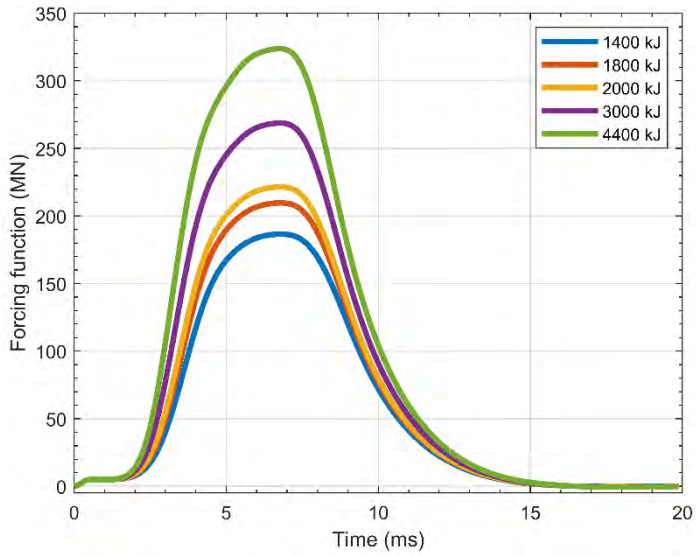

Figure 9. Modeled forcing functions versus time for a 12 m monopile as a function of hammer energy.

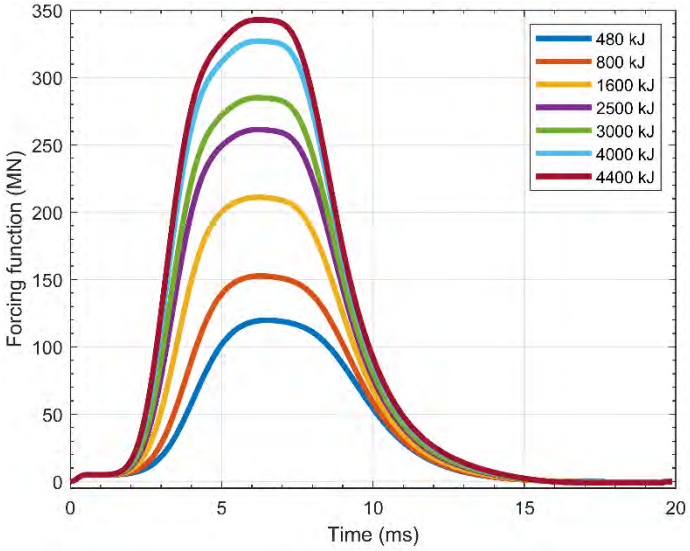

Figure 10. Modeled forcing functions versus time for a 15 m monopile as a function of hammer energy.

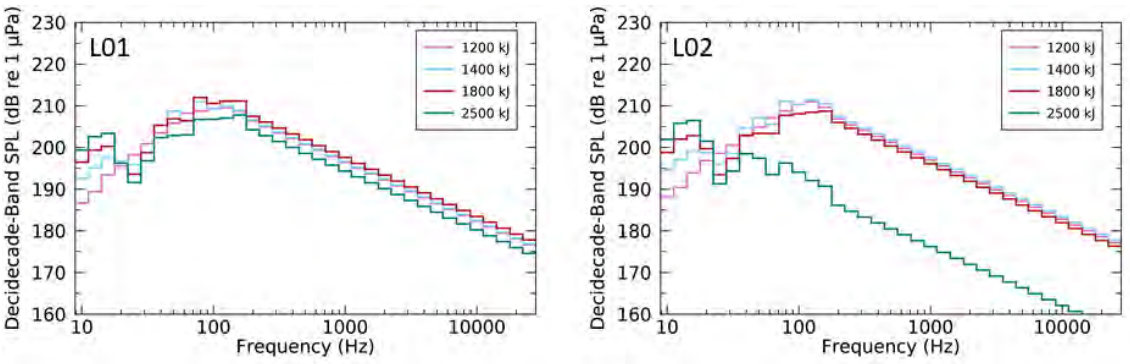

Figure 11. Decidecade band spectral source levels for 5 m jacket foundation pile installation using 2,500 kJ hammer energy at locations L01 and L02 (see Figure 2) with an average summer sound speed profile.

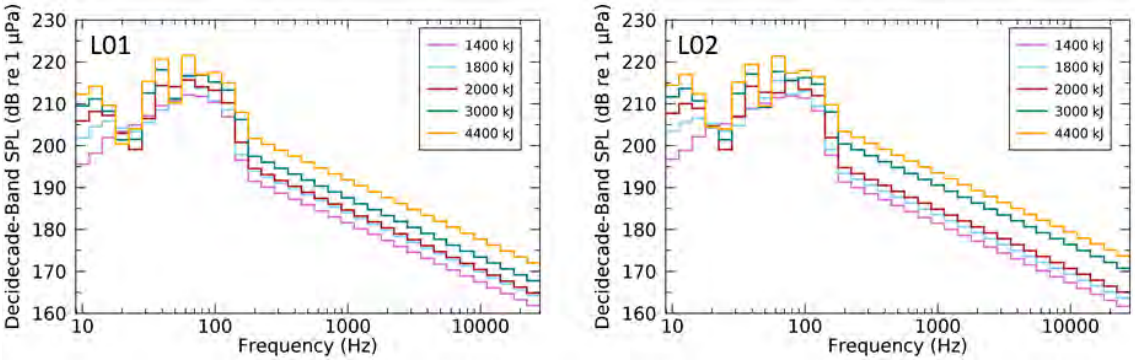

Figure 12. Decidecade band spectral source levels for 12 m monopile installation using 4,400 kJ hammer energy hammer energy at locations L01 and L02 (see Figure 2) with an average summer sound speed profile.

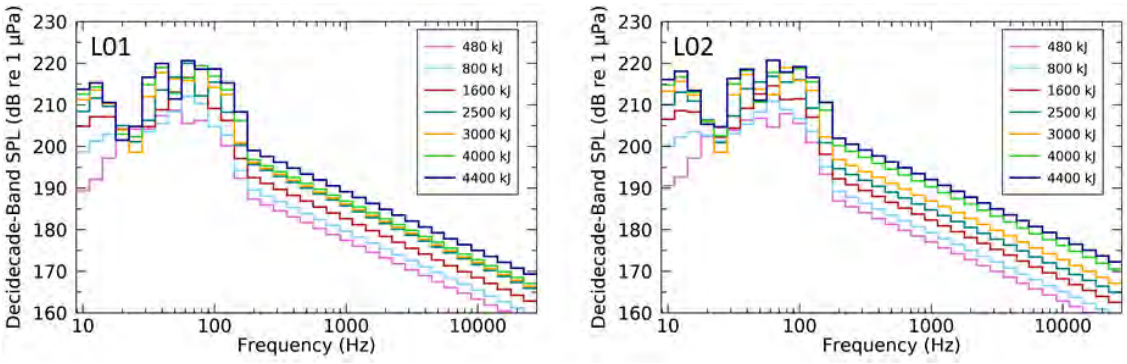

Figure 13. Decidecade band spectral source levels for 15 m monopile installation using 4,400 kJ hammer energy hammer energy at locations L01 and L02 (see Figure 2) with an average summer sound speed profile.

4.2. Exposure Estima tes

The number of real-world animals predicted to exceed thresholds, the exposure estimates, were calculated for marine mammals and sea turtles. The exposure estimates are derived by scaling the number of animats exceeding threshold by the ratio of the real-world density (see Sections 3.2 and 3.4) to the modeling density (see Appendix G.1.3). Exposure estimates of exactly "0" indicate that there were no modeled exposures above threshold. If the exposure estimate is "<0.01", there were exposures above threshold but the number of exposures was less than 0.01.

Sections 4.2.1.1 and 4.2.1.2 include results for each species and metric, assuming broadband attenuation of 0, 6, 10, and 15 dB using a summer season sound speed profile for each of the proposed construction schedules (Section 1.2.4). For yearly results, see Appendix G.2.

4.2.1. Full Buildout

This section contains the marine mammals and sea turtle exposure estimates for the two year duration of the Project, for each of the proposed construction schedules, for the full buildout of the Project (Table 3). For yearly results, please see Appendix G.2.

4.2.1.1. Marine Mammals

Table 15. Construction schedule 1 – Full buildout: the mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	13.38	8.20	5.06	2.22	0.13	<0.01	0	0	25.25	18.32	14.76	11.60	22.21	15.09	11.69	8.54
	Minke whale	131.42	51.72	18.13	3.60	0.22	<0.01	0	0	382.56	289.91	236.61	186.27	283.48	207.28	164.82	126.06
	Humpback whale	13.28	7.40	3.93	1.40	0.09	0.02	0	0	27.26	19.20	14.79	10.91	21.48	15.03	11.54	8.39
	North Atlantic right whale[c] (migrating)	1.31	0.53	0.25	0.06	<0.01	<0.01	<0.01	<0.01	3.83	2.74	2.11	1.61	7.28	5.69	4.72	3.75
	Sei whale[c]	1.59	0.97	0.60	0.26	0.02	<0.01	0	0	3.07	2.23	1.80	1.41	2.70	1.83	1.43	1.04
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.04	0.02	0.02	0	0	0	0	0	481.01	354.22	284.27	219.12	207.45	142.02	106.26	67.06
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	20.89	5.62	1.35	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1529.64	758.06	90.75	0	688.91	325.24	201.49	95.76
	Bottlenose dolphin, offshore	3.52	0	0	0	4.10	0	0	0	10058.16	7324.04	5680.28	4025.82	4225.52	2751.77	1960.99	1267.89
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	16.39	12.02	9.70	7.42	7.08	4.86	3.67	2.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	24.89	8.38	2.45	0.69	13.44	5.84	2.93	0.67	128.86	94.18	76.24	57.97	338.56	255.23	208.32	158.48
PPW	Gray seal	19.84	5.00	0.97	0.39	0.75	0	0	0	339.18	227.19	165.80	123.78	212.32	134.77	101.67	69.23
	Harbor seal	59.96	11.21	2.42	0.12	3.97	0.82	0	0	793.88	525.63	396.48	296.64	493.43	317.29	240.26	164.17

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table 16. Construction schedule 2 – Full buildout: the mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p[a]				L_p[b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	17.65	10.36	6.26	2.74	0.09	<0.01	0	0	29.45	21.25	17.43	12.88	25.95	17.41	13.40	9.50
	Minke whale	182.08	72.83	26.34	4.96	0.22	<0.01	0	0	460.94	340.02	277.09	201.85	335.72	240.32	192.84	142.19
	Humpback whale	19.18	10.03	5.22	1.85	0.07	0.01	0	0	34.37	23.45	18.15	12.43	27.03	18.40	14.23	9.98
	North Atlantic right whale[c] (migrating)	1.96	0.80	0.39	0.09	<0.01	<0.01	<0.01	<0.01	4.80	3.27	2.54	1.72	10.02	7.66	6.35	4.89
	Sei whale[c]	2.13	1.25	0.75	0.33	0.01	<0.01	0	0	3.60	2.60	2.14	1.58	3.18	2.13	1.64	1.17
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.17	0.09	0.02	0	0	0	0	0	572.29	406.89	331.31	236.36	283.45	196.06	143.94	89.99
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	31.21	11.49	1.35	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1825.67	511.58	50.32	0	1154.48	575.37	357.73	165.27
	Bottlenose dolphin, offshore	9.00	0	0	0	2.28	0	0	0	11913.17	8329.22	6517.32	4250.61	5822.29	3879.40	2757.82	1735.93
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	19.76	14.15	11.61	8.42	10.04	6.97	5.18	3.31
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	56.32	27.61	13.91	3.54	12.98	5.13	2.26	0.56	153.85	109.80	89.08	64.21	466.34	359.16	297.00	229.83
PPW	Gray seal	46.51	13.05	2.52	0.25	0.60	0	0	0	392.52	252.87	192.76	134.08	264.91	168.05	128.50	82.30
	Harbor seal	119.22	30.44	8.32	0.74	3.04	0.51	0	0	915.50	592.33	448.91	310.91	612.51	393.09	298.40	194.39

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table 17. Construction schedule 3 – Full buildout: the mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	13.01	7.72	4.67	2.03	0.11	0.01	0	0	23.53	17.53	14.36	11.35	20.31	13.92	10.93	8.11
	Minke whale	127.66	48.74	16.20	3.41	0.56	0.02	0	0	371.22	285.86	235.02	186.49	273.38	202.07	161.54	123.99
	Humpback whale	11.96	6.42	3.40	1.21	0.10	0.02	<0.01	<0.01	24.27	17.14	13.32	9.94	18.88	13.21	10.23	7.52
	North Atlantic right whale[c] (migrating)	1.24	0.52	0.24	0.06	<0.01	<0.01	<0.01	<0.01	3.57	2.56	2.00	1.50	6.61	5.19	4.36	3.47
	Sei whale[c]	1.44	0.86	0.52	0.22	0.01	<0.01	0	0	2.70	2.00	1.64	1.29	2.34	1.60	1.26	0.93
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	412.93	309.91	251.58	195.61	175.95	121.34	90.81	57.22
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	18.28	4.72	0.99	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1459.21	745.16	80.00	0	654.84	321.84	195.58	96.95
	Bottlenose dolphin, offshore	3.52	0	0	0	2.48	1.62	1.62	0	9354.05	6799.51	5330.67	3920.78	3956.25	2666.46	1907.97	1196.28
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	14.12	10.53	8.58	6.69	6.16	4.28	3.25	2.11
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	25.79	7.38	2.11	0.54	13.74	5.54	2.55	0.68	136.99	101.33	81.88	62.80	336.58	256.56	210.94	163.28
PPW	Gray seal	17.15	3.64	0.60	0.21	1.01	0.09	0	0	322.34	217.39	161.06	118.79	196.20	126.68	96.20	65.28
	Harbor seal	53.73	9.70	1.91	0.28	4.19	0.82	0	0	751.38	502.70	378.76	279.21	456.17	296.70	224.52	153.13

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

4.2.1.1.1. Effect of Aversion

The mean exposure estimates reported in Section 4.2.1.1 do not consider animals avoiding loud sounds (aversion) or implementation of mitigation measures other than sound attenuation using NAS. Some marine mammals are well known for their aversive responses to anthropogenic sound (e.g., harbor porpoise), although it is assumed that most species will avert from noise. The Wood et al. (2012) step function includes a probability of response that is based primarily on observed aversive behavior in field studies (see Appendix G.1.2 for more details). Additional exposure estimates with aversion based on the Wood et al. (2012) response probabilities were calculated for harbor porpoise and NARW in this study. For comparative purposes only, the results are shown with and without aversion in Table 18.

Table 18. Construction schedule 2 – Full buildout: mean exposure estimates with and without aversion for NARW and harbor porpoise. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	10 dB attenuation – no aversion				10 dB attenuation – with aversion			
	Injury		Behavior		Injury		Behavior	
	L_E	L_{pk}	L_p [a]	L_p [b]	L_E	L_{pk}	L_p [a]	L_p [b]
North Atlantic right whale[a] (migrating)	0.39	<0.01	2.54	6.35	0.11	0	2.07	6.11
Harbor porpoise (sensitive)	13.91	2.26	89.08	297.00	0.02	0	4.86	206.44

[a] NOAA (2005), [b] Wood et al. (2012) [a] Listed as Endangered under the ESA

4.2.1.2. Sea Turtles

Table 19. Construction schedule 1 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	37.59	9.52	1.96	1.25	0	0	0	0	131.73	73.96	47.13	20.86
Leatherback turtle[a]	12.96	2.73	0.95	0.48	0	0	0	0	73.57	40.86	24.42	9.36
Loggerhead turtle	248.11	65.06	9.01	9.01	0	0	0	0	3157.44	1562.74	815.64	378.05
Green turtle	1.46	0.48	0.11	0.03	0.01	0	0	0	4.05	2.24	1.32	0.65

[a] Listed as Endangered under the ESA.

Table 20. Construction schedule 2 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	35.75	7.51	1.96	0.75	0	0	0	0	139.94	72.45	41.60	17.68
Leatherback turtle[a]	12.27	2.44	0.76	0.38	0	0	0	0	78.97	38.80	21.67	8.67
Loggerhead turtle	256.27	52.83	4.93	4.93	0	0	0	0	3336.89	1530.11	787.10	345.42
Green turtle	1.36	0.36	0.08	0.03	<0.01	0	0	0	4.10	1.99	1.16	0.49

[a] Listed as Endangered under the ESA.

Table 21. Construction schedule 3 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	41.12	9.37	2.32	0.80	0.17	0	0	0	136.20	79.57	50.18	23.16
Leatherback turtle[a]	13.28	2.72	1.14	0.30	0	0	0	0	72.25	38.95	23.01	9.66
Loggerhead turtle	298.31	51.06	14.29	5.69	0	0	0	0	2943.18	1582.13	914.12	442.21
Green turtle	1.51	0.50	0.15	0.03	<0.01	0	0	0	3.98	2.30	1.44	0.65

[a] Listed as Endangered under the ESA.

4.2.2. Project 1 Plus Overlap

This section contains the marine mammals and sea turtle exposure estimates for the two year duration of Project 1 plus the overlap area, for each of the proposed construction schedules (Table 4). For yearly results, please see Appendix G.2.

4.2.2.1. Marine Mammals

Table 22. Construction schedule 1 – Project 1 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table 23. Construction schedule 2 – Project 1 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p[a]				L_p[b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table 24. Construction schedule 3 – Project 1 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	9.14	5.42	3.28	1.43	0.08	<0.01	0	0	16.57	12.34	10.11	7.99	14.30	9.81	7.70	5.71
	Minke whale	112.30	42.85	14.23	2.99	0.48	0.02	0	0	327.21	251.95	207.12	164.38	241.03	178.15	142.40	109.31
	Humpback whale	7.39	3.96	2.10	0.75	0.06	<0.01	<0.01	<0.01	14.82	10.45	8.12	6.06	11.52	8.05	6.24	4.58
	North Atlantic right whale[c] (migrating)	0.70	0.29	0.13	0.03	<0.01	<0.01	<0.01	<0.01	2.00	1.43	1.12	0.84	3.69	2.90	2.44	1.94
	Sei whale[c]	0.91	0.54	0.33	0.14	<0.01	<0.01	0	0	1.69	1.25	1.02	0.81	1.46	1.00	0.79	0.58
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	281.73	211.10	171.42	132.96	121.99	84.21	63.05	39.75
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	12.92	3.42	0.81	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	758.59	388.98	42.66	0	333.28	164.36	99.34	49.34
	Bottlenose dolphin, offshore	1.75	0	0	0	1.40	0.86	0.86	0	5067.93	3688.24	2890.97	2127.78	2130.65	1433.67	1025.29	643.04
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.97	5.20	4.24	3.31	3.05	2.13	1.61	1.05
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	20.95	5.84	1.64	0.41	11.20	4.48	2.03	0.55	112.11	83.04	67.10	51.51	273.05	208.40	171.49	133.01
PPW	Gray seal	12.62	2.70	0.45	0.15	0.74	0.07	0	0	235.44	158.76	117.66	86.75	143.30	92.56	70.31	47.69
	Harbor seal	39.48	7.20	1.44	0.21	3.06	0.60	0	0	548.73	367.15	276.57	203.80	333.18	216.74	164.02	111.83

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

4.2.2.2. Sea Turtles

Table 25. Construction schedule 1 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table 26. Construction schedule 2 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table 27. Construction schedule 3 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	27.95	6.43	1.57	0.57	0.11	0	0	0	92.64	54.18	34.29	15.80
Leatherback turtle[a]	4.95	1.01	0.43	0.11	0	0	0	0	26.87	14.47	8.55	3.60
Loggerhead turtle	215.62	38.19	10.43	4.45	0	0	0	0	2161.96	1159.54	666.95	321.73
Green turtle	1.11	0.37	0.11	0.02	<0.01	0	0	0	2.93	1.70	1.06	0.49

[a] Listed as Endangered under the ESA.

4.2.3. Project 2 Plus Overlap

This section contains the marine mammals and sea turtle exposure estimates for the two year duration of Project 2 plus the overlap area, for each of the proposed construction schedules (Table 4). For yearly results, please see Appendix G.2.

4.2.3.1. Marine Mammals

Table 28. Construction schedule 1 – Project 2 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	6.34	3.88	2.40	1.05	0.06	<0.01	0	0	11.92	8.65	6.97	5.47	10.49	7.13	5.51	4.03
	Minke whale	57.69	22.90	8.12	1.62	0.10	<0.01	0	0	165.67	125.38	102.27	80.35	122.66	89.60	71.23	54.45
	Humpback whale	6.64	3.70	1.97	0.70	0.04	<0.01	0	0	13.63	9.60	7.40	5.45	10.74	7.51	5.77	4.20
	North Atlantic right whale[c] (migrating)	0.71	0.29	0.13	0.03	<0.01	<0.01	<0.01	<0.01	2.08	1.49	1.15	0.87	3.95	3.09	2.57	2.04
	Sei whale[c]	0.86	0.53	0.33	0.14	<0.01	<0.01	0	0	1.68	1.22	0.98	0.77	1.47	1.00	0.78	0.57
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	235.71	173.53	139.26	107.31	101.80	69.70	52.15	32.91
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.30	3.00	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	732.72	362.37	43.03	0	333.07	157.03	97.51	46.31
	Bottlenose dolphin, offshore	1.76	0	0	0	1.95	0	0	0	4825.96	3512.23	2723.97	1929.36	2033.02	1324.80	944.32	610.54
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.85	7.23	5.84	4.47	4.22	2.90	2.19	1.40
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	12.31	4.15	1.22	0.34	6.64	2.89	1.44	0.33	63.64	46.51	37.65	28.63	167.24	126.09	102.91	78.29
PPW	Gray seal	9.99	2.52	0.49	0.20	0.38	0	0	0	171.26	114.72	83.72	62.50	107.19	68.04	51.33	34.95
	Harbor seal	30.23	5.64	1.22	0.06	2.01	0.41	0	0	400.85	265.41	200.21	149.80	249.12	160.19	121.30	82.89

[a] NOAA (2005), [b] Wood et al. (2012) [c] Listed as Endangered under the ESA

Table 29. Construction schedule 2 – Project 2 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	10.96	6.23	3.70	1.62	0.02	<0.01	0	0	16.47	11.82	9.86	6.86	14.53	9.63	7.37	5.07
	Minke whale	108.99	44.27	16.44	3.00	0.10	<0.01	0	0	245.03	176.11	143.27	96.13	175.57	123.05	99.60	70.78
	Humpback whale	13.58	6.79	3.47	1.23	0.02	<0.01	0	0	21.99	14.60	11.35	7.25	17.27	11.47	8.93	6.06
	North Atlantic right whale[c] (migrating)	1.60	0.66	0.32	0.07	<0.01	0	0	0	3.41	2.21	1.74	1.03	7.70	5.78	4.79	3.60
	Sei whale[c]	1.59	0.90	0.53	0.23	<0.01	<0.01	0	0	2.39	1.72	1.44	0.99	2.11	1.40	1.07	0.73
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.17	0.09	0.01	0	0	0	0	0	340.68	234.11	193.35	127.15	189.20	131.84	95.48	59.29
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	24.78	10.66	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1047.78	100.05	0	0	828.58	423.24	263.79	120.29
	Bottlenose dolphin, offshore	7.61	0	0	0	0	0	0	0	6807.23	4585.82	3617.98	2169.45	3738.47	2529.17	1795.39	1110.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	14.81	10.36	8.64	5.93	8.58	6.00	4.42	2.82
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	58.15	32.19	17.93	4.50	5.96	1.85	0.47	0.17	100.08	69.28	56.37	37.73	353.56	277.62	232.23	182.33
PPW	Gray seal	43.81	12.72	2.46	0.02	0.20	0	0	0	238.90	147.29	117.90	75.57	173.88	110.23	85.34	51.52
	Harbor seal	105.36	30.03	8.69	0.85	0.83	0.02	0	0	555.06	349.99	266.69	167.89	400.10	256.30	195.02	121.20

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table 30. Construction schedule 3 – Project 2 plus overlap: The mean number of marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	4.05	2.40	1.45	0.63	0.03	<0.01	0	0	7.31	5.45	4.46	3.53	6.30	4.32	3.39	2.52
	Minke whale	16.00	6.13	2.05	0.44	0.08	<0.01	0	0	46.00	35.46	29.17	23.13	33.82	25.02	20.01	15.36
	Humpback whale	4.62	2.49	1.32	0.46	0.04	<0.01	<0.01	<0.01	9.55	6.76	5.25	3.93	7.43	5.21	4.03	2.97
	North Atlantic right whale[c] (migrating)	0.56	0.23	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.61	1.16	0.90	0.68	2.98	2.34	1.96	1.57
	Sei whale[c]	0.54	0.32	0.20	0.08	<0.01	<0.01	0	0	1.02	0.76	0.62	0.49	0.88	0.60	0.48	0.35
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	<0.01	<0.01	<0.01	0	0	0	0	0	131.38	98.94	80.26	62.73	54.03	37.18	27.79	17.49
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	5.55	1.34	0.18	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	738.40	376.44	39.96	0	334.62	164.26	100.05	49.57
	Bottlenose dolphin, offshore	1.77	0	0	0	1.18	0.80	0.80	0	4536.56	3295.82	2584.39	1901.05	1924.10	1298.28	929.25	582.35
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	7.35	5.48	4.46	3.48	3.18	2.21	1.68	1.09
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	4.93	1.57	0.48	0.13	2.60	1.09	0.52	0.13	25.46	18.72	15.13	11.56	64.86	49.18	40.30	30.93
PPW	Gray seal	4.56	0.95	0.15	0.06	0.27	0.02	0	0	87.69	59.16	43.79	32.32	53.36	34.43	26.13	17.74
	Harbor seal	14.36	2.52	0.48	0.07	1.14	0.22	0	0	204.46	136.78	103.11	76.08	124.06	80.66	61.03	41.66

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

4.2.3.2. Sea Turtles

Table 31. Construction schedule 1 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	17.56	4.43	0.92	0.58	0	0	0	0	61.63	34.51	21.92	9.70
Leatherback turtle[a]	6.35	1.34	0.47	0.23	0	0	0	0	36.07	20.02	11.96	4.59
Loggerhead turtle	115.62	30.00	4.08	4.08	0	0	0	0	1464.88	723.61	377.47	175.11
Green turtle	0.68	0.22	0.05	0.01	<0.01	0	0	0	1.87	1.03	0.61	0.30

[a] Listed as Endangered under the ESA.

Table 32. Construction schedule 2 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	15.69	2.38	0.92	0.07	0	0	0	0	69.97	32.98	16.30	6.47
Leatherback turtle[a]	5.60	1.02	0.25	0.13	0	0	0	0	41.97	17.77	8.96	3.84
Loggerhead turtle	123.78	17.76	0	0	0	0	0	0	1644.46	690.95	348.90	142.46
Green turtle	0.57	0.10	0.02	0.01	0	0	0	0	1.93	0.79	0.44	0.14

[a] Listed as Endangered under the ESA.

Table 33. Construction schedule 3 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table 3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	14.63	3.30	0.83	0.27	0.06	0	0	0	48.35	28.26	17.77	8.22
Leatherback turtle[a]	8.59	1.76	0.74	0.20	0	0	0	0	46.78	25.25	14.93	6.25
Loggerhead turtle	93.56	15.01	4.48	1.55	0	0	0	0	894.54	484.30	282.70	137.47
Green turtle	0.46	0.15	0.05	<0.01	<0.01	0	0	0	1.21	0.70	0.44	0.20

[a] Listed as Endangered under the ESA.

4.3. Exposure Range Estimates

Exposure ranges, or $ER_{95\%}$, are the horizontal distances that include 95% of the CPAs of animats exceeding a given impact threshold. These were calculated for marine mammals and sea turtles, and the

results are summarized in Figure 14 for each of the foundation types and installation schedules included in Table 3. Sections 4.3.1 and 4.3.2 provide additional detail for each species and metric, assuming 0, 6, 10, and 15 dB attenuation and a summer sound speed profile. For yearly results, see Appendix G.2.

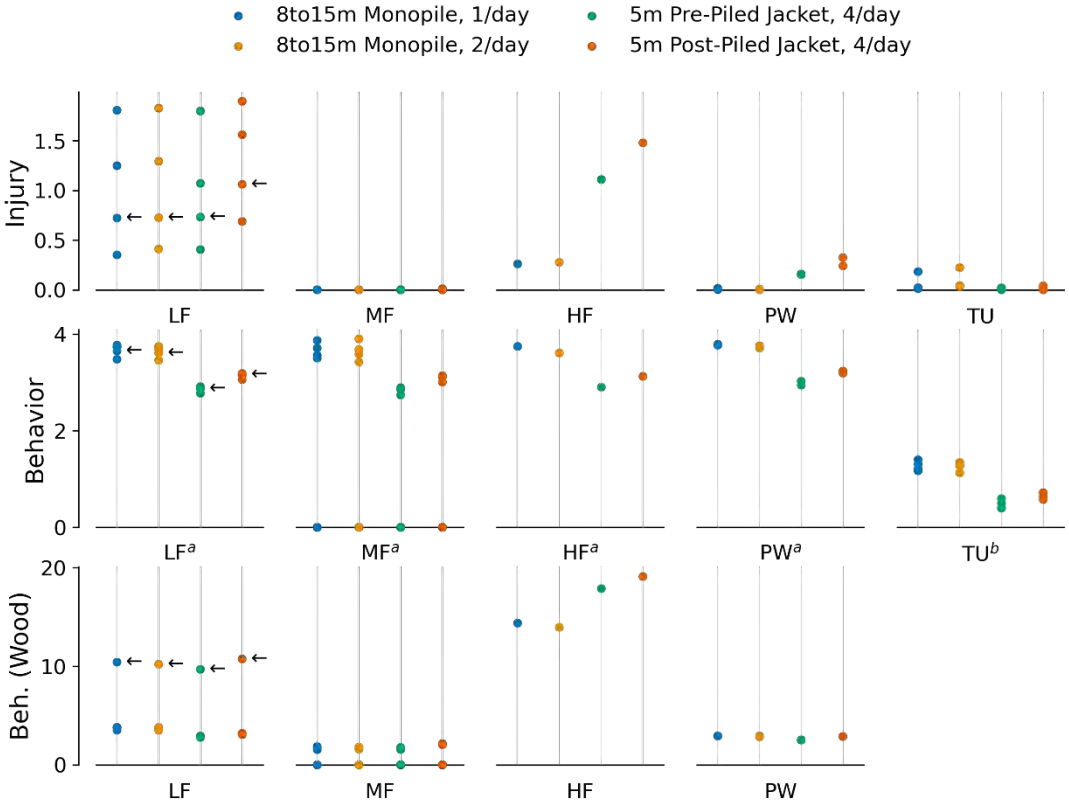

Figure 14. Maximum exposure ranges ($ER_{95\%}$) for injury and behavior thresholds, shown for each hearing group, assuming an attenuation of 10 dB and summer sound speed profile. Each dot represents a species within the indicated hearing group (LF = low frequency, MF = mid frequency, HF = high frequency, PH = pinniped in water, and TU = turtle, and arrows indicate NARW), and dot color represents a combination of foundation type (jacket or monopile) and installation schedule (number of piles installed per day). Note the difference in y-axis scaling between the injury and behavior plots. Superscript a indicates that the NOAA (2005) behavioral thresholds for marine mammals were used, and superscript b indicates that the Finneran et al. (2017) behavioral threshold for turtles was used. Note the different y-axis scales between the rows.

Within the tables in this section, exposure range estimates of exactly "0" indicate that there were no modeled exposures above threshold and therefore the range to threshold is 0 km. If the range is "<0.01", there were exposures above threshold but the computed range was less than 0.01 km.

Single-strike ranges to various isopleths from acoustic modeling can be in found in Appendix F, along with per pile SEL acoustic ranges to isopleths for the hearing groups assuming no movement of animals during pile driving.

4.3.1. Marine Mammals

The exposure ranges to $R_{95\%}$ to injury and behavior thresholds for marine mammals are summarized in Tables 34 to

Species		Injury								Beha				
		L_E				L_{pk}				L_p [a]				
		Attenuation (dB)								Attenuat				
		0	6	10	15	0	6	10	15	0	6	10	15	
LF	Fin whale[c] (sei whale[c,d])	3.71	2.17	1.80	0.50	<0.01	<0.01	0	0	5.36	3.55	2.87	2.04	5
	Minke whale	2.41	1.03	0.40	0.06	0.02	0	0	0	5.01	3.45	2.77	1.88	5
	Humpback whale	3.71	2.12	1.07	0.42	0.01	0	0	0	5.31	3.66	2.91	1.96	5
	North Atlantic right whale[c] (migrating)	3.13	1.49	0.73	0.19	0.01	0	0	0	5.25	3.49	2.87	1.91	15
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	
	Atlantic white-sided dolphin	0.01	0.01	0	0	0	0	0	0	5.27	3.46	2.85	1.88	3
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	4.84	3.78	0	0	3
	Bottlenose dolphin, offshore	0.13	0	0	0	0	0	0	0	4.98	3.28	2.74	1.72	3
	Risso's dolphin	0.02	<0.01	<0.01	0	<0.01	0	0	0	5.24	3.51	2.89	1.93	3
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	
HF	Harbor porpoise (sensitive)	3.23	1.87	1.11	0.42	0.34	0.17	0.09	0.04	5.24	3.56	2.90	1.95	24
PPW	Gray seal	1.49	0.59	0.15	0	0.04	0	0	0	5.53	3.62	2.94	2.03	4
	Harbor seal	1.52	0.79	0.16	0.02	0.02	0	0	0	5.41	3.69	3.02	1.97	4

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] Fin whale used as a surrogate for sei whale behavioral definition

Table 37 for the foundation types included in the construction schedul es (Table 3), assuming 0, 6, 10, and 15 dB broadband attenuation and a summer sound speed profile. Exposure ranges for modeled pile types not included in the constructi on schedules can be found in Appendix G.2.2.

Table 34. Monopile foundation (15 m diameter, one pile per day) exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c] (sei whale[c,d])	3.33	2.13	1.81	0.53	0.03	0	0	0	6.41	4.69	3.73	2.88	6.66	4.83	3.77	2.93
	Minke whale	2.11	0.95	0.35	0.06	0.01	0	0	0	5.92	4.46	3.48	2.78	6.13	4.58	3.51	2.79
	Humpback whale	3.59	2.19	1.25	0.47	0.03	<0.01	0	0	6.35	4.64	3.77	2.89	6.50	4.72	3.82	2.89
	North Atlantic right whale[c] (migrating)	2.64	1.30	0.72	0.37	0.03	<0.01	<0.01	<0.01	6.33	4.64	3.65	2.85	15.05	12.10	10.42	8.16
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	6.25	4.56	3.56	2.79	3.41	2.37	1.74	1.00
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	5.54	4.28	3.87	0	3.69	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	<0.01	0	0	0	5.89	4.50	3.50	2.73	3.31	2.31	1.54	0.82
	Risso's dolphin	0	0	0	0	0	0	0	0	6.29	4.74	3.71	2.92	3.52	2.46	1.85	0.93
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	1.42	0.50	0.26	0.02	0.60	0.28	0.20	0.05	6.36	4.66	3.74	2.86	20.21	16.53	14.39	11.69
PPW	Gray seal	0.56	0.17	0.02	0.02	0.05	0	0	0	6.57	4.74	3.77	2.96	5.29	3.57	2.93	2.05
	Harbor seal	0.84	0.14	<0.01	0	0.05	<0.01	0	0	6.65	4.72	3.79	2.95	5.37	3.56	2.93	2.04

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] Fin whale used as a surrogate for sei whale behavioral definition

Table 35. Monopile foundation (15 m diameter, two piles per day) exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c] (sei whale[c,d])	3.45	2.15	1.83	0.45	0.05	0.02	0	0	6.33	4.67	3.74	2.85	6.56	4.78	3.79	2.91
	Minke whale	2.15	0.95	0.41	0.07	0.05	<0.01	0	0	5.86	4.38	3.45	2.78	6.16	4.50	3.51	2.79
	Humpback whale	3.53	2.08	1.29	0.42	0.04	0.02	<0.01	<0.01	6.32	4.66	3.68	2.87	6.52	4.76	3.72	2.88
	North Atlantic right whale[c] (migrating)	2.68	1.37	0.72	0.39	0.04	0	0	0	6.24	4.58	3.61	2.84	14.89	11.94	10.20	8.07
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	6.06	4.61	3.58	2.86	3.39	2.46	1.80	0.98
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	5.58	4.39	3.90	0	3.77	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	<0.01	<0.01	<0.01	0	5.98	4.40	3.42	2.66	3.25	2.29	1.60	0.89
	Risso's dolphin	0.02	0	0	0	0	0	0	0	6.15	4.56	3.68	2.83	3.49	2.50	1.75	0.97
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	1.41	0.72	0.28	0.03	0.63	0.28	0.17	0.07	6.23	4.61	3.61	2.87	19.94	16.57	13.96	11.60
PPW	Gray seal	0.67	0.26	0	0	0.04	0.02	0	0	6.46	4.77	3.71	2.96	5.29	3.61	2.94	2.10
	Harbor seal	0.61	0.11	<0.01	<0.01	0.05	<0.01	0	0	6.35	4.89	3.76	2.94	5.35	3.63	2.84	2.09

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] fin whale used as a surrogate for sei whale behavioral definition

Table 36. Pre-piled jacket foundation (5 m diameter piles, four piles per day) exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c] (sei whale[c,d])	3.71	2.17	1.80	0.50	<0.01	<0.01	0	0	5.36	3.55	2.87	2.04	5.45	3.59	2.88	2.04
	Minke whale	2.41	1.03	0.40	0.06	0.02	0	0	0	5.01	3.45	2.77	1.88	5.14	3.48	2.78	1.88
	Humpback whale	3.71	2.12	1.07	0.42	0.01	0	0	0	5.31	3.66	2.91	1.96	5.43	3.66	2.93	1.97
	North Atlantic right whale[c] (migrating)	3.13	1.49	0.73	0.19	0.01	0	0	0	5.25	3.49	2.87	1.91	15.27	11.79	9.69	7.20
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.01	0.01	0	0	0	0	0	0	5.27	3.46	2.85	1.88	3.77	2.62	1.74	0.92
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	4.84	3.78	0	0	3.87	0	0	0
	Bottlenose dolphin, offshore	0.13	0	0	0	0	0	0	0	4.98	3.28	2.74	1.72	3.59	2.46	1.56	0.81
	Risso's dolphin	0.02	<0.01	<0.01	0	<0.01	0	0	0	5.24	3.51	2.89	1.93	3.83	2.64	1.77	0.93
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	3.23	1.87	1.11	0.42	0.34	0.17	0.09	0.04	5.24	3.56	2.90	1.95	24.88	20.45	17.92	14.68
PPW	Gray seal	1.49	0.59	0.15	0	0.04	0	0	0	5.53	3.62	2.94	2.03	4.76	3.11	2.51	1.49
	Harbor seal	1.52	0.79	0.16	0.02	0.02	0	0	0	5.41	3.69	3.02	1.97	4.74	3.21	2.55	1.43

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] Fin whale used as a surrogate for sei whale behavioral definition

Table 37. Post-piled jacket foundation[a] (5 m diameter piles, four piles per day) exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p[b]				L_p[c]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[d] (sei whale[d,e])	4.17	2.56	1.90	0.71	0.04	<0.01	0	0	6.20	4.20	3.16	2.42	6.33	4.30	3.19	2.43
	Minke whale	3.02	1.42	0.69	0.15	0.06	0.01	0	0	5.62	3.90	3.05	2.31	5.79	3.95	3.07	2.31
	Humpback whale	4.34	2.58	1.56	0.69	0.05	0.01	0	0	6.09	4.13	3.18	2.39	6.21	4.14	3.19	2.39
	North Atlantic right whale[d] (migrating)	3.53	1.94	1.06	0.47	0.06	0	0	0	5.97	4.11	3.16	2.37	16.56	12.80	10.74	8.05
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.01	0.01	0.01	0	0	0	0	0	5.83	4.02	3.11	2.31	4.35	2.95	2.15	1.23
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	5.31	4.02	0	0	4.17	0	0	0
	Bottlenose dolphin, offshore	0.21	0	0	0	0	0	0	0	5.65	3.80	3.01	2.14	4.24	2.84	2.05	1.11
	Risso's dolphin	0.02	0.02	<0.01	0	<0.01	0	0	0	5.90	4.12	3.14	2.31	4.41	2.97	2.14	1.23
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	3.86	2.29	1.48	0.62	0.43	0.23	0.13	0.04	5.92	4.14	3.13	2.40	26.65	21.84	19.13	16.01
PPW	Gray seal	1.90	0.86	0.24	0.04	0.04	0	0	0	6.06	4.27	3.19	2.44	5.62	3.58	2.88	1.88
	Harbor seal	2.09	0.88	0.32	0.10	0.02	<0.01	0	0	6.05	4.29	3.23	2.49	5.51	3.58	2.87	1.84

[a] Post-piled jacket foundations include a 12 dB shift for post piling, [b] NOAA (2005), [c] Wood et al. (2012), [d] Listed as Endangered under the ESA, [e] Fin whale used as a surrogate for sei whale behavioral definition

4.3.2. Sea Turtles

Similar to the results presented for marine mammals (see Section 4.3.1), the exposure ranges ($ER_{95\%}$) for sea turtles are summarized in Tables 38 to 41 for monopile and jacket foundations included in the construction schedules (Table 3), assuming broadband attenuation of 0, 6, 10, and 15 dB for a summer sound speed profile. Exposure ranges for modeled pile types not included in the construction schedules can be found in Appendix G.2.2.

Table 38. Monopile foundation (15 m diameter, one pile per day): exposure ranges ($ER_{95\%}$) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.03	0.35	0.02	<0.01	0	0	0	0	2.89	1.88	1.31	0.64
Leatherback turtle[a]	1.22	0.28	0.02	0.02	0	0	0	0	2.57	1.76	1.21	0.53
Loggerhead turtle	0.57	0.07	0	0	0	0	0	0	2.54	1.54	1.15	0.62
Green turtle	1.47	0.52	0.18	<0.01	<0.01	0	0	0	2.97	1.87	1.40	0.72

[a] Listed as Endangered under the ESA.

Table 39. Monopile foundation (15 m diameter, two piles per day): exposure ranges ($ER_{95\%}$) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.10	0.41	0.04	0.03	<0.01	0	0	0	2.93	1.92	1.28	0.65
Leatherback turtle[a]	0.90	0.21	0.04	0.02	0	0	0	0	2.73	1.75	1.28	0.49
Loggerhead turtle	0.41	0.05	0	0	0	0	0	0	2.55	1.57	1.10	0.62
Green turtle	1.36	0.68	0.22	<0.01	0	0	0	0	2.94	1.97	1.34	0.64

[a] Listed as Endangered under the ESA.

Table 40. Pre-piled jacket foundation (5 m diameter piles, four piles per day): exposure ranges ($ER_{95\%}$) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.60	0.07	0.02	0	0	0	0	0	1.89	0.86	0.50	0.21
Leatherback turtle[a]	0.46	0.03	0.02	<0.01	0	0	0	0	1.78	0.79	0.40	0.16
Loggerhead turtle	0.12	<0.01	0	0	0	0	0	0	1.63	0.76	0.41	0.12
Green turtle	0.76	0.07	0.02	0.02	0	0	0	0	1.99	0.84	0.59	0.12

[a] Listed as Endangered under the ESA.

Table 41. Post-piled jacket foundation[a] (5 m diameter piles, four piles per day): exposure ranges (ER95%) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)				Attenuation (dB)				Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[b]	0.86	0.16	0.03	0.02	0	0	0	0	2.32	1.23	0.72	0.27
Leatherback turtle[b]	0.73	0.07	0.01	0.02	0	0	0	0	2.16	1.06	0.64	0.24
Loggerhead turtle	0.22	0.02	0	0	0	0	0	0	1.95	0.98	0.58	0.28
Green turtle	1.31	0.28	0.04	0.02	0	0	0	0	2.43	1.33	0.72	0.28

[a] Post-piled foundations include a 2 dB shift for post piling.
[b] Listed as Endangered under the ESA.

4.4. Acoustic Impacts to Fish

Unlike marine mammals and sea turtles, fish were assumed to remain stationary during pile driving so ranges to regulatory thresholds (Andersson et al. 2007, Wysocki et al. 2007, FHWG 2008, Stadler and Woodbury 2009, Mueller-Blenkle et al. 2010, Purser and Radford 2011, Popper et al. 2014) were calculated directly from the sound fields (see Section 2.6). Like the criteria for marine mammals and sea turtles, dual acoustic criteria are used to assess the potential for physiological injury to fish. For the sound exposure level, SEL, acoustic energy was accumulated for all pile driving strikes in a 24 h period. Distances to potential injury and behavioral disruption thresholds for fish exposed to pile driving sound for the different piles (jacket: 5 m, and monopile: 12 m and 15 m) are shown in Tables 42 to 44.

Table 42. Acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish for 12 m monopiles using a 4,400 kJ hammer energy with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)									
			L01					L02				
			1,400	1,800	2,000	3,000	4,400	1,400	1,800	2,000	3,000	4,400
Small fish[a]	L_E	183	10.51					9.55				
	L_{pk}	206	0.19	0.21	0.32	0.38	0.44	0.22	0.25	0.27	0.35	0.47
Large fish[a]	L_E	187	8.90					8.10				
	L_{pk}	206	0.19	0.21	0.32	0.38	0.44	0.22	0.25	0.27	0.35	0.47
All fish[b]	L_p	150	8.16	8.78	9.25	10.20	10.99	7.45	7.89	8.39	9.41	10.08
Fish without swim bladder[c]	L_E	216	1.19					1.14				
	L_{pk}	213	0.08	0.09	0.10	0.12	0.20	0.07	0.07	0.08	0.13	0.17
Fish with swim bladder[c]	L_E	203	3.95					3.55				
	L_{pk}	207	0.17	0.20	0.22	0.36	0.41	0.15	0.22	0.25	0.3	0.37
All fish[c]	L_E	186	9.29					8.47				

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa^2·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g; large fish are defined as having a total mass of greater than or equal to 2 g.
[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)
[c] Popper et al. (2014)

Table 43. Acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish for 15 m monopiles using a 4,400 kJ hammer energy with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)												
			L01							L02							
			480	800	1,600	2,500	3,000	4,000	4,400	480	800	1,600	2,500	3,000	4,000	4,400
Small fish[a]	L_E	183	11.05							9.98						
	L_{pk}	206	0.09	0.11	0.19	0.33	0.35	0.40	0.43	0.08	0.09	0.23	0.28	0.34	0.46	0.50
Large fish[a]	L_E	187	9.46							8.57						
	L_{pk}	206	0.09	0.11	0.19	0.33	0.35	0.40	0.43	0.08	0.09	0.23	0.28	0.34	0.46	0.50
All fish[b]	L_p	150	6.25	7.03	8.15	9.61	10.02	10.60	11.16	5.79	6.30	7.33	8.56	9.06	9.90	10.24
Fish without swim bladder[c]	L_E	216	1.45							1.34						
	L_{pk}	213	0.04	0.06	0.08	0.10	0.11	0.19	0.21	0.04	0.05	0.07	0.08	0.09	0.16	0.18
Fish with swim bladder[c]	L_E	203	4.34							3.90						
	L_{pk}	207	0.08	0.10	0.15	0.30	0.33	0.38	0.41	0.07	0.08	0.13	0.26	0.28	0.33	0.46
All fish[c]	L_E	186	9.85							8.92						

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa²·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g; large fish are defined as having a total mass of greater than or equal to 2 g.
[a] FHWG (2008), Stadler and Woodbury (2009)
[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)
[c] Popper et al. (2014)

Table 44. Acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish (GARFO 2020) for 5 m jacket foundations using a 2,500 kJ hammer energy with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	11.94				10.38			
	L_{pk}	206	0.29	0.33	0.21	0.14	0.26	0.28	0.21	0.13
Large fish[a]	L_E	187	9.94				8.68			
	L_{pk}	206	0.29	0.33	0.21	0.14	0.26	0.28	0.21	0.13
All fish[b]	L_p	150	9.82	9.63	10.16	7.98	9.07	9.28	8.36	3.10
Fish without swim bladder[c]	L_E	216	0.88				0.78			
	L_{pk}	213	0.10	0.10	0.07	0.06	0.08	0.08	0.05	0.07
Fish with swim bladder[c]	L_E	203	3.82				3.21			
	L_{pk}	207	0.27	0.30	0.17	0.12	0.24	0.27	0.19	0.12
All fish[c]	L_E	186	10.44				9.10			

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g; large fish are defined as having a total mass of greater than or equal to 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table 45. Acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish for 5 m jacket foundations using a 2,500 kJ hammer energy with 0 dB attenuation and a post-piling 2 dB shift.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	12.99				11.31			
	L_{pk}	206	0.39	0.37	0.28	0.23	0.33	0.32	0.25	0.14
Large fish[a]	L_E	187	10.95				9.52			
	L_{pk}	206	0.39	0.37	0.28	0.23	0.33	0.32	0.25	0.14
All fish[b]	L_p	150	10.79	10.62	11.13	8.90	9.92	10.14	9.22	3.32
Fish without swim bladder[c]	L_E	216	1.18				1.03			
	L_{pk}	213	0.17	0.11	0.09	0.07	0.14	0.12	0.07	0.08
Fish with swim bladder[c]	L_E	203	4.42				3.78			
	L_{pk}	207	0.33	0.35	0.25	0.15	0.31	0.30	0.24	0.13
All fish[c]	L_E	186	11.43				9.94			

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa²·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g; large fish are defined as having a total mass of greater than or equal to 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

5. Discussion

This work evaluated the noise associated with the construction of an offshore wind farm with four foundation configurations: two monopile foundations (one with 12 m monopiles and one with 15 m monopiles) and two jacketed foundation types (one pre-piled and one post-piled). While a variety of factors ultimately contribute to the sound levels and spectra experienced by marine animals, in general, larger piles with larger hammers generally produce louder sounds than smaller piles driven by smaller hammers. For this study, a conservative approach was taken in evaluating the potential impacts of monopile foundations in that only the 15 m monopile was included in the construction schedules. Both pre- and post-piled jacked foundations were included in the construction schedules for evaluation.

The analysis for all pile types predicted the number of individual animals potentially exposed to sound levels above SEL and PK injury threshold criteria using only noise mitigation. The highest predicted number of exposures overall, for both injury and behavior, was for Schedule 2, which assumed mostly jacket foundations would be installed. While the sound produced by the jacket piles has shorter exposure ranges to threshold, more strikes are modeled per 24-hour period. This, predictably, affects the cumulative SEL metric since the effective dwell time is extended. However, the longer duration also affects single-exposure metrics. As the duration of installation increases, more animats swimming nearby have the potential to become exposed above threshold. If we were simply integrating a static density over an impact area, single-exposure metrics would not increase with longer-duration operations. But with moving animats, the simulations recreate a more realistic flux of animals through the area over time. No substantive difference was observed between exposure range results for one monopile per day versus two monopiles per day. When two piles are installed in a day, they are effectively acting as two independent events. Exceedances are generally a result of exposure to one pile or the other and are not a result of both together.

Summarizing the effects for the full buildout scenario, for critically endangered NARW, a simulation with conservative assumptions and no mitigation other than NAS resulted in fewer than two potential injurious exposures. The foundation type with the longest exposure ranges for marine mammals was the post-piled jacket foundation, with an exposure range of 3.53 km to the SEL injury criteria threshold for NARW (Table 35). Exposure modeling results for behavioral thresholds were assessed using both NOAA (2005) and Wood et al. (2012) for marine mammals. The results predicted that ~5 individual NARWs would be exposed to sound levels that could elicit a behavioral response using the NOAA (2005) criteria and up to ~10 individuals using the Wood et al. (2012) criteria (Table 16). Using criteria described by Finneran et al. (2017) approximately 41 Kemp's ridley, 13 leatherback, 2 green sea turtles, and up to 298 loggerhead sea turtles are predicted to be exposed above the regulatory-defined threshold for injury (Tables 19–21), with a maximum exposure range of 1.47 km from the 15 m monopile (Table 38). The criteria described by McCauley et al. (2000) and Finneran et al. (2017) that is potentially associated with behavioral response results in approximately 140 exposures for Kemp's ridley, 79 leatherback, and 4 green sea turtles. Because of the way that loggerhead turtles sample the water column (as a result of their diving and swimming behaviors), they are less exposed to the highest sound levels than the other turtle species. Therefore, they have, on average, less exposures above threshold and shorter ranges to threshold criteria. However, the density for loggerhead turtles is predicted to be an order of magnitude higher than any of the other sea turtle species, and this is reflected in the higher behavioral exposures with up to 914 exceedances at 10 dB attenuation (Table 21). For turtles, exposure ranges to behavioral criteria thresholds are longest for the 15 m monopile, at up to 2.97 km from the source (Table 38). Exposure ranges to behavioral thresholds for jacketed foundations are lower at less than 2.43 km for all turtle species (Tables 38 to 41).

Due to differences in estimated local species density, monthly construction schedule, and modeled swimming and diving behavior, the predicted number of exposures above threshold may vary substantially, even within marine mammal hearing groups or across the different sea turtle species. Conversely, exposure range estimates ($ER_{95\%}$) are not related to animal density or construction schedule. Variability in exposure ranges depends entirely on parameters such as swim speed, time spent at the surface, and the length and nature of dive profiles, all of which determine how the animats sample the sound field both vertically and horizontally.

Atlantic Shores is committed to implementing monitoring and mitigation measures specified in the BOEM lease documentation for the lease area, including seasonal restrictions on construction activity, piling energy ramp up, Protected Species Observers (PSOs), Passive Acoustic Monitoring (PAM), and species-specific exclusion zones. After mitigation measures are implemented, the residual risk of impacts is expected to be significantly reduced.

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Appendix A. Glossary

1/3-octave

One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017).

1/3-octave-band

Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

absorption

The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

bandwidth

The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) ([ANSI] American National Standards Institute and [ASA] Acoustical Society of America S1.13-2005 (R2010)).

bathymetry

The submarine topography of a region, usually expressed in terms of water depth.

broadband sound level

The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

decibel (dB)

One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

frequency

The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

geoacoustic

Relating to the acoustic properties of the seabed.

hertz (Hz)

A unit of frequency defined as one cycle per second.

impulsive sound

Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, [ANSI] American National Standards Institute S12.7-1986 (R2006)). For example, seismic airguns and impact pile driving.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak pressure level (PK)

The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

permanent threshold shift (PTS)

A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

point source

A source that radiates sound as if from a single point ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

pressure, acoustic

The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: p.

pressure, hydrostatic

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

propagation loss

The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also called transmission loss.

received level (RL)

The sound level measured (or that would be measured) at a defined location.

rms

root-mean-square.

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound

A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure

Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

sound exposure level (SEL)

A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for airguns], single-strike SEL [for pile drivers], 24-hour SEL).

sound field

Region containing sound waves ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

sound pressure level (SPL)

The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

For sound in water, the reference sound pressure is one micropascal ($P_0 = 1$ µPa) and the unit for SPL is dB re 1 μPa^2:

Unless otherwise stated, SPL refers to the root-mean-square (rms) pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

The sound level measured in the far-field and scaled back to a standard reference distance of 1 meter from the acoustic centre of the source. Unit: dB re 1 $\mu Pa \cdot m$ (pressure level) or dB re 1 $\mu Pa^2 \cdot s \cdot m$ (exposure level).

temporary threshold shift (TTS)

Temporary loss of hearing sensitivity caused by excessive noise exposure.

Appendix B. Summary of Acoustic Assessment Assumptions

B.1. Impact Pile Driving

The amount of sound generated during pile installation varies with the energy required to drive the piles to the desired depth, which depends on the sediment resistance encountered. Sediment types with greater resistance require pile drivers that deliver higher energy strikes. Maximum sound levels from pile installation usually occur during the last stage of driving (Betke 2008). The representative make and model of impact hammers, and the hammering energy schedule were provided by Atlantic Shores.

The different foundation types that are considered within this acoustic and exposure modeling assessment for the Atlantic Shores Project are described below in Table B-1. The foundations may consist of piles to secure a jacket structure or monopiles consisting of single piles. For jacket foundation models, the piles are assumed to be vertical and driven to a penetration depth of 55 m with self-penetration of 15 m. For monopile foundation models, the piles are assumed to be vertical and driven to a penetration depth of 45 m with self-penetration of 15 m. While pile penetrations across the Projects will vary, these values were chosen as maximum penetration depths. The estimated number of strikes required to install piles to completion were obtained from Atlantic Shores in consultation with potential hammer suppliers. All acoustic evaluation was performed assuming that only one pile is driven at a time. Sound from the piling barge was not included in the model.

Table B-1. Impact pile driving: Summary of model inputs, assumptions, and methods.

Parameter	Description
Jacket foundation	
Modeling method	Finite-difference structural model of pile vibration based on thin-shell theory; Hammer forcing functions computed using GRLWEAP
Impact hammer energy	2,500 kJ
Ram weight	1,227.32 kN
Helmet weight	711 kN
Strike rate (min^{-1})	30
Estimated number of strikes to drive pile	6,750
Expected penetration	70 m
Modeled seabed penetration	10, 20, 15, and 10 m
Pile length	76 m
Pile diameter	5 m
Pile wall thickness	72 mm
15 m monopile foundation	
Modeling method	Finite-difference structural model of pile vibration based on thin-shell theory; Hammer forcing functions computed using GRLWEAP
Impact hammer energy	4,400 kJ
Ram weight	2,157 kN
Helmet weight	2,351 kN
Strike rate (min^{-1})	30
Estimated number of strikes to drive pile	15,387
Expected penetration	60 m
Modeled seabed penetration	8, 3, 4, 5, 10, 9 and 6 m
Pile length	105 m
Pile diameter	tapered 8 to 15 m
Pile wall thickness	162 mm
12 m monopile foundation	
Modeling method	Finite-difference structural model of pile vibration based on thin-shell theory; Hammer forcing functions computed using GRLWEAP
Impact hammer energy	4,400 kJ
Ram weight	2,157 kN
Helmet weight	2,351 kN
Strike rate (min^{-1})	30
Estimated number of strikes to drive pile	12,350
Expected penetration	60 m
Modeled seabed penetration	5, 5, 15, 15 and 5 m
Pile length	101 m
Pile diameter	tapered 8 to 12 m
Pile wall thickness	130 mm
Environmental parameters for all pile types	
Sound speed profile	GDEM data averaged over region
Bathymetry	GEBCO_2019 grid
Geoacoustics	Elastic seabed properties based on description of surficial sediment samples
Quake (shaft and toe)	Shaft: 2.54 mm; Toe: 2.54 mm (Jacket), 2.862 mm (12 m Monopile) and 2.837 mm (15 m Monopile)
Shaft damping	0.164 s/m
Toe damping	0.49 s/m
Shaft resistance	64, 76, 81, 83% (for each energy level – Jackets) 53, 59, 70, 73, 78% (for each energy level – 12 m Monopile) 56, 61, 64, 67, 73, 76, 78% (for each energy level – 15 m Monopile)
Propagation model for all pile types	
Modeling method	Parabolic-equation propagation model with 2.5° azimuthal resolution; FWRAM full-waveform parabolic equation propagation model for 4 radials
Source representation	Vertical line array
Frequency range	10 to 25,000 Hz
Synthetic trace length	400 ms (Jacket), 400 ms (12 m Monopile), 350 ms (15 m Monopile)
Maximum modeled range	100 km

Appendix C. Underwater Acoustics

This section provides a detailed description of the acoustic metrics relevant to the modeling study and the modeling methodology.

C.1. Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic air guns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017).

The zero-to-peak sound pressure, or peak sound pressure (PK or $L_{p,\text{pk}}$; dB re 1 µPa), is the decibel level of the maximum instantaneous acoustic pressure in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,\text{pk}} = 10 \log_{10} \frac{\max|p^2(t)|}{p_0^2} = 20 \log_{10} \frac{\max|p(t)|}{p_0} \qquad \text{(C-1)}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of an acoustic event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure (PK-PK or $L_{p,\text{pk-pk}}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure, possibly filtered in a stated frequency band, attained by an impulsive sound, $p(t)$:

$$L_{p,\text{pk-pk}} = 10 \log_{10} \frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2} \qquad \text{(C-2)}$$

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10 \log_{10} \left(\frac{1}{T} \int_T g(t)\, p^2(t)\, dt \Big/ p_0^2 \right) \text{ dB} \qquad \text{(C-3)}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness

of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,\text{fast}}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,\text{boxcar 125ms}}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90% SPL ($L_{p,90\%}$).

The sound exposure level (SEL or L_E; dB re 1 µPa²·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10 \log_{10} \left(\int_T p^2(t)\, dt \Big/ T_0 p_0^2 \right) \text{dB} \qquad \text{(C-4)}$$

where T_0 is a reference time interval of one second. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10 \log_{10} \left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}} \right) \text{dB} \qquad \text{(C-5)}$$

Because the SPL(T_{90}) and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \qquad \text{(C-6)}$$

$$L_{p90} = L_{\text{E}} - 10\log_{10}(T_{90}) - 0.458 \qquad \text{(C-7)}$$

where the 0.458 dB factor accounts for the 10% of pulse SEL missing from the SPL(T_{90}) integration time window.

Energy equivalent SPL (L_{eq}; dB re 1 µPa) denotes the SPL of a stationary (constant amplitude) sound that generates the same SEL as the signal being examined, $p(t)$, over the same time period, T:

$$L_{\text{eq}} = 10 \log_{10} \left(\frac{1}{T} \int_T p^2(t)\, dt \Big/ p_0^2 \right) \qquad \text{(C-8)}$$

The equations for SPL and the energy-equivalent SPL are numerically identical. Conceptually, the difference between the two metrics is that the SPL is typically computed over short periods (typically of

one second or less) and tracks the fluctuations of a non-steady acoustic signal, whereas the L_{eq} reflects the average SPL of an acoustic signal over time periods typically of one minute to several hours.

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,\mathrm{LF},24\mathrm{h}}$; see Appendix D) or auditory-weighted SPL ($L_{p,\mathrm{ht}}$). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should also be specified.

C.2. Decidecade Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analyzing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3-octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_{\mathrm{c}}(i)$, is defined as:

$$f_{\mathrm{c}}(i) = 10^{\frac{i}{10}}\ \mathrm{kHz} \tag{C-9}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_{\mathrm{c}}(i) \quad \text{and} \quad f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_{\mathrm{c}}(i) \tag{C-10}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure C-1). In this report, the acoustic modeling spans from band −24 ($f_{\mathrm{c}}(-24)$ = 0.004 kHz) to band 14 ($f_{\mathrm{c}}(14)$ = 25 kHz).

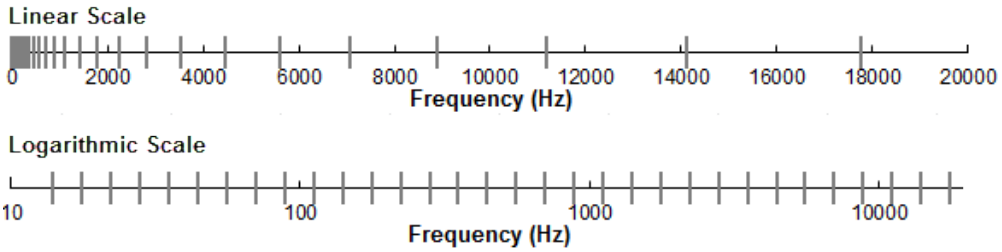

Figure C-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\text{lo},i}$ and $f_{\text{hi},i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{\text{lo},i}}^{f_{\text{hi},i}} S(f)\, df \qquad \text{(C-11)}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}} \qquad \text{(C-12)}$$

Figure C-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient noise signal. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

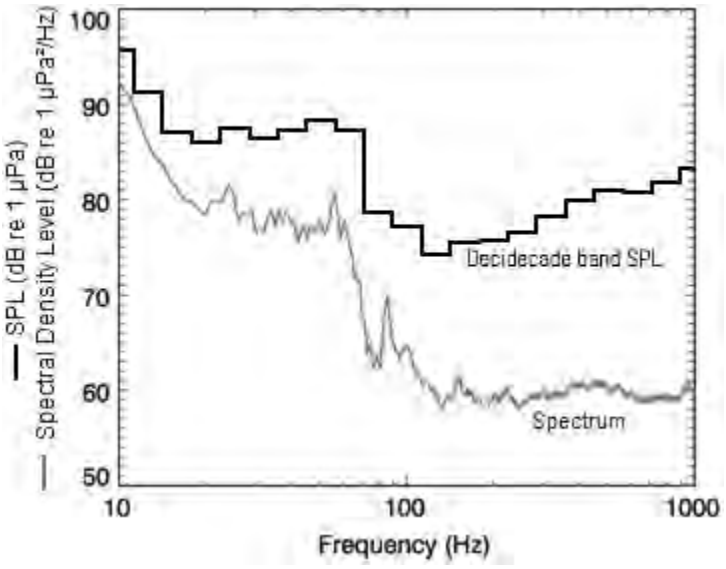

Figure C-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

Appendix D. Auditory (Frequency) Weighting Functions

The potential for noise to affect animals of a certain species depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The auditory weighting functions for marine mammals are applied in a similar way as A-weighting for noise level assessments for humans. The new frequency-weighting functions are expressed as:

$$G(f) = K + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \quad \text{(D-1)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses acoustic impacts on marine mammals (NMFS 2018). The updates did not affect the content related to either the definitions of M-weighting functions or the threshold values. Table D-1 lists the frequency-weighting parameters for each hearing group. Figure D-1 shows the resulting frequency-weighting curves.

In 2017, the Criteria and Thresholds for US Navy Acoustic and Explosive Effects Analysis (Finneran et al. 2017) updated the auditory weighting functions to include sea turtles. The sea turtle weighting curve uses the same equation used for marine mammal auditory weighting functions (Equation D-1). Parameters are provided in Table D-1.

Table D-1. Parameters for the auditory weighting functions recommended by NMFS (2018) and Finneran et al. (2017).

Functional hearing group	a	b	f_1 (Hz)	f_2 (Hz)	K (dB)
Low-frequency cetaceans	1.0	2	200	19,000	0.13
Mid-frequency cetaceans	1.6	2	8,800	110,000	1.20
High-frequency cetaceans	1.8	2	12,000	140,000	1.36
Phocid pinnipeds in water	1.0	2	1,900	30,000	0.75
Otariid pinnipeds in water	2.0	2	940	25,000	0.64
Sea turtles	1.4	2	77	440	2.35

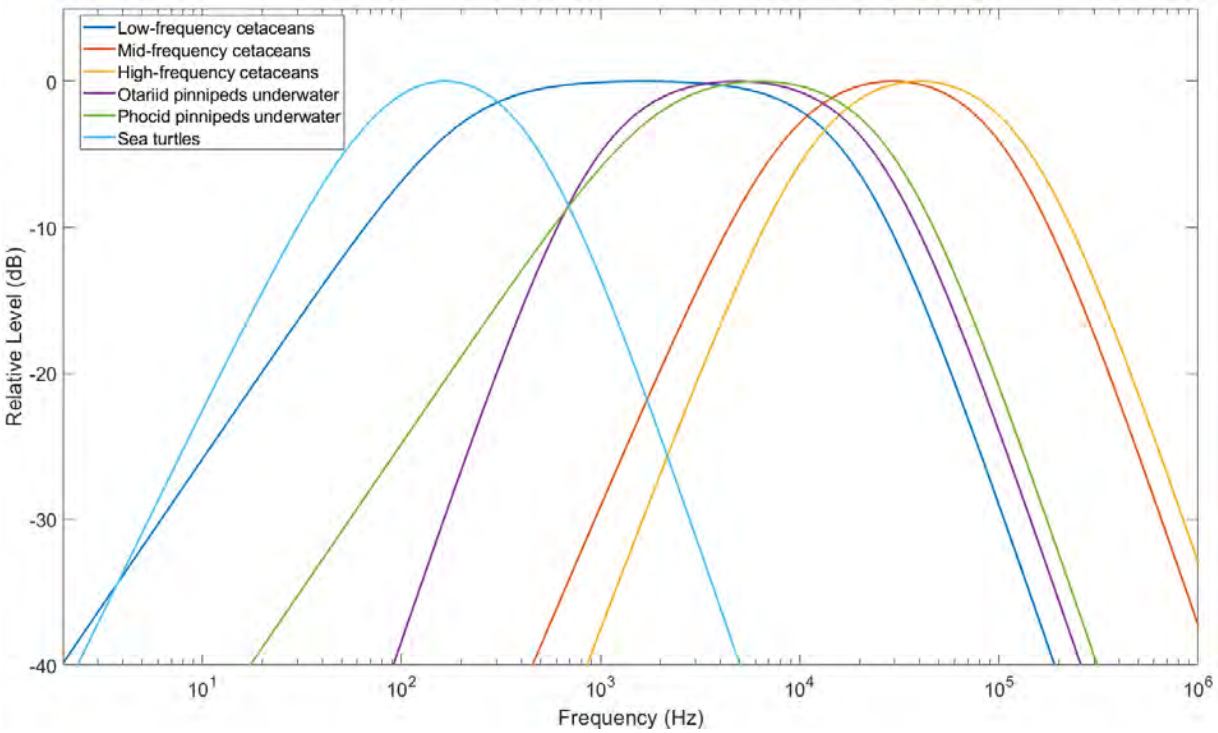

Figure D-1. Auditory weighting functions for the functional marine mammal hearing groups as recommended by NMFS (2018).

Auditory weighting functions for marine mammals—called M-weighting functions—were proposed by Southall et al. (2007). These M-weighting functions are applied in a similar way as A-weighting for noise level assessments for humans. Functions were defined for five hearing groups of marine mammals:

- Low-frequency (LF) cetaceans—mysticetes (baleen whales);
- Mid-frequency (MF) cetaceans—some odontocetes (toothed whales);
- High-frequency (HF) cetaceans—odontocetes specialized for using high-frequencies;
- Pinnipeds in water (Pw)—seals, sea lions, and walrus; and
- Pinnipeds in air (not addressed here).

The M-weighting functions have unity gain (0 dB) through the passband and their high- and low-frequency roll-offs are approximately –12 dB per octave. The amplitude response in the frequency domain of each M-weighting function is defined by:

$$G(f) = -20\log_{10}\left[\left(1+\frac{a^2}{f^2}\right)\left(1+\frac{f^2}{b^2}\right)\right] \quad \text{(D-2)}$$

where G is the weighting function amplitude (in dB) at the frequency f (in Hz), and a and b are the estimated lower and upper hearing limits, respectively, which control the roll -off and passband of the weighting function. The parameters a and b are defined uniquely for each hearing group (Table D-2). Figure D-2 shows the auditory weighting functions.

Table D-2. Parameters for the auditory weighting functions recommended by Southall et al. (2007).

Functional hearing group	a (Hz)	b (Hz)
Low-frequency cetaceans	7	22,000
Mid-frequency cetaceans	150	160,000
High-frequency cetaceans	200	180,000
Pinnipeds in water	75	75,000

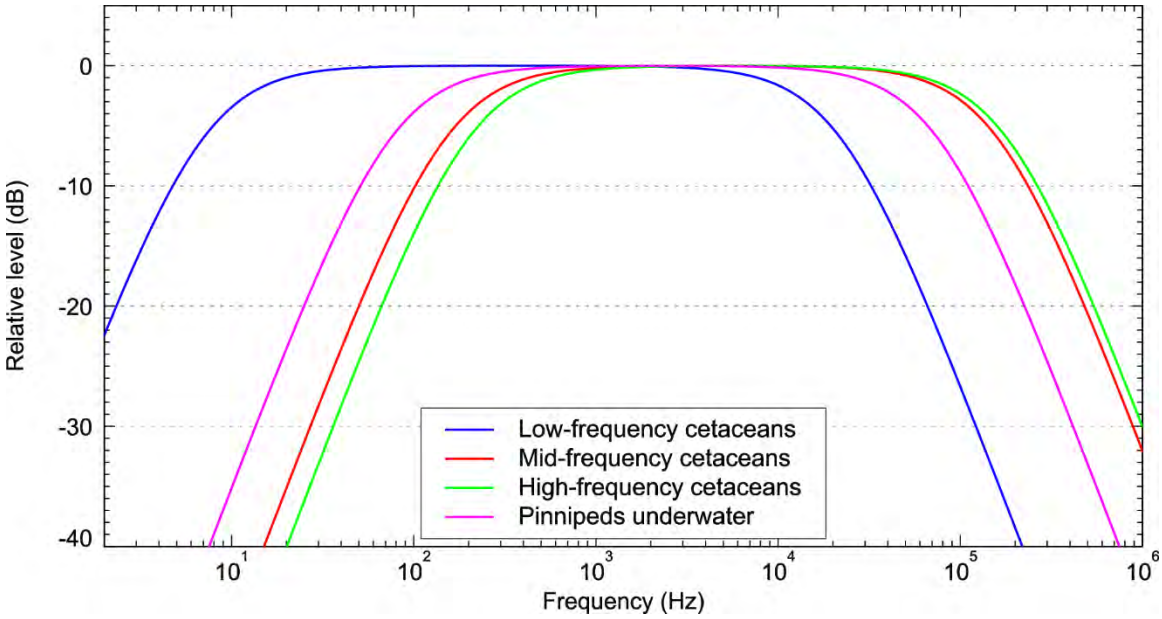

Figure D-2. Auditory weighting functions for the functional marine mammal hearing groups as recommended by Southall et al. (2007).

Appendix E. Sound Propagation Modeling

E.1. Pile Driving Source Model (PDSM)

A physical model of pile vibration and near-field sound radiation is used to calculate source levels of piles. The physical model employed in this study computes the underwater vibration and sound radiation of a pile by solving the theoretical equations of motion for axial and radial vibrations of a cylindrical shell. These equations of motion are solved subject to boundary conditions, which describe the forcing function of the hammer at the top of the pile and the soil resistance at the base of the pile (Figure E-1). Damping of the pile vibration due to radiation loading is computed for Mach waves emanating from the pile wall. The equations of motion are discretised using the finite difference (FD) method and are solved on a discrete time and depth mesh.

To model the sound emissions from the piles, the force of the pile driving hammers also had to be modeled. The force at the top of each pile was computed using the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010), which includes a large database of simulated hammers—both impact and vibratory—based on the manufacturer's specifications. The forcing functions from GRLWEAP were used as inputs to the FD model to compute the resulting pile vibrations.

The sound radiating from the pile itself is simulated using a vertical array of discrete point sources. The point sources are centered on the pile axis. Their amplitudes are derived using an inverse technique, such that their collective particle velocity, calculated using a near-field wave-number integration model, matches the particle velocity in the water at the pile wall. The sound field propagating away from the vertical source array is then calculated using a time-domain acoustic propagation model (see Appendix E.5). MacGillivray (2014) describes the theory behind the physical model in more detail.

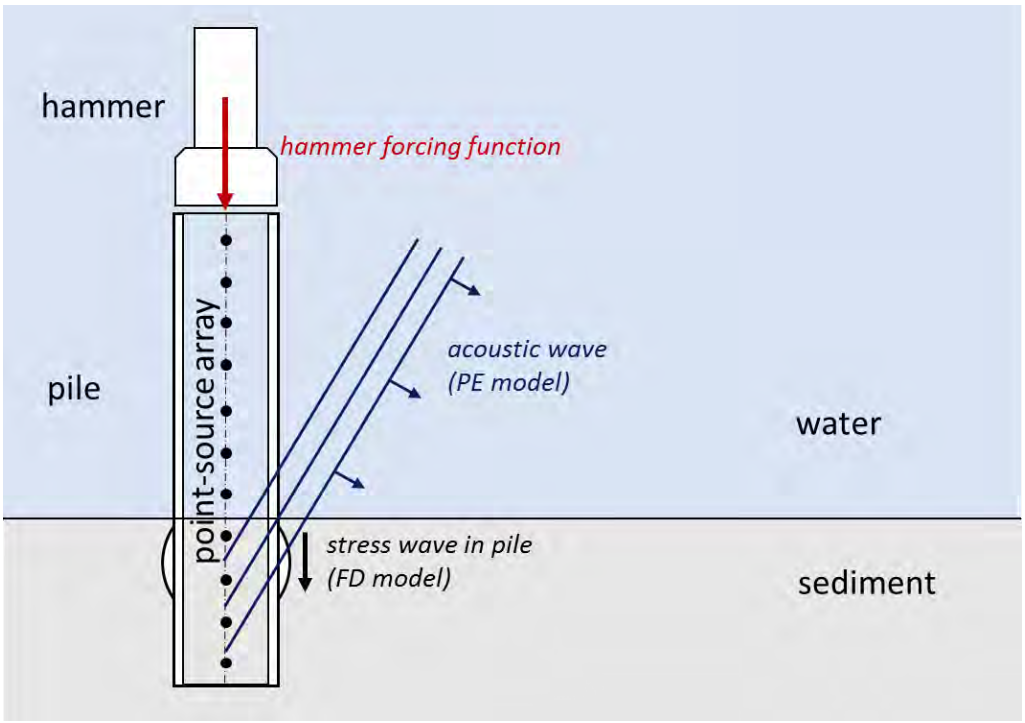

Figure E-1. Physical model geometry for impact driving of a cylindrical pile (vertical cross-section). The hammer forcing function is used with the finite difference (FD) model to compute the stress wave vibration in the pile. A vertical array of point sources is used with the parabolic equation (PE) model to compute the acoustic waves that the pile wall radiates.

E.2. Environmental Parameters

E.2.1. Bathymetry

A bathymetry grid for the acoustic propagation model was obtained from GEBCO 2019 grid for the general lease area.

E.2.2. Geoacoustics

In shallow water environments where there is increased interaction with the seafloor, the properties of the substrate have a large influence over the sound propagation. The dominant soil type in the area is expected to be sand. Table E-1 shows the sediment layer geoacoustic property profile based on the sediment type and generic porosity-depth profile using a sediment grain-shearing model (Buckingham 2005).

Table E-1. Estimated geoacoustic properties used for modeling. Within each depth range, each parameter varies linearly within the stated range. The compressional wave is the primary wave. The shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–7.5	Sand	2.086–2.096	1,764–1,774	0.88–0.878	300	3.65
7.5–15		2.096–2.106	1,774–1,784	0.878–0.876		
15–25		2.106–2.119	1,784–1,796	0.876–0.873		
25–55		2.119–2.159	1,796–1,834	0.873–0.864		
55–80		2.159–2.191	1,834–1,864	0.864–0.855		
80–220		2.191–2.360	1,864–2,018	0.855–0.798		
220–360		2.360–2.508	2,017–2,150	0.798–0.732		
360–500		2.508–2.634	2,150–2, 263	0.732–0.665		
>500		2.634	2,263	0.665		

E.2.3. Sound Speed Profile

The speed of sound in sea-water is a function of temperature, salinity and pressure (depth) (Coppens 1981). Sound speed profiles were obtained from the U.S. Navy's Generalized Digital Environmental Model (GDEM; NAVO 2003). Considering the greater area around the proposed construction area and deep waters, we see that the shape of the sound speed profiles do not change much during the summer months, from June to August (Figure E-2). Water depths in the Atlantic Shores Project area are less than 40 m; sound speed profiles for the shallow water are provided in (Figure E-3). An average profile, obtained by calculating the mean of all profiles shown in Figure E-2 was assumed representative of summer for the area for modeling purposes.

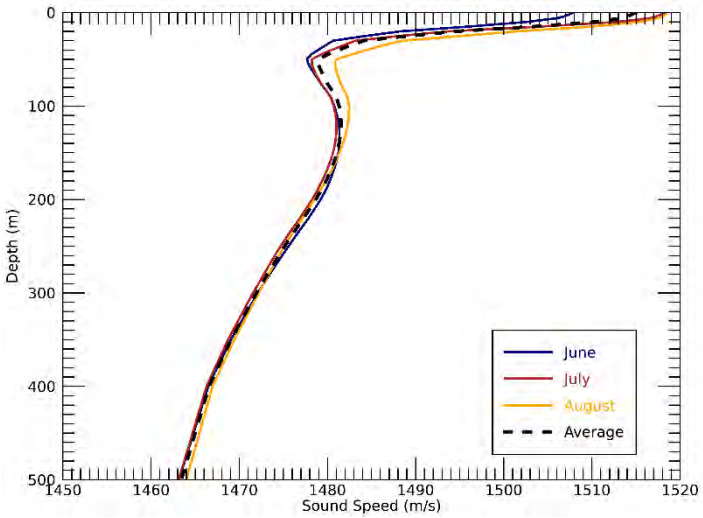

Figure E-2. Sound speed profiles for the months of June through August for the Project area, and the mean summer profile used in the modeling and obtained by taking the average of all profiles.

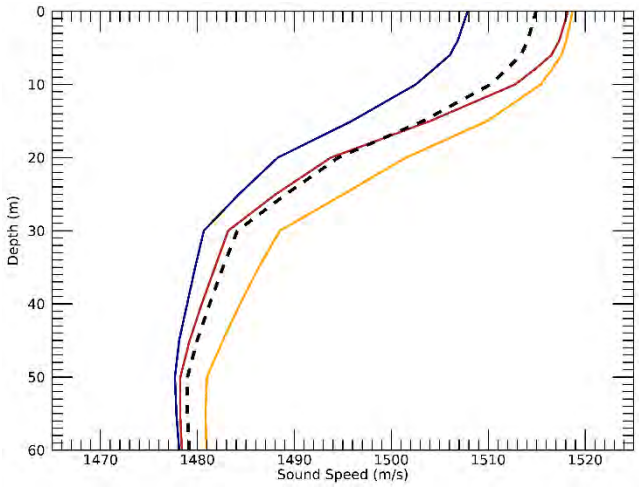

Figure E-3. Sound speed profiles up to 60 m depth for the months of June through August for the Project area, and the mean summer profile used in the modeling and obtained by taking the average of all profiles.

E.3. Transmission Loss

The propagation of sound through the environment was modelled by predicting the acoustic transmission loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which transmission loss occurs. Transmission loss also happens when the sound is absorbed and scattered by the seawater, and absorbed scattered, and reflected at the water surface and within the seabed. Transmission loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic source level (SL), expressed in dB re 1 μPa^2m^2s, and transmission loss (TL), in units of dB, at a given frequency are known, then the received level (RL) at a receiver location can be calculated in dB re 1 μPa^2s by:

$$RL = SL - TL \quad \text{(E-1)}$$

E.4. Sound Propagation with MONM

Transmission loss (i.e., sound propagation) can be predicted with JASCO's Marine Operations Noise Model (MONM). MONM computes received sound energy, the sound exposure level (L_E or SEL), for directional sources. MONM uses a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the US Naval Research Laboratory's Rangedependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005b, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b). MONM accounts for the additional reflection loss at the seabed due to partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates site-specific environmental properties, such as bathymetry, underwater sound speed as a function of depth, and a geoacoustic profile the seafloor.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of decidecades. At each center frequency, the transmission loss is modeled as a function of depth and range from the source. Composite broadband received SEL are then computed by summing the received decidecade levels across the modeled frequency range.

For computational efficiency, MONM and similar models such as PE-RAM, do not track temporal aspects of the propagating signal (as opposed to models that can output time-domain pressure signals, see Appendix E.5). It is the total sound energy transmission loss that is calculated. For our purposes, that is equivalent to propagating the L_E acoustic metric. For continuous, steady-state signals SPL is readily obtained from the SEL.

Acoustic fields in three dimensions are generated by modeling propagation loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D (Figure E-4). These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ planes.

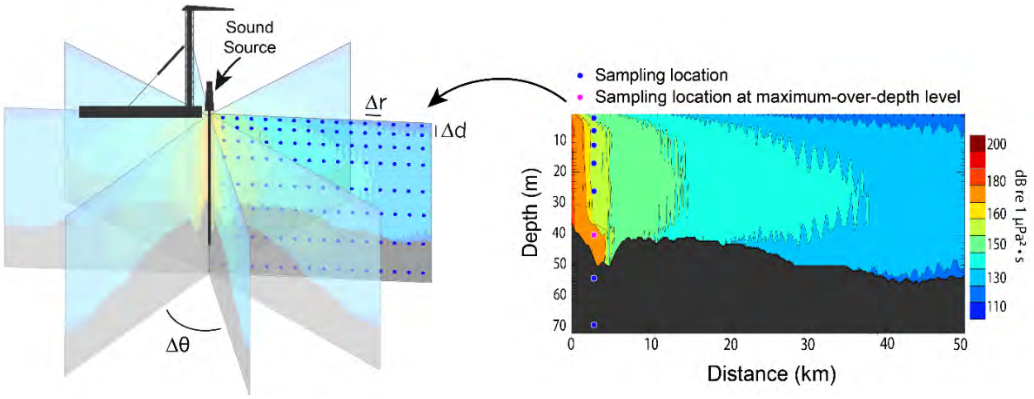

Figure E-4. Modeled three-dimensional sound field (N×2-D method) and maximum-over-depth modeling approach. Sampling locations are shown as blue dots on both figures. On the right panel, the pink dot represents the sampling location where the sound level is maximum over the water column. This maximum-over-depth level is used in calculating distances to sound level thresholds for some marine animals.

E.5. Sound Propagation with FWRAM

For impulsive sounds from impact pile driving, time-domain representations of the pressure waves generated in the water are required for calculating SPL and peak pressure level. Furthermore, the pile must be represented as a distributed source to accurately characterize vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seabed geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Synthetic pressure waveforms were modeled over the frequency range 10 to 2,048 Hz, inside a 1 s window (e.g., Figure E-5). The synthetic pressure waveforms were post-processed, after applying a travel time correction, to calculate standard SPL and SEL metrics versus range and depth from the source.

Besides providing direct calculations of the peak pressure level and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

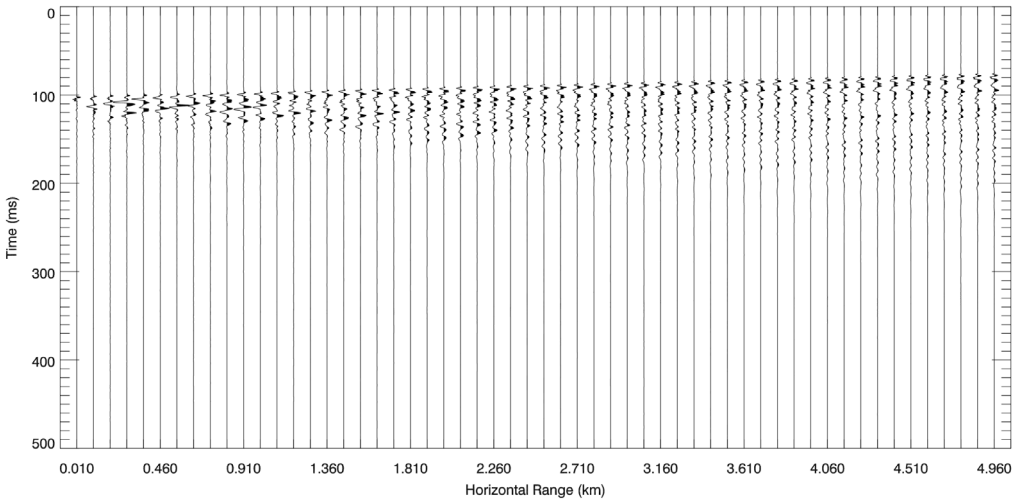

Figure E-5. Example of synthetic pressure waveforms computed by FWRAM at multiple range offsets. Receiver depth is 35 m and the amplitudes of the pressure traces have been normalised for display purposes.

E.6. Estimating Acoustic Range to Threshold Levels

A maximum-over depth approach is used to determine acoustic ranges to the defined thresholds (ranges to isopleths). That is, at each horizontal sampling range, the maximum received level that occurs within the water column is used as the value at that range. The ranges to a threshold typically differ along different radii and may not be continuous because sound levels may drop below threshold at some ranges and then exceed threshold at farther ranges. Figure E-6 shows an example of an area with sound levels above threshold and two methods of reporting the injury or behavioral disruption range: (1) R_{max}, the maximum range at which the sound level was encountered in the modeled maximum-over-depth sound field, and (2) $R_{95\%}$, the maximum range at which the sound level was encountered after the 5% farthest such points were excluded. $R_{95\%}$ is used because, regardless of the shape of the maximum-over-depth footprint, the predicted range encompasses at least 95% of the horizontal area that would be exposed to sound at or above the specified level. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the heterogeneity of the acoustic environment. $R_{95\%}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonification zone.

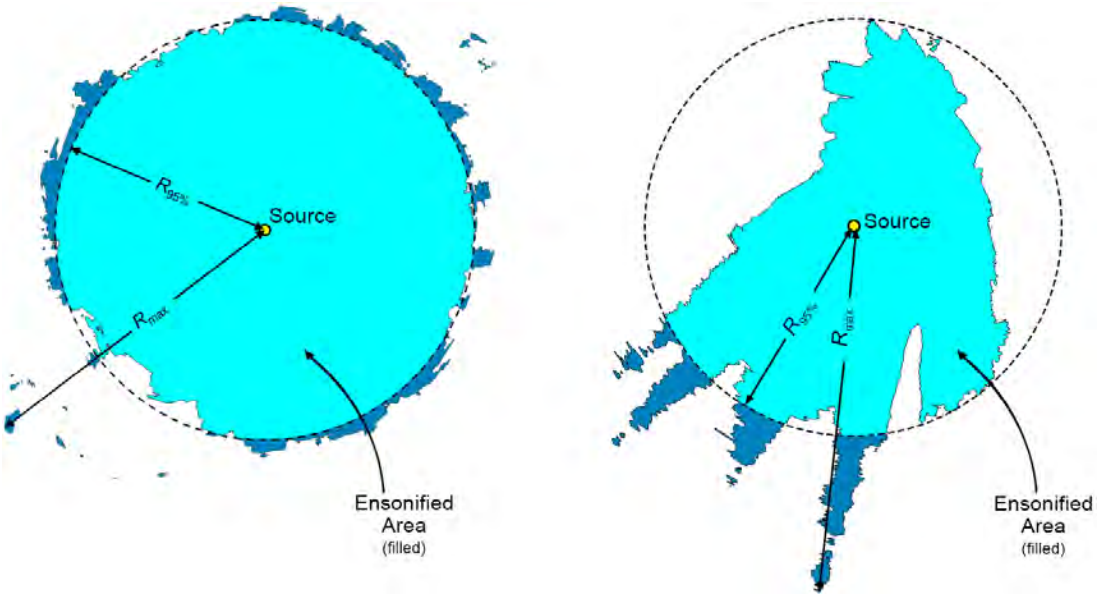

Figure E-6. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

E.7. Model Validation Information

Predictions from JASCO's propagation models (MONM and FWRAM) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the U.S. and Canadian Arctic, Canadian and southern U.S. waters, Greenland, Russia and Australia (Hannay and Racca 2005a, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modeling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix F. Acoustic Radial Isopleths

The following subsections contain tables of ranges to nominal SEL isopleths from impact pile driving of jacket and monopile foundation scenarios. An example map of the unweighted single-strike SEL is provided for source location L01 (Figure F-1).

F.1. Ranges to Single -strike SEL Thresholds

The following tables present single-strike SEL isopleth ranges. R_{max} is the maximum range at which the sound level was encountered in the modeled maximum-over-depth sound field and $R_{95\%}$ is the maximum range at which the sound level was encountered after the 5% farthest such points were excluded (see Appendix E.6). Ranges are calculated on unweighted and weighted sound fields described in Appendix D. Weightings used are designated as follows: Flat is unweighted, LFC is low-frequency cetaceans, MFC is mid-frequency cetaceans, HFC is high-frequency cetaceans, PPW is pinnipeds in water, and TUW is turtles in water. TUW weighting functions are from the US Navy (Finneran et al. 2017), the rest are from the Technical Guidance (NMFS 2018). All calculations use an average summer sound speed profile.

F.1.1. Location L01

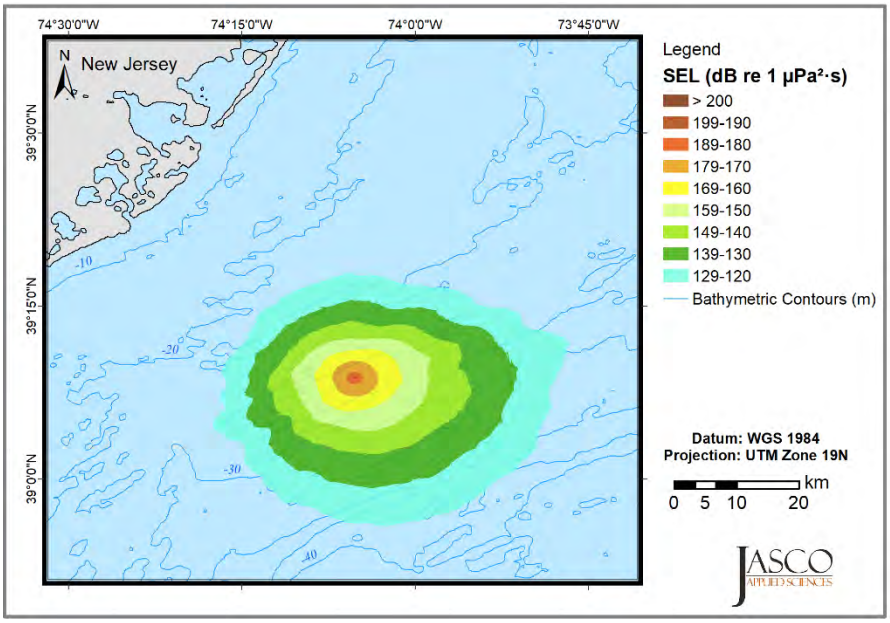

Figure F-1. Unweighted single-strike sound exposure level (SEL) for a 12 m pile at Location L01, summer sound speed profile and energy level of 4,400 kJ.

Table F-1. Distance (km) to single strike sound exposure level (SEL) for a 12 m pile at location L01 using a Menck MHU4400S hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	-	-	-	-	-	-	-	-	0.03	0.03
180	0.26	0.25	0.05	0.05	-	-	-	-	-	-	0.17	0.17
170	1.41	1.32	0.30	0.28	-	-	-	-	-	-	0.87	0.83
160	3.71	3.38	1.66	1.47	-	-	-	-	0.09	0.08	3.00	2.76
150	6.88	6.01	4.19	3.78	-	-	-	-	0.48	0.47	6.38	5.48
140	10.81	9.50	7.85	6.82	0.09	0.09	0.04	0.04	2.17	1.98	10.26	8.96
130	16.01	13.70	12.41	10.88	0.80	0.61	0.42	0.29	5.16	4.63	15.48	13.23
120	21.42	18.67	18.36	15.78	2.90	2.30	1.95	1.58	9.37	8.21	21.08	18.28

A dash (-) indicates that the threshold distance was not reached.

Table F-2. Distance (km) to single strike sound exposure level (SEL) for a 12m pile at location L01 using a Menck MHU4400S hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.09	0.08	-	-	-	-	-	-	-	-	0.04	0.04
180	0.39	0.38	0.09	0.08	-	-	-	-	-	-	0.22	0.20
170	1.71	1.60	0.43	0.41	-	-	-	-	0.02	0.02	1.20	1.14
160	4.22	3.84	2.00	1.83	-	-	-	-	0.13	0.13	3.53	3.26
150	7.56	6.58	4.74	4.29	0.02	0.02	-	-	0.67	0.64	6.90	6.00
140	11.47	10.18	8.55	7.40	0.13	0.13	0.08	0.08	2.63	2.40	10.90	9.60
130	17.00	14.49	13.13	11.54	1.22	0.84	0.61	0.53	5.94	5.21	16.23	13.92
120	22.10	19.46	19.16	16.61	3.56	2.94	2.51	1.95	10.40	9.04	21.72	19.01

A dash (-) indicates that the threshold distance was not reached.

Table F-3. Distance (km) to single strike sound exposure level (SEL) for a 12m pile at location L01 using a Menck MHU4400S hammer operating at 2,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	-	-	-	-	-	-	-	-	0.05	0.05
180	0.48	0.46	0.10	0.10	-	-	-	-	-	-	0.26	0.25
170	2.00	1.86	0.53	0.51	-	-	-	-	0.02	0.02	1.41	1.32
160	4.55	4.12	2.27	2.04	-	-	-	-	0.16	0.16	3.90	3.54
150	7.94	6.94	5.18	4.63	0.03	0.03	-	-	0.82	0.76	7.35	6.39
140	12.14	10.71	9.17	7.97	0.15	0.14	0.09	0.09	2.90	2.68	11.54	10.23
130	17.90	15.28	14.32	12.26	1.30	1.01	0.63	0.59	6.40	5.61	17.39	14.82
120	23.25	20.39	20.08	17.49	3.78	3.16	2.53	2.05	10.95	9.57	22.78	20.01

A dash (-) indicates that the threshold distance was not reached.

Table F-4. Distance (km) to single strike sound exposure level (SEL) for a 12 m pile at location L01 using a Menck MHU4400S hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-	-	-
190	0.13	0.13	0.02	0.02	-	-	-	-	-	-	0.06	0.06
180	0.66	0.63	0.15	0.15	-	-	-	-	-	-	0.41	0.39
170	2.39	2.22	0.73	0.69	-	-	-	-	0.03	0.03	1.92	1.69
160	5.22	4.65	2.84	2.55	-	-	-	-	0.22	0.22	4.61	4.12
150	8.93	7.72	6.18	5.38	0.03	0.03	0.02	0.02	1.15	1.10	8.29	7.23
140	13.46	11.77	10.32	9.09	0.26	0.24	0.14	0.13	3.68	3.39	13.05	11.34
130	19.22	16.67	15.94	13.68	1.92	1.54	1.22	0.84	7.50	6.58	18.92	16.28
120	25.63	22.02	21.97	19.13	4.71	3.96	3.34	2.82	12.52	10.88	25.14	21.69

A dash (-) indicates that the threshold distance was not reached.

Table F-5. Distance (km) to single strike sound exposure level (SEL) for a 12m pile at location L01 using a Menck MHU4400S hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	-	-
190	0.19	0.18	0.03	0.03	-	-	-	-	-	-	0.12	0.12
180	0.99	0.95	0.21	0.20	-	-	-	-	-	-	0.58	0.56
170	3.03	2.80	1.07	1.01	-	-	-	-	0.06	0.06	2.34	2.17
160	6.10	5.31	3.43	3.17	-	-	-	-	0.35	0.34	5.35	4.73
150	9.84	8.55	6.98	6.06	0.09	0.09	0.06	0.04	1.78	1.65	9.22	8.01
140	14.78	12.68	11.40	10.04	0.80	0.62	0.43	0.35	4.66	4.21	14.31	12.22
130	20.44	17.75	17.39	14.97	2.91	2.37	1.96	1.61	8.78	7.79	20.06	17.38
120	27.46	23.32	23.66	20.62	6.35	5.27	4.76	4.01	14.62	12.49	26.98	22.94

A dash (-) indicates that the threshold distance was not reached.

Table F-6. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L01 using a Menck MHU4400S hammer operating at 480 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	-	-	-	-	-	-	-	-	-	-
180	0.15	0.14	0.02	0.02	-	-	-	-	-	-	0.07	0.06
170	0.77	0.74	0.15	0.14	-	-	-	-	-	-	0.40	0.38
160	2.54	2.34	0.72	0.68	-	-	-	-	0.03	0.03	1.78	1.65
150	5.16	4.61	2.66	2.44	-	-	-	-	0.21	0.20	4.36	3.95
140	8.59	7.45	5.82	5.07	0.03	0.03	0.02	0.02	1.10	1.05	7.88	6.85
130	12.79	11.24	9.83	8.50	0.25	0.24	0.13	0.13	3.46	3.18	12.15	10.72
120	18.42	15.86	15.04	12.87	1.92	1.51	1.20	0.83	7.31	6.22	17.94	15.40

A dash (-) indicates that the threshold distance was not reached.

Table F-7. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L01 using a Menck MHU4400S hammer operating at 800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	-	-
180	0.19	0.18	0.03	0.03	-	-	-	-	-	-	0.13	0.13
170	1.00	0.95	0.19	0.19	-	-	-	-	-	-	0.61	0.58
160	3.07	2.85	1.08	1.00	-	-	-	-	0.05	0.05	2.34	2.17
150	6.12	5.33	3.39	3.09	-	-	-	-	0.32	0.30	5.24	4.67
140	9.62	8.40	6.68	5.82	0.06	0.06	0.03	0.03	1.60	1.46	8.93	7.73
130	14.28	12.25	10.69	9.45	0.53	0.45	0.23	0.22	4.24	3.86	13.34	11.67
120	19.53	16.95	16.18	13.91	2.14	1.86	1.55	1.24	8.21	7.11	18.96	16.41

A dash (-) indicates that the threshold distance was not reached.

Table F-8. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L01 using a Menck MHU4400S hammer operating at 1,600 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	-	-	-	-	-	-	-	-	0.03	0.03
180	0.38	0.36	0.08	0.07	-	-	-	-	-	-	0.19	0.19
170	1.68	1.58	0.38	0.37	-	-	-	-	-	-	1.08	1.01
160	4.04	3.72	1.77	1.64	-	-	-	-	0.12	0.12	3.34	3.06
150	7.25	6.32	4.38	4.00	0.02	0.02	-	-	0.59	0.57	6.50	5.69
140	10.97	9.72	7.92	6.94	0.11	0.10	0.06	0.06	2.34	2.17	10.30	9.06
130	16.03	13.76	12.39	10.88	0.84	0.77	0.48	0.43	5.46	4.82	15.38	13.17
120	21.38	18.58	18.32	15.72	3.30	2.61	1.99	1.68	9.62	8.42	20.88	18.13

A dash (-) indicates that the threshold distance was not reached.

Table F-9. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L01 using a Menck MHU4400S hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-	-	-
190	0.13	0.13	0.02	0.02	-	-	-	-	-	-	0.08	0.08
180	0.63	0.60	0.14	0.14	-	-	-	-	-	-	0.37	0.36
170	2.37	2.20	0.75	0.71	-	-	-	-	0.03	0.03	1.75	1.61
160	5.06	4.57	2.60	2.37	-	-	-	-	0.19	0.19	4.34	3.93
150	8.51	7.40	5.58	4.96	0.03	0.03	-	-	1.03	0.98	7.75	6.75
140	12.70	11.10	9.51	8.28	0.22	0.20	0.10	0.09	3.26	3.03	12.05	10.53
130	18.14	15.58	14.69	12.47	1.53	1.23	0.81	0.72	6.86	5.92	17.49	15.04
120	23.30	20.55	20.38	17.62	4.05	3.39	2.91	2.37	11.24	9.90	22.81	20.10

A dash (-) indicates that the threshold distance was not reached.

Table F-10. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L01 using a Menck MHU4400S hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-	-	-
190	0.15	0.14	0.03	0.03	-	-	-	-	-	-	0.07	0.06
180	0.70	0.68	0.16	0.15	-	-	-	-	-	-	0.43	0.42
170	2.50	2.32	0.78	0.69	-	-	-	-	0.03	0.03	1.97	1.76
160	5.28	4.72	2.83	2.55	-	-	-	-	0.21	0.20	4.60	4.13
150	8.91	7.69	6.12	5.30	0.03	0.03	0.02	0.02	1.15	1.07	8.24	7.13
140	13.21	11.58	10.17	8.81	0.23	0.22	0.12	0.10	3.60	3.26	12.71	11.10
130	18.88	16.26	15.37	13.17	1.56	1.24	0.85	0.77	7.30	6.26	18.56	15.82
120	24.65	21.39	21.12	18.38	4.44	3.58	3.29	2.48	11.90	10.36	24.14	21.00

A dash (-) indicates that the threshold distance was not reached.

Table F-11. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L01 using a Menck MHU4400S hammer operating at 4,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	-	-
190	0.17	0.16	0.03	0.03	-	-	-	-	-	-	0.10	0.09
180	0.83	0.78	0.19	0.18	-	-	-	-	-	-	0.49	0.47
170	2.70	2.53	0.92	0.88	-	-	-	-	0.04	0.04	2.10	1.93
160	5.76	5.04	3.17	2.89	-	-	-	-	0.25	0.23	5.04	4.51
150	9.52	8.23	6.66	5.75	0.03	0.03	0.02	0.02	1.37	1.26	8.92	7.70
140	14.33	12.29	10.86	9.52	0.24	0.23	0.13	0.12	3.97	3.60	13.52	11.84
130	19.78	17.21	16.57	14.10	1.73	1.31	0.98	0.80	7.76	6.78	19.30	16.78
120	26.12	22.44	22.09	19.45	4.60	3.74	3.31	2.70	12.56	11.04	25.65	22.08

A dash (-) indicates that the threshold distance was not reached.

Table F-12. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L01 using a Menck MHU4400S hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	0.02	0.02
190	0.19	0.19	0.03	0.03	-	-	-	-	-	-	0.13	0.12
180	0.99	0.96	0.22	0.21	-	-	-	-	-	-	0.59	0.57
170	3.08	2.85	1.13	1.07	-	-	-	-	0.06	0.06	2.37	2.22
160	6.18	5.40	3.63	3.27	-	-	-	-	0.33	0.31	5.50	4.87
150	9.94	8.74	7.12	6.21	0.06	0.06	0.03	0.03	1.68	1.59	9.53	8.25
140	15.16	12.91	11.48	10.17	0.47	0.43	0.22	0.20	4.48	4.03	14.71	12.48
130	20.66	17.93	17.46	14.99	2.08	1.73	1.41	1.22	8.45	7.43	20.28	17.59
120	27.47	23.37	23.33	20.45	5.40	4.40	3.90	3.23	13.78	11.88	27.00	23.03

A dash (-) indicates that the threshold distance was not reached.

Table F-13. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 1,200 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	0.03	0.03
180	0.23	0.22	0.10	0.10	-	-	-	-	-	-	0.19	0.18
170	1.17	1.11	0.51	0.49	-	-	-	-	0.07	0.06	0.90	0.84
160	3.70	3.35	2.28	2.11	0.03	0.03	0.02	0.02	0.48	0.45	3.39	3.06
150	7.54	6.59	5.71	5.19	0.23	0.22	0.13	0.12	2.17	1.95	7.12	6.22
140	12.71	11.12	11.07	9.49	1.56	1.25	0.85	0.78	5.70	4.97	12.17	10.67
130	19.48	16.81	17.34	15.10	4.46	3.63	3.30	2.56	10.48	9.14	18.76	16.27
120	27.32	23.17	25.31	21.41	8.14	6.96	6.54	5.36	16.98	14.35	26.51	22.55

A dash (-) indicates that the threshold distance was not reached.

Table F-14. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,200 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.02	0.02	-	-	-	-	-	-	0.03	0.03
180	0.30	0.29	0.13	0.13	-	-	-	-	-	-	0.24	0.23
170	1.64	1.48	0.72	0.70	-	-	-	-	0.11	0.10	1.22	1.15
160	4.32	3.94	3.11	2.73	0.04	0.04	0.03	0.03	0.66	0.63	3.88	3.56
150	8.49	7.39	6.86	5.96	0.43	0.34	0.16	0.15	2.86	2.41	8.03	6.97
140	14.31	12.10	12.00	10.56	1.97	1.63	1.30	1.15	6.83	5.72	13.61	11.62
130	20.72	17.95	18.80	16.32	5.08	4.23	3.63	3.12	11.62	10.12	20.28	17.48
120	29.19	24.58	27.02	22.81	9.18	7.71	7.18	6.02	18.52	15.49	28.64	23.90

A dash (-) indicates that the threshold distance was not reached.

Table F-15. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.04	0.04	-	-	-	-	-	-	-	-	0.03	0.03
180	0.24	0.23	0.11	0.11	-	-	-	-	-	-	0.20	0.19
170	1.28	1.18	0.63	0.59	-	-	-	-	0.07	0.07	1.03	0.94
160	3.80	3.52	2.42	2.19	0.03	0.03	0.02	0.02	0.49	0.46	3.43	3.17
150	7.67	6.76	5.92	5.30	0.24	0.22	0.13	0.12	2.37	1.99	7.22	6.36
140	13.06	11.26	11.09	9.64	1.69	1.27	0.86	0.79	5.78	5.05	12.35	10.81
130	19.52	16.97	17.38	15.26	4.46	3.67	3.30	2.65	10.53	9.26	19.08	16.45
120	27.58	23.34	25.34	21.59	8.32	7.05	6.54	5.44	17.00	14.47	26.98	22.74

A dash (-) indicates that the threshold distance was not reached.

Table F-16. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 1,400 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.02	0.02	-	-	-	-	-	-	0.04	0.04
180	0.33	0.31	0.15	0.14	-	-	-	-	-	-	0.26	0.24
170	1.69	1.58	0.81	0.73	-	-	-	-	0.11	0.10	1.31	1.23
160	4.66	4.08	3.18	2.82	0.06	0.06	0.03	0.03	0.66	0.64	4.15	3.68
150	8.62	7.56	6.90	6.06	0.44	0.37	0.18	0.16	2.87	2.47	8.26	7.13
140	14.33	12.31	12.41	10.69	1.98	1.65	1.31	1.20	6.85	5.81	13.82	11.79
130	20.87	18.12	19.02	16.47	5.36	4.28	3.78	3.17	11.96	10.22	20.44	17.64
120	29.65	24.75	27.28	22.98	9.19	7.82	7.19	6.11	18.52	15.62	28.69	24.11

A dash (-) indicates that the threshold distance was not reached.

Table F-17. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	-	-	-	-	-	-	-	-	0.03	0.03
180	0.27	0.26	0.13	0.13	-	-	-	-	-	-	0.23	0.23
170	1.54	1.40	0.69	0.66	-	-	-	-	0.09	0.08	1.16	1.10
160	4.24	3.81	2.89	2.54	0.03	0.03	0.03	0.03	0.64	0.60	3.80	3.51
150	8.26	7.24	6.46	5.76	0.26	0.24	0.14	0.13	2.55	2.16	7.97	6.88
140	13.83	11.94	11.68	10.26	1.92	1.54	1.22	0.84	6.16	5.42	13.28	11.49
130	20.46	17.74	18.36	15.98	4.76	3.97	3.34	2.83	11.18	9.75	19.98	17.28
120	29.11	24.24	26.48	22.40	8.65	7.40	6.74	5.77	17.52	15.06	28.11	23.66

A dash (-) indicates that the threshold distance was not reached.

Table F-18. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,800 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.03	0.03	-	-	-	-	-	-	0.05	0.05
180	0.39	0.37	0.19	0.18	-	-	-	-	-	-	0.30	0.28
170	1.99	1.80	1.08	0.90	-	-	-	-	0.13	0.12	1.64	1.49
160	4.90	4.41	3.42	3.14	0.06	0.06	0.03	0.03	0.86	0.79	4.68	4.09
150	9.41	8.13	7.37	6.54	0.52	0.44	0.23	0.22	3.29	2.79	8.98	7.70
140	15.27	12.99	13.08	11.31	2.14	1.85	1.55	1.24	7.30	6.17	14.79	12.52
130	21.73	18.92	19.88	17.20	5.48	4.58	3.96	3.33	12.50	10.70	21.26	18.43
120	30.73	25.67	28.62	23.81	9.59	8.16	7.57	6.41	18.92	16.22	29.71	25.05

A dash (-) indicates that the threshold distance was not reached.

Table F-19. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	-	-	-	-	-	-	-	-	0.02	0.02
180	0.17	0.16	0.06	0.06	-	-	-	-	-	-	0.12	0.12
170	0.83	0.78	0.39	0.37	-	-	-	-	0.05	0.05	0.66	0.64
160	3.02	2.82	1.79	1.68	0.03	0.03	-	-	0.29	0.28	2.67	2.48
150	6.68	5.84	4.97	4.51	0.15	0.14	0.09	0.08	1.76	1.61	6.26	5.48
140	11.53	10.17	10.01	8.57	1.24	0.89	0.63	0.57	4.82	4.24	11.19	9.76
130	18.14	15.67	15.93	13.95	3.61	3.08	2.52	2.01	9.50	8.18	17.50	15.16
120	25.87	21.93	23.56	20.15	7.44	6.17	5.86	4.75	15.52	13.20	24.82	21.39

A dash (-) indicates that the threshold distance was not reached.

Table F-20. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 2,500 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	0.03	0.03
180	0.22	0.22	0.10	0.10	-	-	-	-	-	-	0.18	0.18
170	1.14	1.08	0.56	0.49	-	-	-	-	0.07	0.06	0.86	0.83
160	3.59	3.27	2.32	2.11	0.03	0.03	0.02	0.02	0.48	0.45	3.40	3.03
150	7.53	6.57	5.80	5.20	0.23	0.22	0.12	0.11	2.17	1.94	7.12	6.24
140	12.76	11.14	11.06	9.52	1.56	1.25	0.85	0.78	5.69	4.95	12.27	10.73
130	19.50	16.89	17.36	15.16	4.44	3.61	3.29	2.52	10.48	9.12	18.96	16.39
120	27.55	23.28	25.33	21.49	8.14	6.92	6.36	5.33	16.98	14.33	26.96	22.72

A dash (-) indicates that the threshold distance was not reached.

F.1.2. Location L02

Table F-21. Distance (km) to single strike sound exposure level (SEL) for a 12 m pile at location L02 using a Menck MHU4400S hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	-	-	-	-	-	-	-	-	0.03	0.03
180	0.31	0.31	0.07	0.07	-	-	-	-	-	-	0.17	0.17
170	1.33	1.25	0.37	0.36	-	-	-	-	-	-	0.94	0.90
160	3.23	3.02	1.58	1.48	-	-	-	-	0.11	0.11	2.77	2.61
150	6.10	5.56	3.93	3.60	-	-	-	-	0.58	0.56	5.64	5.17
140	9.61	8.59	7.08	6.48	0.10	0.09	0.06	0.06	2.07	1.96	9.26	8.24
130	14.25	12.49	11.36	9.97	0.77	0.72	0.41	0.39	4.92	4.48	13.75	12.12
120	19.57	17.03	16.44	14.47	2.69	2.26	1.92	1.49	8.78	7.82	19.27	16.67

A dash (-) indicates that the threshold distance was not reached.

Table F-22. Distance (km) to single strike sound exposure level (SEL) for a 12m pile at location L02 using a Menck MHU4400S hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.09	0.08	-	-	-	-	-	-	-	-	0.04	0.04
180	0.40	0.38	0.10	0.10	-	-	-	-	-	-	0.23	0.23
170	1.54	1.48	0.50	0.47	-	-	-	-	0.03	0.03	1.20	1.12
160	3.66	3.40	1.83	1.74	-	-	-	-	0.15	0.14	3.18	2.94
150	6.56	5.99	4.37	3.99	0.02	0.02	-	-	0.74	0.71	6.14	5.60
140	10.23	9.10	7.64	6.94	0.13	0.12	0.07	0.07	2.49	2.32	9.84	8.73
130	14.91	13.12	11.97	10.51	1.13	0.80	0.58	0.50	5.43	4.97	14.51	12.74
120	20.22	17.82	17.37	15.13	3.11	2.66	2.36	1.88	9.60	8.45	19.92	17.41

A dash (-) indicates that the threshold distance was not reached.

Table F-23. Distance (km) to single strike sound exposure level (SEL) for a 12m pile at location L02 using a Menck MHU4400S hammer operating at 2,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.02	0.02	-	-	-	-	-	-	0.06	0.06
180	0.50	0.47	0.12	0.12	-	-	-	-	-	-	0.32	0.32
170	1.76	1.66	0.61	0.59	-	-	-	-	0.03	0.03	1.38	1.31
160	3.97	3.68	2.10	1.99	-	-	-	-	0.17	0.16	3.53	3.26
150	7.02	6.38	4.84	4.41	0.04	0.04	-	-	0.90	0.86	6.59	6.03
140	10.99	9.65	8.24	7.48	0.19	0.17	0.10	0.09	2.78	2.62	10.55	9.34
130	15.82	13.89	12.86	11.27	1.25	1.12	0.77	0.72	5.95	5.44	15.44	13.56
120	21.39	18.95	18.58	16.01	3.72	3.04	2.67	2.22	10.43	9.07	21.01	18.56

A dash (-) indicates that the threshold distance was not reached.

Table F-24. Distance (km) to single strike sound exposure level (SEL) for a 12 m pile at location L02 using a Menck MHU4400S hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-	-	-
190	0.14	0.13	0.03	0.03	-	-	-	-	-	-	0.10	0.09
180	0.71	0.67	0.17	0.16	-	-	-	-	-	-	0.47	0.43
170	2.17	2.06	0.88	0.84	-	-	-	-	0.05	0.05	1.78	1.68
160	4.69	4.32	2.74	2.58	-	-	-	-	0.30	0.29	4.24	3.90
150	7.92	7.18	5.73	5.27	0.10	0.07	0.05	0.05	1.47	1.36	7.53	6.85
140	12.33	10.76	9.78	8.66	0.76	0.58	0.24	0.23	3.85	3.62	11.96	10.46
130	17.77	15.36	14.85	13.04	2.38	2.02	1.57	1.30	7.92	6.92	17.15	15.07
120	23.89	21.27	20.76	18.36	5.47	4.72	4.10	3.46	12.96	11.24	23.46	20.91

A dash () indicates that the threshold distance was not reached.

Table F-25. Distance (km) to single strike sound exposure level (SEL) for a12 m pile at location L02 using a Menck MHU4400S hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	0.02	0.02
190	0.19	0.19	0.04	0.04	-	-	-	-	-	-	0.13	0.13
180	0.96	0.92	0.23	0.23	-	-	-	-	-	-	0.66	0.64
170	2.69	2.51	1.21	1.11	-	-	-	-	0.09	0.09	2.22	2.09
160	5.32	4.89	3.29	3.05	0.02	0.02	-	-	0.47	0.45	4.89	4.49
150	8.71	7.82	6.46	5.90	0.13	0.12	0.07	0.07	1.95	1.79	8.27	7.49
140	13.26	11.61	10.61	9.47	1.13	0.80	0.58	0.51	5.03	4.37	12.86	11.25
130	18.90	16.29	15.98	14.06	3.11	2.66	2.36	1.88	9.10	7.99	18.54	15.97
120	25.28	22.50	22.49	19.93	6.67	5.72	5.10	4.32	14.56	12.58	24.78	22.11

A dash () indicates that the threshold distance was not reached.

Table F-26. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L02 using a Menck MHU4400S hammer operating at 480 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	-	-
180	0.15	0.14	0.03	0.03	-	-	-	-	-	-	0.09	0.09
170	0.74	0.70	0.15	0.15	-	-	-	-	-	-	0.45	0.42
160	2.14	2.04	0.80	0.76	-	-	-	-	0.04	0.04	1.70	1.58
150	4.55	4.15	2.48	2.33	-	-	-	-	0.23	0.22	3.96	3.66
140	7.47	6.81	5.24	4.79	0.05	0.05	0.02	0.02	1.19	1.07	7.05	6.41
130	11.52	10.07	8.72	7.84	0.23	0.23	0.13	0.13	3.19	3.00	11.05	9.69
120	16.29	14.30	13.31	11.70	1.57	1.35	1.13	0.80	6.57	5.95	15.84	13.92

A dash () indicates that the threshold distance was not reached.

Table F-27. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L02 using a Menck MHU4400S hammer operating at 800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	0.02	0.02
180	0.18	0.17	0.03	0.03	-	-	-	-	-	-	0.12	0.12
170	0.94	0.89	0.20	0.20	-	-	-	-	-	-	0.62	0.59
160	2.56	2.42	1.07	1.00	-	-	-	-	0.06	0.06	2.05	1.95
150	5.09	4.67	2.94	2.74	-	-	-	-	0.34	0.33	4.55	4.18
140	8.15	7.39	5.82	5.35	0.06	0.06	0.05	0.05	1.47	1.39	7.68	6.98
130	12.35	10.77	9.57	8.52	0.45	0.42	0.20	0.19	3.84	3.56	11.92	10.37
120	17.35	15.13	14.36	12.66	2.32	1.84	1.30	1.16	7.30	6.66	16.79	14.78

A dash (-) indicates that the threshold distance was not reached.

Table F-28. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L02 using a Menck MHU4400S hammer operating at 1,600 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	-	-	-	-	-	-	-	-	0.03	0.03
180	0.35	0.34	0.09	0.09	-	-	-	-	-	-	0.20	0.20
170	1.44	1.36	0.40	0.38	-	-	-	-	0.02	0.02	1.06	0.98
160	3.39	3.16	1.62	1.54	-	-	-	-	0.12	0.12	2.87	2.67
150	6.17	5.64	3.94	3.62	0.02	0.02	-	-	0.62	0.59	5.65	5.18
140	9.61	8.57	7.06	6.44	0.10	0.10	0.06	0.06	2.20	2.02	9.17	8.15
130	14.04	12.38	11.23	9.88	0.80	0.74	0.44	0.41	5.07	4.55	13.61	11.96
120	19.45	16.85	16.35	14.34	3.06	2.46	1.97	1.64	9.09	7.92	19.07	16.46

A dash (-) indicates that the threshold distance was not reached.

Table F-29. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L02 using a Menck MHU4400S hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-	-	-
190	0.12	0.12	0.02	0.02	-	-	-	-	-	-	0.09	0.08
180	0.63	0.59	0.14	0.13	-	-	-	-	-	-	0.38	0.37
170	1.99	1.90	0.72	0.68	-	-	-	-	0.03	0.03	1.57	1.49
160	4.36	3.97	2.29	2.17	-	-	-	-	0.19	0.18	3.79	3.49
150	7.27	6.60	4.99	4.58	0.03	0.03	-	-	1.01	0.95	6.80	6.20
140	11.20	9.79	8.34	7.53	0.19	0.17	0.10	0.09	2.93	2.72	10.60	9.41
130	15.82	13.90	12.81	11.20	1.24	1.12	0.77	0.72	6.01	5.49	15.33	13.50
120	21.20	18.75	18.23	15.80	3.72	3.03	2.67	2.21	10.43	9.02	20.77	18.28

A dash (-) indicates that the threshold distance was not reached.

Table F-30. Distance (km) to single strike sound exposure level (SEL) for a 15 m pile at location L02 using a Menck MHU4400S hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	-	-
190	0.14	0.13	0.03	0.03	-	-	-	-	-	-	0.10	0.09
180	0.71	0.68	0.16	0.16	-	-	-	-	-	-	0.47	0.44
170	2.18	2.05	0.86	0.81	-	-	-	-	0.04	0.04	1.77	1.67
160	4.66	4.26	2.64	2.44	-	-	-	-	0.24	0.23	4.21	3.84
150	7.72	7.04	5.47	5.02	0.05	0.05	0.02	0.02	1.24	1.16	7.31	6.68
140	11.93	10.41	9.19	8.15	0.23	0.23	0.13	0.12	3.42	3.13	11.54	10.06
130	16.79	14.75	13.76	12.15	1.57	1.32	1.13	0.80	6.67	6.09	16.38	14.41
120	22.69	20.10	19.47	16.93	4.17	3.63	3.08	2.60	11.39	9.92	22.28	19.67

A dash (-) indicates that the threshold distance was reached.

Table F-31. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L02 using a Menck MHU4400S hammer operating at 4,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	0.02	0.02
190	0.17	0.16	0.03	0.03	-	-	-	-	-	-	0.12	0.12
180	0.87	0.82	0.21	0.21	-	-	-	-	-	-	0.59	0.56
170	2.50	2.35	1.11	1.05	-	-	-	-	0.06	0.06	2.06	1.96
160	5.13	4.71	3.10	2.88	-	-	-	-	0.36	0.34	4.73	4.35
150	8.51	7.66	6.25	5.69	0.07	0.07	0.05	0.05	1.61	1.49	8.08	7.35
140	12.96	11.33	10.20	9.12	0.59	0.54	0.23	0.23	4.16	3.82	12.61	11.01
130	18.40	15.91	15.29	13.50	2.38	1.96	1.56	1.25	8.02	7.12	18.10	15.63
120	24.56	21.84	21.25	18.87	5.47	4.67	3.97	3.40	13.08	11.31	24.23	21.50

A dash (-) indicates that the threshold distance was not reached.

Table F-32. Distance (km) to single strike sound exposure level (SEL) for a 15m pile at location L02 using a Menck MHU4400S hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	0.03	0.03	-	-	-	-	-	-	-	-	0.02	0.02
190	0.19	0.19	0.04	0.04	-	-	-	-	-	-	0.14	0.13
180	0.98	0.94	0.24	0.23	-	-	-	-	-	-	0.69	0.66
170	2.73	2.56	1.28	1.16	-	-	-	-	0.09	0.09	2.28	2.16
160	5.41	4.98	3.35	3.13	-	-	-	-	0.45	0.44	5.02	4.61
150	8.90	7.97	6.56	6.00	0.10	0.10	0.06	0.06	1.86	1.70	8.50	7.66
140	13.42	11.78	10.81	9.54	0.79	0.74	0.43	0.40	4.75	4.21	13.10	11.44
130	19.02	16.43	16.00	14.08	2.77	2.34	1.96	1.56	8.69	7.67	18.67	16.13
120	25.38	22.56	22.38	19.80	6.11	5.23	4.68	3.86	14.06	12.07	25.02	22.22

A dash (-) indicates that the threshold distance was not reached.

Table F-33. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L02 using an IHC S-2,500 hammer operating at 1,200 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	-	-	-	-	-	-	-	-	0.04	0.04
180	0.25	0.24	0.13	0.13	-	-	-	-	-	-	0.20	0.20
170	1.35	1.26	0.63	0.61	-	-	-	-	0.07	0.07	1.09	1.02
160	3.53	3.27	2.43	2.22	0.05	0.05	0.02	0.02	0.54	0.48	3.35	3.02
150	7.09	6.43	5.68	5.17	0.23	0.23	0.13	0.12	2.38	2.00	6.73	6.12
140	11.94	10.44	10.43	9.16	1.57	1.31	1.13	0.80	5.55	5.03	11.54	10.04
130	18.11	15.59	16.41	14.17	4.17	3.63	3.09	2.60	10.85	9.11	17.35	15.08
120	25.38	22.36	23.30	20.67	8.16	6.93	6.35	5.41	15.91	14.05	24.74	21.68

A dash () indicates that the threshold distance was not reached.

Table F-34. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,200 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.03	0.03	-	-	-	-	-	-	0.05	0.05
180	0.37	0.36	0.17	0.17	-	-	-	-	-	-	0.28	0.27
170	1.64	1.52	0.85	0.82	-	-	-	-	0.12	0.12	1.42	1.32
160	4.22	3.85	3.03	2.73	0.06	0.06	0.04	0.04	0.79	0.75	3.88	3.57
150	8.00	7.15	6.44	5.89	0.44	0.41	0.20	0.18	2.95	2.58	7.64	6.83
140	13.13	11.37	11.54	10.04	2.32	1.79	1.29	1.15	6.45	5.74	12.43	10.93
130	19.32	16.72	17.63	15.27	5.08	4.25	3.73	3.05	11.78	10.06	18.74	16.16
120	27.46	23.66	25.26	22.10	8.83	7.69	7.17	6.07	17.38	15.07	26.40	23.00

A dash (-) indicates that the threshold distance was not reached.

Table F-35. Distance (km) to single strike sound exposure level (SEL) for a5 m pile at location L02 using an IHC S-2,500 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.02	0.02	-	-	-	-	-	-	0.05	0.05
180	0.29	0.28	0.14	0.14	-	-	-	-	-	-	0.22	0.21
170	1.39	1.31	0.71	0.68	-	-	-	-	0.10	0.10	1.21	1.09
160	3.77	3.45	2.63	2.37	0.05	0.05	0.03	0.03	0.57	0.54	3.40	3.18
150	7.32	6.68	5.84	5.40	0.26	0.25	0.17	0.15	2.59	2.24	7.03	6.34
140	12.33	10.69	10.89	9.42	1.90	1.47	1.20	0.93	5.84	5.24	11.92	10.30
130	18.48	15.93	16.85	14.52	4.64	3.76	3.11	2.69	10.92	9.41	17.80	15.44
120	26.07	22.78	23.80	21.14	8.28	7.17	6.60	5.60	16.89	14.35	25.30	22.11

A dash () indicates that the threshold distance was not reached.

Table F-36. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L02 using an IHC S-2,500 hammer operating at 1,400 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.03	0.03	-	-	-	-	-	-	0.06	0.06
180	0.43	0.41	0.19	0.19	-	-	-	-	0.02	0.02	0.33	0.32
170	1.77	1.64	0.98	0.93	-	-	-	-	0.13	0.13	1.53	1.43
160	4.47	4.02	3.05	2.87	0.06	0.06	0.05	0.05	0.86	0.79	4.03	3.73
150	8.14	7.42	6.78	6.10	0.45	0.43	0.22	0.19	3.07	2.66	7.73	7.08
140	13.32	11.70	11.92	10.33	2.34	1.86	1.51	1.18	6.61	5.98	12.87	11.22
130	19.63	17.13	18.20	15.61	5.11	4.38	3.84	3.18	11.81	10.37	19.18	16.52
120	28.08	24.08	25.84	22.54	9.61	7.95	7.28	6.26	17.66	15.41	27.11	23.41

A dash (-) indicates that the threshold distance was not reached.

Table F-37. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	-	-	-	-	-	-	-	-	0.03	0.03
180	0.20	0.20	0.11	0.11	-	-	-	-	-	-	0.17	0.16
170	1.02	0.98	0.54	0.52	-	-	-	-	0.06	0.06	0.83	0.79
160	3.06	2.88	2.11	1.95	0.05	0.05	0.02	0.02	0.45	0.44	3.00	2.64
150	6.48	5.93	5.30	4.78	0.21	0.19	0.11	0.11	2.20	1.88	6.19	5.61
140	11.35	9.90	9.96	8.68	1.51	1.18	0.81	0.75	5.36	4.73	10.69	9.50
130	17.34	14.99	15.60	13.62	3.96	3.37	2.77	2.40	9.99	8.72	16.56	14.47
120	24.33	21.65	22.53	19.96	7.79	6.63	6.02	5.09	15.46	13.60	23.77	20.95

A dash (-) indicates that the threshold distance was not reached.

Table F-38. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,800 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.02	0.02	-	-	-	-	-	-	0.04	0.04
180	0.27	0.26	0.15	0.14	-	-	-	-	-	-	0.21	0.21
170	1.38	1.29	0.71	0.68	-	-	-	-	0.11	0.11	1.10	1.05
160	3.65	3.40	2.65	2.42	0.06	0.06	0.03	0.03	0.74	0.66	3.39	3.15
150	7.32	6.66	5.96	5.48	0.41	0.40	0.18	0.17	2.68	2.29	7.03	6.31
140	12.37	10.76	10.91	9.58	1.95	1.52	1.24	1.10	6.06	5.42	11.94	10.34
130	18.70	16.06	17.28	14.71	4.70	3.94	3.41	2.92	11.33	9.65	18.02	15.51
120	26.41	23.00	24.25	21.43	8.59	7.36	6.67	5.76	17.32	14.61	25.35	22.30

A dash(-) indicates that the threshold distance was not reached.

Table F-39. Distance (km) to single strike sound exposure level (SEL) for a 5 m pile at location L02 using a IHC S-2,500 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-	-
180	0.06	0.06	-	-	-	-	-	-	-	-	-	-
170	0.17	0.17	0.03	0.03	-	-	-	-	-	-	0.09	0.09
160	0.77	0.73	0.18	0.17	-	-	-	-	-	-	0.46	0.43
150	2.26	2.12	0.91	0.87	-	-	-	-	0.10	0.10	1.70	1.60
140	4.65	4.26	2.88	2.61	0.05	0.05	0.02	0.02	0.54	0.50	4.05	3.75
130	7.80	7.12	5.98	5.47	0.22	0.19	0.12	0.11	2.36	1.94	7.41	6.75
120	12.41	10.88	10.47	9.26	1.53	1.19	0.81	0.76	5.41	4.85	11.99	10.52

A dash (-) indicates that the threshold distance was not reached.

Table F-40. Distance (km) to single strike sound exposure level (SEL) for a 5m pile at location L02 using a IHC S-2,500 hammer operating at 2,500 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$	TUW R_{max}	TUW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	-	-	-	-	-	-	-	-	-	-
180	0.07	0.07	-	-	-	-	-	-	-	-	0.02	0.02
170	0.23	0.23	0.05	0.05	-	-	-	-	-	-	0.12	0.12
160	0.99	0.94	0.24	0.23	-	-	-	-	-	-	0.61	0.58
150	2.66	2.46	1.20	1.11	-	-	-	-	0.13	0.13	2.08	1.96
140	5.21	4.76	3.37	3.12	0.06	0.06	0.04	0.04	0.79	0.74	4.71	4.32
130	8.70	7.79	6.77	6.13	0.41	0.40	0.19	0.17	2.74	2.44	8.15	7.43
120	13.61	11.83	11.74	10.12	1.96	1.53	1.24	1.11	6.16	5.57	13.12	11.40

A dash (-) indicates that the threshold distance was not reached.

F.2. Ranges to SPL Thresholds

The following tables present single-strike SPL isopleth ranges. R_{max} is the maximum range at which the sound level was encountered in the modeled maximum-over-depth sound field and $R_{95\%}$ is the maximum range at which the sound level was encountered after the 5% farthest such points were excluded (see Appendix E.6). Ranges are calculated on unweighted and weighted sound fields described in Appendix D. Weightings used are designated as follows: Flat is unweighted, LFC is low-frequency cetaceans, MFC is mid-frequency cetaceans, HFC is high-frequency cetaceans, PPW is pinnipeds in water (Southall et al. 2007). R_{max} is the maximum range at which the sound level was encountered in the modeled maximum-over-depth sound field and $R_{95\%}$ is the maximum range at which the sound level was encountered after the 5% farthest such points were excluded. All calculations use an average summer sound speed profile.

F.2.1. Location L01

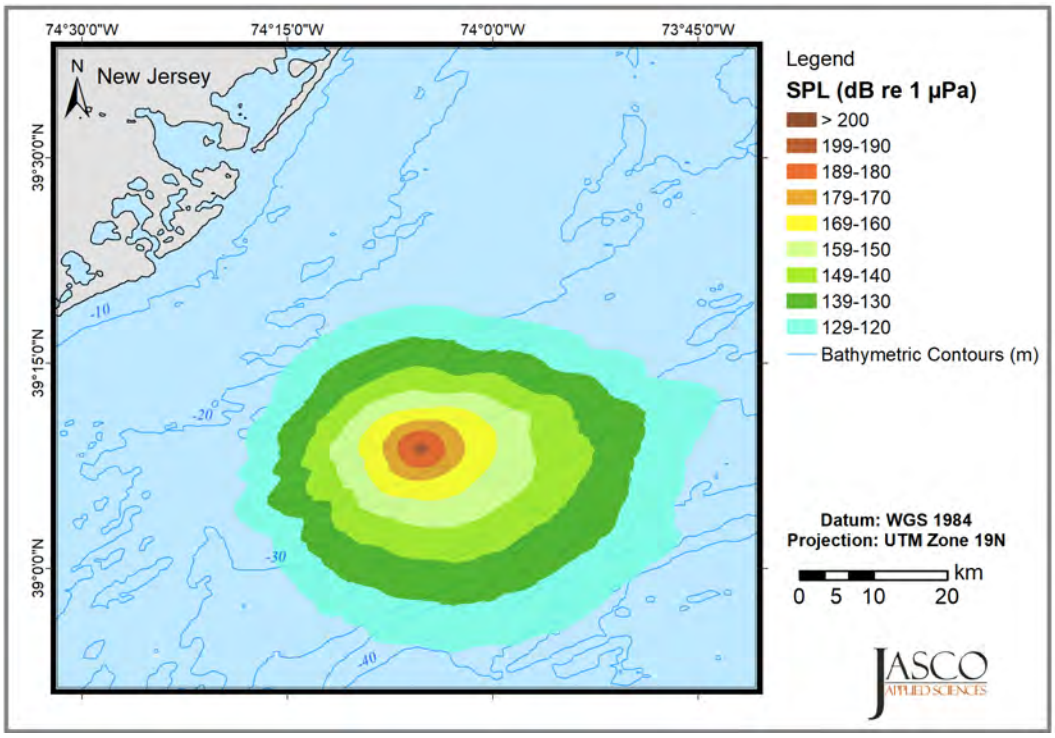

Figure F-2. Unweighted single-strike sound pressure level (SPL) for a 12 m pile at location L01, summer sound speed profile and energy level of 4,400 kJ.

Table F-41. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L01 using a Menck MHU4400 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.22	0.21	0.21	0.20	0.02	0.02	-	-	0.06	0.06
180	1.20	1.13	1.18	1.12	0.15	0.14	0.06	0.06	0.43	0.42
170	3.19	2.99	3.17	2.97	0.68	0.65	0.40	0.37	1.99	1.79
160	5.74	5.03	5.70	5.00	2.67	2.50	2.00	1.80	3.98	3.59
150	9.37	8.16	9.36	8.13	5.20	4.62	3.99	3.63	7.58	6.57
140	13.95	12.14	13.94	12.12	9.35	8.15	7.88	6.89	12.03	10.53
130	19.54	16.99	19.54	16.97	14.74	12.62	12.89	11.26	17.92	15.30
120	25.70	22.20	25.69	22.18	20.78	18.03	19.22	16.64	23.63	20.61

A dash (-) indicates that the threshold distance was not reached.

Table F-42. Distance (km) to the single strike sound pressure level (SPL) for a 12m pile at location L01 using a Menck MHU4400 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.05	0.05	0.05	-	-	-	-	-	-
190	0.34	0.33	0.33	0.32	0.03	0.03	-	-	0.12	0.11
180	1.54	1.42	1.52	1.40	0.19	0.18	0.10	0.10	0.57	0.55
170	3.45	3.23	3.43	3.22	0.92	0.88	0.54	0.52	2.33	2.14
160	6.40	5.54	6.38	5.52	3.04	2.84	2.28	2.08	4.42	4.03
150	9.97	8.78	9.95	8.76	5.82	5.09	4.50	4.07	8.15	7.06
140	14.95	12.78	14.85	12.76	10.14	8.74	8.55	7.45	12.71	11.10
130	20.34	17.65	20.30	17.63	15.55	13.38	13.83	12.00	18.62	15.98
120	26.96	22.95	26.96	22.93	21.63	18.90	20.09	17.55	24.79	21.41

A dash (-) indicates that the threshold distance was not reached.

Table F-43. Distance (km) to the single strike sound pressure level (SPL) for a 12m pile at location L01 using a Menck MHU4400 hammer operating at 2,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.09	0.09	0.08	0.08	-	-	-	-	0.02	0.02
190	0.41	0.39	0.39	0.38	0.03	0.03	0.02	0.02	0.15	0.14
180	1.77	1.64	1.71	1.62	0.22	0.21	0.13	0.13	0.67	0.63
170	3.64	3.37	3.62	3.36	1.13	1.07	0.64	0.61	2.63	2.37
160	6.68	5.83	6.68	5.81	3.30	3.08	2.64	2.39	4.78	4.36
150	10.55	9.25	10.50	9.23	6.40	5.56	5.04	4.48	8.67	7.57
140	15.67	13.43	15.65	13.41	10.69	9.41	9.29	8.09	13.46	11.78
130	21.15	18.40	21.14	18.38	16.59	14.22	14.84	12.72	19.46	16.86
120	28.32	23.92	28.31	23.90	22.66	19.81	21.06	18.29	26.04	22.35

A dash (-) indicates that the threshold distance was not reached.

Table F-44. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L01 using a Menck MHU4400 hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.12	0.12	0.11	0.11	-	-	-	-	0.03	0.03
190	0.57	0.55	0.56	0.54	0.06	0.06	0.03	0.03	0.19	0.19
180	2.12	1.98	2.10	1.96	0.33	0.31	0.21	0.20	0.95	0.91
170	4.04	3.70	4.02	3.68	1.72	1.59	0.97	0.93	3.05	2.86
160	7.43	6.44	7.40	6.42	3.70	3.44	3.13	2.93	5.82	5.06
150	11.49	10.20	11.47	10.18	7.46	6.45	6.16	5.36	9.90	8.62
140	17.23	14.75	17.21	14.73	12.12	10.72	10.66	9.36	15.29	13.07
130	22.76	19.93	22.74	19.91	18.62	15.92	16.65	14.40	21.14	18.37
120	30.73	25.75	30.49	25.73	25.16	21.71	23.21	20.21	28.75	24.25

A dash (-) indicates that the threshold distance was not reached.

Table F-45. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L01 using a Menck MHU4400 hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.17	0.16	0.16	0.16	-	-	-	-	0.05	0.05
190	0.84	0.80	0.82	0.78	0.09	0.08	0.05	0.05	0.25	0.23
180	2.69	2.50	2.67	2.48	0.52	0.50	0.26	0.25	1.34	1.24
170	4.72	4.26	4.70	4.24	2.12	1.96	1.54	1.35	3.39	3.16
160	8.20	7.12	8.17	7.10	4.34	3.90	3.46	3.26	6.46	5.67
150	12.49	10.99	12.45	10.97	8.28	7.24	7.09	6.18	10.70	9.44
140	18.34	15.74	18.34	15.73	13.50	11.76	11.97	10.56	16.54	14.10
130	24.18	21.06	24.17	21.04	19.98	17.31	18.60	15.96	22.37	19.60
120	32.46	27.11	32.45	27.09	27.84	23.43	25.92	22.06	30.75	25.77

A dash (-) indicates that the threshold distance was not reached.

Table F-46. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L01 using a Menck MHU4400 hammer operating at 480 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.02	0.02	-	-	-	-	-	-	-	-
190	0.13	0.13	0.13	0.13	-	-	-	-	0.03	0.03
180	0.65	0.62	0.62	0.60	0.05	0.05	0.03	0.03	0.17	0.17
170	2.29	2.12	2.24	2.07	0.27	0.24	0.17	0.17	0.87	0.84
160	4.04	3.69	4.01	3.66	1.48	1.34	0.82	0.78	2.88	2.68
150	7.16	6.25	7.13	6.23	3.43	3.21	2.90	2.68	5.24	4.69
140	10.99	9.71	10.95	9.69	6.78	5.90	5.50	4.85	9.19	7.99
130	16.21	13.90	16.19	13.88	11.25	9.90	10.01	8.62	14.30	12.21
120	21.69	18.89	21.68	18.87	17.18	14.89	15.69	13.48	20.04	17.37

A dash (-) indicates that the threshold distance was not reached.

Table F-47. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L01 using a Menck MHU4400 hammer operating at 800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.17	0.16	0.17	0.16	-	-	-	-	0.05	0.05
180	0.86	0.81	0.84	0.79	0.08	0.07	0.03	0.03	0.26	0.26
170	2.71	2.54	2.70	2.52	0.43	0.41	0.22	0.22	1.34	1.24
160	4.72	4.28	4.70	4.26	2.01	1.84	1.20	1.14	3.33	3.11
150	8.14	7.03	8.12	7.01	3.90	3.58	3.30	3.08	6.20	5.43
140	12.09	10.66	12.08	10.63	7.62	6.62	6.38	5.57	10.20	8.88
130	17.43	15.00	17.41	14.98	12.32	10.79	10.86	9.52	15.34	13.15
120	22.76	19.95	22.74	19.93	18.60	15.95	16.76	14.60	21.10	18.31

A dash (-) indicates that the threshold distance was not reached.

Table F-48. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L01 using a Menck MHU4400 hammer operating at 1,600 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.06	0.05	0.05	-	-	-	-	-	-
190	0.33	0.32	0.32	0.30	0.02	0.02	-	-	0.10	0.10
180	1.44	1.36	1.44	1.35	0.16	0.15	0.07	0.07	0.52	0.49
170	3.27	3.08	3.24	3.06	0.77	0.73	0.43	0.40	2.04	1.90
160	5.88	5.15	5.86	5.13	2.71	2.53	2.01	1.83	3.96	3.59
150	9.35	8.15	9.32	8.13	5.00	4.45	3.77	3.55	7.33	6.39
140	13.65	11.93	13.57	11.90	8.96	7.80	7.58	6.63	11.49	10.18
130	19.06	16.51	19.04	16.49	14.30	12.21	12.49	10.95	17.17	14.77
120	24.85	21.62	24.84	21.61	20.38	17.64	18.68	16.29	22.82	20.07

A dash (-) indicates that the threshold distance was not reached.

Table F-49. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L01 using a Menck MHU4400 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.12	0.12	0.11	0.11	-	-	-	-	0.03	0.03
190	0.56	0.54	0.56	0.53	0.05	0.05	0.03	0.03	0.17	0.17
180	2.07	1.94	2.05	1.92	0.25	0.23	0.15	0.15	0.84	0.80
170	3.97	3.62	3.92	3.60	1.36	1.23	0.79	0.75	2.86	2.65
160	7.11	6.20	7.05	6.18	3.40	3.16	2.76	2.52	5.14	4.62
150	10.89	9.61	10.87	9.58	6.48	5.68	5.21	4.63	8.98	7.80
140	15.95	13.66	15.92	13.64	10.82	9.50	9.39	8.19	13.62	11.89
130	21.36	18.49	21.34	18.47	16.59	14.25	14.85	12.81	19.50	16.88
120	28.09	23.90	28.07	23.88	22.65	19.79	21.10	18.35	25.91	22.28

A dash (-) indicates that the threshold distance was not reached.

Table F-50. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L01 using a Menck MHU4400 hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.13	0.13	0.12	0.12	-	-	-	-	0.03	0.03
190	0.62	0.59	0.60	0.58	0.06	0.06	0.03	0.03	0.19	0.19
180	2.27	2.10	2.23	2.04	0.31	0.30	0.19	0.18	0.95	0.91
170	4.06	3.73	4.04	3.71	1.67	1.49	0.92	0.87	3.01	2.83
160	7.35	6.40	7.33	6.38	3.60	3.32	3.01	2.82	5.54	4.91
150	11.28	10.02	11.26	9.99	7.02	6.11	5.80	5.04	9.58	8.31
140	16.81	14.33	16.79	14.30	11.50	10.15	10.18	8.79	14.72	12.57
130	22.01	19.28	22.01	19.26	17.52	15.07	15.70	13.50	20.38	17.68
120	29.50	24.85	29.48	24.83	23.67	20.64	21.82	19.10	27.39	23.22

A dash (-) indicates that the threshold distance was not reached.

Table F-51. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L01 using a Menck MHU4400 hammer operating at 4,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.15	0.14	0.14	0.13	-	-	-	-	0.03	0.03
190	0.70	0.67	0.68	0.65	0.06	0.06	0.03	0.03	0.22	0.21
180	2.46	2.25	2.39	2.23	0.43	0.41	0.22	0.22	1.18	1.12
170	4.38	3.97	4.36	3.95	2.01	1.83	1.15	1.09	3.20	3.02
160	7.85	6.80	7.83	6.77	3.90	3.57	3.28	3.04	6.16	5.37
150	12.08	10.60	12.07	10.59	7.70	6.68	6.40	5.58	10.26	8.97
140	17.73	15.18	17.71	15.16	12.43	10.92	10.83	9.52	15.65	13.40
130	22.97	20.26	22.97	20.25	18.64	16.04	16.77	14.44	21.38	18.59
120	30.84	25.96	30.84	25.94	25.14	21.70	22.91	20.13	28.80	24.37

A dash(-) indicates that the threshold distance was not reached.

Table F-52. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L01 using a Menck MHU4400 hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.17	0.16	0.17	0.16	-	-	-	-	0.05	0.05
190	0.85	0.81	0.83	0.80	0.09	0.09	0.05	0.05	0.28	0.27
180	2.71	2.53	2.69	2.51	0.54	0.51	0.28	0.25	1.52	1.38
170	4.74	4.31	4.72	4.29	2.30	2.09	1.55	1.38	3.42	3.19
160	8.30	7.23	8.29	7.21	4.36	3.94	3.45	3.24	6.68	5.78
150	12.75	11.16	12.74	11.14	8.29	7.24	6.98	6.08	10.90	9.57
140	18.58	15.88	18.58	15.87	13.36	11.66	11.57	10.29	16.63	14.18
130	24.18	21.10	24.16	21.08	19.55	17.01	17.98	15.48	22.31	19.53
120	32.14	26.97	32.13	26.96	26.98	22.84	24.82	21.28	30.14	25.47

A dash (-) indicates that the threshold distance was not reached.

Table F-53. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 1,200 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.20	0.19	0.20	0.19	0.06	0.06	0.05	0.05	0.12	0.11
180	1.05	0.98	1.03	0.96	0.37	0.34	0.29	0.27	0.65	0.63
170	3.33	3.03	3.32	3.02	1.78	1.67	1.56	1.35	2.54	2.28
160	6.38	5.63	6.38	5.62	4.34	3.92	3.75	3.55	5.37	4.83
150	11.20	9.82	11.19	9.81	9.16	7.81	8.28	7.19	10.27	8.98
140	17.50	15.19	17.48	15.18	15.25	13.02	14.44	12.25	16.52	14.37
130	24.84	21.39	24.84	21.38	22.18	19.12	21.20	18.19	23.77	20.58
120	34.23	28.49	34.23	28.48	31.74	26.22	30.20	25.21	33.25	27.72

A dash (-) indicates that the threshold distance was not reached.

Table F-54. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,200 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.02	0.02
190	0.26	0.25	0.26	0.25	0.09	0.09	0.06	0.06	0.16	0.16
180	1.33	1.26	1.32	1.25	0.51	0.48	0.44	0.41	0.85	0.82
170	3.62	3.40	3.61	3.39	2.22	2.08	1.99	1.73	3.18	2.86
160	7.17	6.36	7.16	6.35	5.01	4.57	4.58	4.08	6.26	5.56
150	12.28	10.79	12.27	10.78	10.23	8.73	9.53	8.08	11.26	9.94
140	18.80	16.41	18.80	16.40	16.35	14.22	15.51	13.41	17.94	15.57
130	26.96	22.73	26.96	22.72	23.77	20.46	22.73	19.53	25.88	21.92
120	36.06	30.08	36.05	30.07	33.25	27.75	32.24	26.73	35.24	29.27

A dash (-) indicates that the threshold distance was not reached.

Table F-55. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.22	0.21	0.21	0.21	0.06	0.06	0.05	0.05	0.12	0.12
180	1.14	1.08	1.13	1.07	0.42	0.38	0.29	0.28	0.67	0.65
170	3.31	3.09	3.30	3.08	1.81	1.70	1.59	1.46	2.61	2.40
160	6.28	5.54	6.28	5.52	4.11	3.73	3.66	3.46	5.23	4.70
150	11.07	9.63	11.05	9.61	8.74	7.59	8.20	6.97	10.24	8.77
140	17.16	14.94	17.16	14.93	15.01	12.72	13.92	11.95	16.20	14.06
130	24.32	21.05	24.32	21.04	21.94	18.76	20.72	17.87	23.57	20.24
120	33.74	28.11	33.74	28.10	31.24	25.83	29.69	24.82	32.76	27.33

A dash (-) indicates that the threshold distance was not reached.

Table F-56. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 1,400 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.27	0.27	0.27	0.26	0.10	0.09	0.07	0.07	0.18	0.17
180	1.57	1.42	1.56	1.41	0.51	0.50	0.45	0.43	0.92	0.85
170	3.53	3.32	3.53	3.32	2.26	2.11	2.03	1.77	3.18	2.91
160	7.12	6.23	7.12	6.22	4.93	4.42	4.40	3.91	6.02	5.39
150	12.07	10.62	12.05	10.61	10.01	8.49	9.17	7.85	11.17	9.74
140	18.66	16.13	18.66	16.12	15.93	13.91	15.25	13.10	17.48	15.27
130	26.47	22.39	26.47	22.38	23.56	20.10	22.22	19.17	25.33	21.58
120	35.53	29.65	35.53	29.64	32.77	27.35	31.76	26.32	34.72	28.87

A dash (-) indicates that the threshold distance was not reached.

Table F-57. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.04	0.04	0.03	0.03	-	-	-	-	0.02	0.02
190	0.24	0.23	0.23	0.23	0.08	0.08	0.06	0.06	0.15	0.14
180	1.20	1.15	1.20	1.14	0.48	0.46	0.32	0.31	0.81	0.73
170	3.40	3.16	3.39	3.16	2.15	1.93	1.77	1.66	2.99	2.75
160	6.71	5.88	6.69	5.86	4.56	4.07	4.00	3.59	5.67	5.05
150	11.52	10.16	11.52	10.15	9.24	8.01	8.41	7.34	10.67	9.28
140	17.98	15.59	17.98	15.58	15.44	13.26	14.57	12.44	16.78	14.71
130	25.36	21.80	25.36	21.79	22.67	19.40	21.36	18.42	24.31	20.94
120	34.70	28.90	34.70	28.89	31.78	26.51	30.72	25.46	33.75	28.08

A dash (-) indicates that the threshold distance was not reached.

Table F-58. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 1,800 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.03	0.03
190	0.32	0.31	0.31	0.31	0.12	0.12	0.09	0.09	0.22	0.21
180	1.68	1.57	1.67	1.57	0.68	0.65	0.50	0.48	1.11	1.06
170	3.72	3.46	3.70	3.45	2.70	2.41	2.21	2.04	3.31	3.09
160	7.54	6.60	7.54	6.59	5.19	4.73	4.62	4.23	6.64	5.79
150	12.75	11.13	12.74	11.12	10.26	8.94	9.60	8.24	11.70	10.27
140	19.48	16.80	19.46	16.79	16.65	14.48	15.70	13.62	18.34	15.93
130	27.31	23.13	27.31	23.12	24.29	20.73	23.19	19.76	26.45	22.30
120	36.61	30.53	36.61	30.52	33.75	28.05	32.72	26.99	35.53	29.65

A dash (-) indicates that the threshold distance was not reached.

Table F-59. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L01 using an IHC S-2,500 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.02	0.02	0.02	0.02	-	-	-	-	-	-
190	0.14	0.13	0.13	0.13	0.05	0.05	0.03	0.03	0.07	0.07
180	0.70	0.67	0.69	0.67	0.27	0.26	0.20	0.19	0.45	0.43
170	2.66	2.47	2.65	2.45	1.38	1.29	1.12	1.06	2.03	1.89
160	4.76	4.31	4.75	4.30	3.37	3.10	3.18	2.93	3.83	3.60
150	9.24	7.98	9.16	7.96	6.91	6.08	6.36	5.52	8.24	7.19
140	15.25	12.89	15.25	12.88	12.49	10.81	11.52	10.01	14.31	12.08
130	21.73	18.86	21.73	18.85	19.18	16.67	18.06	15.79	20.82	18.05
120	30.73	25.64	30.73	25.63	27.58	23.26	26.50	22.25	29.68	24.83

A dash (-) indicates that the threshold distance was not reached.

Table F-60. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L01 using an IHC S-2,500 hammer operating at 2,500 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.19	0.19	0.19	0.06	0.06	0.05	0.05	0.11	0.11
180	1.02	0.91	1.00	0.88	0.38	0.34	0.29	0.28	0.65	0.63
170	2.99	2.81	2.98	2.81	1.78	1.66	1.53	1.33	2.48	2.26
160	5.50	4.89	5.50	4.88	3.70	3.49	3.57	3.21	4.70	4.22
150	10.24	8.90	10.24	8.89	7.82	6.93	7.35	6.31	9.41	8.09
140	16.20	14.05	16.20	14.04	13.80	11.91	12.98	11.11	15.66	13.21
130	23.22	20.16	23.21	20.15	20.72	17.86	19.50	17.00	22.64	19.33
120	32.70	27.10	32.70	27.09	29.68	24.75	28.26	23.70	31.72	26.29

A dash (-) indicates that the threshold distance was not reached.

F.2.2. Location L02

Table F-61. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L02 using a Menck MHU4400 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	-	-
190	0.26	0.25	0.24	0.23	0.03	0.03	-	-	0.10	0.10
180	1.15	1.10	1.15	1.09	0.16	0.16	0.10	0.10	0.50	0.47
170	2.81	2.67	2.81	2.66	0.86	0.81	0.48	0.46	1.85	1.75
160	5.04	4.62	5.01	4.60	2.66	2.46	1.89	1.78	3.67	3.44
150	8.24	7.45	8.22	7.43	4.95	4.53	3.91	3.58	6.83	6.24
140	12.58	10.93	12.57	10.92	8.53	7.72	7.29	6.67	10.96	9.65
130	17.77	15.38	17.76	15.36	13.29	11.70	11.91	10.44	15.96	14.01
120	23.64	20.99	23.62	20.98	19.16	16.58	17.59	15.28	21.75	19.29

A dash (-) indicates that the threshold distance was not reached.

Table F-62. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L02 using a Menck MHU4400 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.07	0.07	0.07	0.07	-	-	-	-	0.02	0.02
190	0.34	0.33	0.33	0.32	0.03	0.03	0.02	0.02	0.13	0.13
180	1.38	1.32	1.38	1.31	0.21	0.20	0.13	0.13	0.65	0.61
170	3.01	2.86	3.00	2.85	1.06	0.98	0.63	0.60	2.14	2.03
160	5.48	5.02	5.45	5.00	2.83	2.67	2.24	2.08	4.11	3.77
150	8.80	7.89	8.76	7.87	5.36	4.93	4.31	3.95	7.30	6.66
140	13.13	11.50	13.10	11.48	9.23	8.18	7.85	7.12	11.58	10.14
130	18.48	15.96	18.46	15.94	14.06	12.38	12.68	11.05	16.56	14.60
120	24.53	21.75	24.51	21.73	19.94	17.43	18.72	16.05	22.78	20.19

A dash (-) indicates that the threshold distance was not reached.

Table F-63. Distance (km) to the single strike sound pressure level (SPL) for a 12m pile at location L02 using a Menck MHU4400 hammer operating at 2,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.09	0.08	0.09	0.08	-	-	-	-	0.03	0.03
190	0.42	0.40	0.41	0.39	0.05	0.05	0.03	0.03	0.15	0.15
180	1.58	1.51	1.56	1.49	0.25	0.24	0.16	0.15	0.79	0.74
170	3.20	3.01	3.19	3.00	1.36	1.27	0.80	0.75	2.49	2.35
160	5.87	5.38	5.85	5.36	3.04	2.89	2.59	2.42	4.55	4.17
150	9.36	8.39	9.34	8.37	5.96	5.44	4.89	4.48	7.93	7.18
140	13.98	12.30	13.97	12.28	9.99	8.87	8.58	7.79	12.41	10.84
130	19.45	16.84	19.44	16.82	15.06	13.29	13.61	11.96	17.82	15.48
120	25.71	22.84	25.70	22.83	21.03	18.64	19.54	17.08	24.17	21.39

A dash (-) indicates that the threshold distance was not reached.

Table F-64. Distance (km) to the single strike sound pressure level (SPL) for a 12m pile at location L02 using a Menck MHU4400 hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.12	0.12	0.12	0.12	-	-	-	-	0.03	0.03
190	0.61	0.58	0.60	0.57	0.10	0.10	0.05	0.05	0.21	0.21
180	1.97	1.87	1.95	1.85	0.42	0.41	0.25	0.24	1.12	1.06
170	3.68	3.44	3.67	3.43	1.80	1.69	1.35	1.26	2.86	2.70
160	6.68	6.10	6.62	6.08	3.70	3.46	3.04	2.88	5.41	4.98
150	10.60	9.41	10.59	9.40	7.20	6.54	6.11	5.61	9.26	8.25
140	15.57	13.71	15.56	13.69	11.92	10.41	10.87	9.38	14.09	12.42
130	21.35	18.96	21.35	18.94	17.78	15.33	16.21	14.21	19.93	17.46
120	28.97	24.99	28.79	24.97	24.38	21.73	23.21	20.38	27.48	23.85

A dash (-) indicates that the threshold distance was not reached.

Table F-65. Distance (km) to the single strike sound pressure level (SPL) for a 12 m pile at location L02 using a Menck MHU4400 hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.16	0.16	0.16	0.15	0.02	0.02	-	-	0.06	0.06
190	0.86	0.81	0.84	0.80	0.13	0.13	0.06	0.06	0.34	0.33
180	2.39	2.26	2.37	2.24	0.62	0.60	0.36	0.35	1.42	1.34
170	4.24	3.91	4.22	3.89	2.24	2.09	1.64	1.52	3.13	2.94
160	7.31	6.68	7.30	6.66	4.31	3.96	3.47	3.25	6.05	5.54
150	11.54	10.08	11.53	10.07	8.00	7.23	6.88	6.33	10.09	8.93
140	16.51	14.54	16.50	14.53	12.90	11.32	11.86	10.33	15.11	13.34
130	22.81	20.21	22.81	20.19	19.15	16.48	17.80	15.40	21.22	18.73
120	30.70	26.20	30.59	26.19	26.59	23.21	24.87	22.03	29.10	25.08

A dash (-) indicates that the threshold distance was not reached.

Table F-66. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L02 using a Menck MHU4400 hammer operating at 480 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.02	0.02	0.02	0.02	-	-	-	-	-	-
190	0.13	0.13	0.12	0.12	-	-	-	-	0.03	0.03
180	0.63	0.60	0.62	0.59	0.06	0.06	0.03	0.03	0.19	0.18
170	1.94	1.84	1.92	1.82	0.35	0.34	0.17	0.17	0.99	0.92
160	3.58	3.34	3.56	3.32	1.51	1.39	0.94	0.90	2.70	2.55
150	6.35	5.79	6.34	5.77	3.23	3.04	2.73	2.59	4.95	4.55
140	9.92	8.81	9.89	8.79	6.28	5.73	5.23	4.76	8.29	7.50
130	14.38	12.70	14.37	12.69	10.42	9.21	9.08	8.15	12.80	11.18
120	19.75	17.24	19.72	17.22	15.51	13.69	14.14	12.48	18.24	15.81

A dash (-) indicates that the threshold distance was not reached.

Table F-67. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L02 using a Menck MHU4400 hammer operating at 800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.15	0.15	0.15	0.15	-	-	-	-	0.05	0.05
180	0.81	0.78	0.80	0.77	0.10	0.10	0.05	0.05	0.29	0.28
170	2.29	2.18	2.27	2.16	0.48	0.46	0.25	0.24	1.30	1.20
160	4.01	3.72	3.99	3.70	1.81	1.72	1.31	1.18	2.91	2.76
150	6.88	6.30	6.87	6.28	3.65	3.42	2.99	2.82	5.47	5.02
140	10.60	9.41	10.59	9.39	6.88	6.31	5.81	5.35	8.97	8.08
130	15.27	13.46	15.25	13.44	11.36	9.94	10.01	8.89	13.64	12.01
120	20.76	18.30	20.74	18.28	16.86	14.65	15.28	13.46	19.30	16.72

A dash (-) indicates that the threshold distance was not reached.

Table F-68. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L02 using a Menck MHU4400 hammer operating at 1,600 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	-	-
190	0.30	0.30	0.30	0.29	0.03	0.03	-	-	0.11	0.11
180	1.29	1.20	1.27	1.18	0.16	0.16	0.10	0.10	0.54	0.51
170	2.79	2.66	2.79	2.65	0.86	0.81	0.50	0.47	1.87	1.78
160	5.02	4.62	5.00	4.60	2.53	2.41	1.85	1.76	3.63	3.39
150	8.07	7.33	8.05	7.31	4.71	4.33	3.70	3.48	6.61	6.06
140	12.27	10.68	12.25	10.66	8.20	7.47	7.06	6.44	10.57	9.37
130	17.11	15.02	17.09	15.00	12.97	11.36	11.78	10.23	15.50	13.63
120	23.08	20.50	23.07	20.48	18.79	16.27	17.38	15.09	21.23	18.80

A dash (-) indicates that the threshold distance was not reached.

Table F-69. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L02 using a Menck MHU4400 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.11	0.11	0.11	0.11	-	-	-	-	0.03	0.03
190	0.53	0.51	0.53	0.50	0.05	0.05	0.03	0.03	0.16	0.16
180	1.78	1.70	1.77	1.68	0.32	0.31	0.16	0.16	0.90	0.86
170	3.43	3.21	3.42	3.20	1.38	1.30	0.85	0.79	2.58	2.44
160	6.17	5.63	6.15	5.61	3.10	2.91	2.56	2.43	4.75	4.35
150	9.62	8.56	9.61	8.55	5.96	5.45	4.90	4.48	8.01	7.25
140	14.01	12.35	14.00	12.33	9.95	8.78	8.50	7.68	12.37	10.78
130	19.28	16.71	19.27	16.70	14.86	13.04	13.29	11.71	17.53	15.29
120	25.36	22.54	25.26	22.53	20.67	18.20	19.24	16.71	23.62	20.99

A dash (-) indicates that the threshold distance was not reached.

Table F-70. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L02 using a Menck MHU4400 hammer operating at 3,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.12	0.12	0.12	0.12	-	-	-	-	0.03	0.03
190	0.62	0.59	0.61	0.58	0.07	0.07	0.04	0.04	0.21	0.21
180	1.96	1.87	1.95	1.85	0.39	0.37	0.21	0.21	1.11	1.02
170	3.63	3.39	3.61	3.37	1.64	1.54	1.11	1.03	2.74	2.62
160	6.53	5.93	6.51	5.92	3.41	3.20	2.79	2.66	5.15	4.73
150	10.18	9.06	10.16	9.04	6.55	5.99	5.40	4.99	8.60	7.78
140	14.88	13.08	14.85	13.06	10.64	9.51	9.32	8.38	13.20	11.56
130	20.20	17.74	20.20	17.72	15.96	14.00	14.53	12.73	18.72	16.21
120	26.83	23.66	26.81	23.65	22.30	19.64	20.56	18.04	25.06	22.24

A dash (-) indicates that the threshold distance was not reached.

Table F-71. Distance (km) to the single strike sound pressure level (SPL) for a 15 m pile at location L02 using a Menck MHU4400 hammer operating at 4,000 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.15	0.15	0.15	0.14	-	-	-	-	0.05	0.05
190	0.75	0.72	0.74	0.70	0.11	0.11	0.05	0.05	0.31	0.30
180	2.27	2.14	2.25	2.12	0.56	0.54	0.33	0.33	1.38	1.30
170	4.07	3.75	4.05	3.73	2.05	1.94	1.43	1.37	3.01	2.85
160	7.13	6.52	7.12	6.51	4.09	3.75	3.27	3.04	5.89	5.40
150	11.29	9.90	11.27	9.89	7.60	6.90	6.47	5.91	9.82	8.71
140	16.26	14.27	16.22	14.25	12.31	10.74	10.99	9.64	14.69	12.95
130	22.05	19.60	22.04	19.58	18.13	15.65	16.42	14.42	20.40	17.98
120	29.47	25.43	29.47	25.41	24.79	22.00	23.27	20.57	27.86	24.20

A dash (-) indicates that the threshold distance was not reached.

Table F-72. Distance (km) to the single strike sound pressure level (SPL) for a 15m pile at location L02 using a Menck MHU4400 hammer operating at 4,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.17	0.16	0.16	0.16	0.02	0.02	-	-	0.06	0.06
190	0.87	0.82	0.86	0.81	0.13	0.13	0.06	0.06	0.35	0.34
180	2.46	2.31	2.44	2.29	0.65	0.61	0.37	0.36	1.52	1.41
170	4.38	4.00	4.36	3.98	2.27	2.14	1.65	1.54	3.21	3.01
160	7.44	6.80	7.43	6.79	4.45	4.05	3.53	3.26	6.25	5.68
150	11.66	10.24	11.66	10.23	8.04	7.30	6.88	6.31	10.18	9.09
140	16.76	14.72	16.75	14.71	12.87	11.30	11.77	10.20	15.25	13.46
130	22.85	20.35	22.85	20.33	18.95	16.33	17.39	15.17	21.23	18.77
120	30.57	26.21	30.56	26.20	26.13	22.93	24.29	21.60	29.03	24.99

A dash (-) indicates that the threshold distance was not reached.

Table F-73. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,200 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	0.02	0.02
190	0.21	0.21	0.21	0.21	0.07	0.07	0.06	0.06	0.15	0.15
180	1.10	1.05	1.09	1.05	0.43	0.42	0.34	0.33	0.71	0.68
170	3.07	2.91	3.06	2.91	1.94	1.71	1.58	1.47	2.62	2.40
160	5.80	5.34	5.80	5.33	4.16	3.78	3.63	3.39	5.08	4.66
150	10.16	9.07	10.16	9.07	8.14	7.37	7.61	6.83	9.51	8.40
140	15.97	13.89	15.97	13.88	14.06	12.01	12.97	11.36	15.09	13.18
130	22.79	20.11	22.79	20.10	20.28	17.74	19.47	16.87	21.75	19.26
120	31.88	26.91	31.88	26.90	29.13	24.88	28.03	24.02	31.26	26.20

A dash (-) indicates that the threshold distance was not reached.

Table F-74. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L02 using an IHC S-2,500 hammer operating at 1,200 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.03	0.03
190	0.31	0.31	0.31	0.30	0.12	0.12	0.07	0.07	0.19	0.19
180	1.43	1.34	1.42	1.33	0.61	0.59	0.50	0.44	1.00	0.95
170	3.39	3.22	3.39	3.21	2.32	2.19	1.99	1.88	3.05	2.86
160	6.67	6.01	6.66	6.00	4.88	4.43	4.44	3.91	5.78	5.35
150	11.35	9.92	11.35	9.91	9.50	8.24	8.62	7.66	10.48	9.28
140	17.33	14.96	17.32	14.95	15.09	13.10	14.52	12.42	16.44	14.27
130	24.29	21.54	24.28	21.53	21.83	19.21	20.89	18.26	23.32	20.76
120	34.29	28.40	34.28	28.40	31.36	26.33	29.77	25.41	32.97	27.69

A dash (-) indicates that the threshold distance was not reached.

Table F-75. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,400 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.24	0.23	0.24	0.23	0.07	0.07	0.06	0.06	0.16	0.16
180	1.31	1.18	1.30	1.16	0.52	0.50	0.40	0.38	0.79	0.77
170	3.05	2.90	3.05	2.90	2.00	1.88	1.63	1.54	2.70	2.54
160	6.06	5.50	6.05	5.49	4.42	3.91	3.78	3.45	5.34	4.81
150	10.51	9.28	10.50	9.27	8.43	7.58	7.92	7.03	9.66	8.59
140	16.13	14.15	16.12	14.14	14.12	12.27	13.17	11.61	15.26	13.45
130	23.20	20.47	23.19	20.47	20.66	18.07	19.93	17.18	22.17	19.60
120	32.41	27.25	32.41	27.24	29.60	25.20	28.51	24.34	31.39	26.55

A dash (-) indicates that the threshold distance was not reached.

Table F-76. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,400 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.03	0.03
190	0.35	0.34	0.35	0.34	0.14	0.13	0.10	0.10	0.21	0.21
180	1.58	1.47	1.55	1.46	0.70	0.64	0.54	0.52	1.07	1.02
170	3.39	3.19	3.39	3.19	2.50	2.30	2.22	1.94	3.04	2.86
160	6.80	6.17	6.79	6.17	5.04	4.58	4.72	4.09	6.07	5.50
150	11.54	10.14	11.54	10.13	9.54	8.43	9.05	7.90	10.89	9.46
140	17.52	15.21	17.51	15.20	15.22	13.34	14.64	12.64	16.82	14.52
130	24.78	21.85	24.78	21.84	22.32	19.57	21.12	18.61	23.79	21.09
120	34.75	28.77	34.74	28.76	31.85	26.67	30.32	25.75	33.77	28.06

A dash (-) indicates that the threshold distance was not reached.

Table F-77. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L02 using an IHC S-2,500 hammer operating at 1,800 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.17	0.17	0.17	0.17	0.06	0.06	0.05	0.05	0.12	0.12
180	0.88	0.83	0.87	0.82	0.38	0.36	0.26	0.25	0.60	0.56
170	2.69	2.54	2.68	2.54	1.60	1.52	1.34	1.27	2.26	2.08
160	5.16	4.71	5.15	4.70	3.63	3.36	3.24	3.04	4.61	4.12
150	9.31	8.36	9.31	8.35	7.60	6.81	6.81	6.29	8.64	7.75
140	14.96	13.07	14.96	13.06	12.91	11.30	12.26	10.70	14.24	12.40
130	21.41	19.01	21.39	19.00	19.46	16.84	18.73	16.07	20.71	18.20
120	30.75	25.91	30.74	25.90	28.04	24.00	26.76	23.13	29.63	25.24

A dash (-) indicates that the threshold distance was not reached.

Table F-78. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 1,800 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.02	0.02
190	0.23	0.23	0.23	0.22	0.10	0.10	0.06	0.06	0.16	0.16
180	1.19	1.08	1.18	1.08	0.53	0.52	0.41	0.40	0.79	0.77
170	3.00	2.78	3.00	2.77	2.09	1.90	1.67	1.57	2.65	2.51
160	5.85	5.39	5.83	5.38	4.44	3.93	3.83	3.49	5.29	4.75
150	10.45	9.22	10.42	9.21	8.52	7.63	7.94	7.12	9.66	8.58
140	16.14	14.13	16.13	14.12	14.50	12.37	13.50	11.73	15.39	13.48
130	23.23	20.52	23.23	20.51	20.89	18.23	19.96	17.35	22.32	19.70
120	32.45	27.37	32.45	27.36	29.74	25.36	28.66	24.51	31.84	26.69

A dash (-) indicates that the threshold distance was not reached.

Table F-79. Distance (km) to the single strike sound pressure level (SPL) for a 5m pile at location L02 using an IHC S-2,500 hammer operating at 2,500 kJ.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	-	-
180	0.16	0.16	0.15	0.15	-	-	-	-	0.03	0.03
170	0.66	0.63	0.65	0.62	0.10	0.10	0.06	0.06	0.21	0.20
160	1.98	1.88	1.96	1.86	0.53	0.51	0.36	0.34	1.05	0.99
150	3.28	3.10	3.27	3.09	1.95	1.81	1.55	1.44	2.54	2.42
140	5.46	5.02	5.43	5.00	3.41	3.24	3.12	3.00	4.29	3.97
130	9.01	8.13	9.00	8.12	6.52	5.95	5.73	5.32	8.02	7.19
120	14.07	12.33	14.06	12.32	11.54	10.05	10.89	9.36	13.11	11.34

A dash (-) indicates that the threshold distance was not reached.

Table F-80. Distance (km) to the single strike sound pressure level (SPL) for a 5 m pile at location L02 using an IHC S-2,500 hammer operating at 2,500 kJ, with 2 dB shift for post-piling installation.

Level (SEL)	Flat R_{max}	Flat $R_{95\%}$	LFC R_{max}	LFC $R_{95\%}$	MFC R_{max}	MFC $R_{95\%}$	HFC R_{max}	HFC $R_{95\%}$	PPW R_{max}	PPW $R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	-	-
180	0.20	0.19	0.19	0.19	0.02	0.02	-	-	0.06	0.06
170	0.86	0.81	0.83	0.80	0.14	0.14	0.10	0.10	0.31	0.30
160	2.28	2.15	2.26	2.14	0.69	0.66	0.52	0.50	1.38	1.30
150	3.49	3.32	3.49	3.31	2.28	2.17	1.96	1.82	2.97	2.72
140	6.11	5.59	6.10	5.57	3.67	3.48	3.41	3.24	5.05	4.59
130	10.00	8.88	9.98	8.87	7.45	6.68	6.73	6.03	8.88	7.96
120	15.18	13.34	15.18	13.33	12.55	10.98	11.81	10.28	14.18	12.38

A dash (-) indicates that the threshold distance was not reached.

F.3. Ranges to PK Thresholds

The following tables present max single-strike PK isopleth ranges (R_{max}). PK metrics are implicitly unweighted. All calculations use an average summer sound speed profile.

F.3.1. Location L01

Table F-81. Distance (km) to the single strike peak pressure level (PK) for a 12m pile using a Menck MHU4400S hammer.

Level (L_{pk})	Flat R_{max}				
	Hammer energy (kJ)				
	1,400	1,800	2,000	3,000	4,400
230	0.00	0.00	0.00	0.00	0.01
219	0.04	0.05	0.06	0.07	0.08
218	0.05	0.05	0.06	0.07	0.09
216	0.06	0.07	0.08	0.09	0.11
213	0.08	0.09	0.10	0.12	0.20
210	0.10	0.11	0.16	0.22	0.33
207	0.17	0.20	0.22	0.36	0.41
206	0.19	0.21	0.32	0.38	0.44
202	0.35	0.43	0.48	0.60	0.72
200	0.46	0.52	0.66	0.76	0.96

Table F-82. Distance (km) to the single strike peak pressure level (PK) for a 15m pile using a Menck MHU440S hammer.

Level (L_{pk})	Flat R_{max}						
	Hammer energy (kJ)						
	480	800	1,600	2,500	3,000	4,000	4,400
230	0.00	0.00	0.00	0.00	0.01	0.01	0.01
219	0.01	0.01	0.04	0.06	0.07	0.08	0.08
218	0.01	0.01	0.05	0.06	0.07	0.09	0.09
216	0.01	0.04	0.06	0.08	0.09	0.10	0.11
213	0.04	0.06	0.08	0.10	0.11	0.19	0.21
210	0.06	0.08	0.10	0.13	0.19	0.24	0.32
207	0.08	0.10	0.15	0.30	0.33	0.38	0.41
206	0.09	0.11	0.19	0.33	0.35	0.40	0.43
202	0.12	0.29	0.36	0.47	0.64	0.64	0.78
200	0.28	0.34	0.47	0.68	0.86	0.80	0.96

Table F-83. Distance (km) to the single strike peak pressure level (PK) for a 5 m pile using an IHC S-2,500 hammer.

Level (L_{pk})	Flat R_{max}			
	Hammer energy (kJ)			
	1,200	1,400	1,800	2,500
230	0.00	0.00	0.00	0.00
219	0.06	0.05	0.03	0.02
218	0.07	0.06	0.04	0.03
216	0.08	0.08	0.05	0.04
213	0.10	0.10	0.07	0.06
210	0.19	0.19	0.11	0.08
207	0.27	0.30	0.17	0.12
206	0.29	0.33	0.21	0.14
202	0.50	0.43	0.38	0.28
200	0.56	0.52	0.48	0.35

Table F-84. Distance (km) to the single strike peak pressure level (PK) for a 5 m pile using an IHC S-2,500 hammer, with 2 dB shift for post-piling installation.

Level (L_{pk})	Flat R_{max}			
	Hammer energy (kJ)			
	1,200	1,400	1,800	2,500
230	0.00	0.00	0.00	0.00
219	0.00	0.00	0.00	0.01
218	0.07	0.07	0.05	0.03
216	0.08	0.08	0.05	0.04
213	0.09	0.09	0.07	0.05
210	0.17	0.11	0.09	0.07
207	0.21	0.26	0.14	0.10
206	0.33	0.35	0.25	0.15
202	0.39	0.37	0.28	0.23
200	0.56	0.52	0.48	0.35

F.3.2. Location L02

Table F-85. Distance (km) to the single strike peak pressure level (PK) for a 12 m pile using an Menck MHU4400S hammer.

Level (L_{pk})	Flat R_{max}				
	Hammer energy (kJ)				
	1,400	1,800	2,000	3,000	4,400
230	0.00	0.00	0.00	0.00	0.01
219	0.03	0.04	0.05	0.06	0.06
218	0.04	0.05	0.05	0.06	0.07
216	0.05	0.06	0.06	0.08	0.09
213	0.07	0.07	0.08	0.13	0.17
210	0.09	0.09	0.14	0.25	0.29
207	0.15	0.22	0.25	0.30	0.37
206	0.22	0.25	0.27	0.35	0.47
202	0.35	0.41	0.45	0.58	0.74
200	0.44	0.46	0.56	0.76	0.86

Table F-86. Distance (km) to the single strike peak pressure level (PK) for a 15 m pile using an Menck MHU440S hammer.

Level (L_{pk})	Flat R_{max}						
	Hammer energy (kJ)						
	480	800	1,600	2,500	3,000	4,000	4,400
230	0.00	0.00	0.00	0.01	0.01	0.01	0.01
219	0.01	0.01	0.04	0.05	0.06	0.07	0.07
218	0.01	0.02	0.04	0.05	0.06	0.07	0.08
216	0.01	0.03	0.05	0.06	0.07	0.09	0.10
213	0.04	0.05	0.07	0.08	0.09	0.16	0.18
210	0.05	0.07	0.09	0.13	0.17	0.27	0.29
207	0.07	0.08	0.13	0.26	0.28	0.33	0.46
206	0.08	0.09	0.23	0.28	0.34	0.46	0.50
202	0.12	0.25	0.38	0.45	0.49	0.64	0.78
200	0.24	0.28	0.44	0.62	0.62	3.00	3.00

Table F-87. Distance (km) to the single strike peak pressure level (PK) for a 5 m pile at location L02 using an IHC S-2,500 hammer.

Level (L_{pk})	Flat R_{max}			
	Hammer energy (kJ)			
	1,200	1,400	1,800	2,500
230	0.00	0.00	0.00	0.00
219	0.05	0.05	0.03	0.02
218	0.05	0.05	0.04	0.03
216	0.07	0.07	0.05	0.04
213	0.08	0.08	0.07	0.06
210	0.16	0.16	0.11	0.08
207	0.24	0.27	0.17	0.12
206	0.26	0.28	0.21	0.14
202	0.41	0.37	0.38	0.28
200	0.48	0.48	0.48	0.35

Table F-88. Distance (km) to the single strike peak pressure level (PK) for a 5 m pile at location L02 using an IHC S-2,500 hammer, with 2 dB shift for post-piling installation.

Level (L_{pk})	Flat R_{max}			
	Hammer energy (kJ)			
	1,200	1,400	1,800	2,500
230	0.00	0.00	0.00	0.01
219	0.00	0.00	0.01	0.01
218	0.06	0.06	0.03	0.04
216	0.07	0.07	0.04	0.05
213	0.08	0.08	0.05	0.06
210	0.14	0.12	0.07	0.08
207	0.22	0.25	0.12	0.11
206	0.31	0.30	0.24	0.13
202	0.33	0.32	0.25	0.14
200	0.48	0.48	0.35	0.17

F.4. Ranges to Per-Pile SEL Thresholds

Table F-89. Ranges ($R_{95\%}$ in km) to cumulative SEL injury thresholds for one 12 m monopile using a Menck MHU1900S hammer with attenuation at two modeling locations (L01 and L02).

Hearing group	Threshold (dB)	L01				L02			
		Attenuation level (dB)				Attenuation level (dB)			
		0	6	10	15	0	6	10	15
Low-frequency cetaceans	183	7.80	5.70	4.49	3.13	7.46	5.52	4.34	2.99
Mid-frequency cetaceans	185	0.12	0.03	0.02	0.00	0.17	0.06	0.04	0.00
High-frequency cetaceans	155	4.34	2.75	1.80	0.99	4.76	3.05	2.23	1.20
Phocid pinnipeds	185	2.16	0.99	0.54	0.22	2.28	1.16	0.68	0.28
Sea turtles	204	3.11	1.72	1.00	0.47	2.90	1.69	1.08	0.54

Table F-90. Ranges ($R_{95\%}$ in km) to cumulative SEL injury thresholds for one 15 m monopile using a Menck MHU4400S hammer with attenuation at two selected modeling locations (L01 and L02).

Hearing group	Threshold (dB)	L01				L02			
		Attenuation level (dB)				Attenuation level (dB)			
		0	6	10	15	0	6	10	15
Low-frequency cetaceans	183	8.29	6.10	4.87	3.50	7.82	5.88	4.68	3.31
Mid-frequency cetaceans	185	0.11	0.03	0.02	0.00	0.17	0.06	0.03	0.00
High-frequency cetaceans	155	4.28	2.69	1.72	0.87	4.71	3.02	2.20	1.19
Phocid pinnipeds	185	2.34	1.14	0.63	0.26	2.43	1.30	0.76	0.34
Sea turtles	204	3.50	2.02	1.28	0.60	3.24	1.95	1.30	0.66

Table F-91. Ranges ($R_{95\%}$ in km) to cumulative SEL injury thresholds for four 5 m jackets using an IHC S-2,500 hammer with attenuation at two selected modeling locations (L01 and L02).

Hearing group	Threshold (dB)	L01				L02			
		Attenuation level (dB)				Attenuation level (dB)			
		0	6	10	15	0	6	10	15
Low-frequency cetaceans	183	10.29	7.44	5.78	4.04	9.12	6.61	5.13	3.51
Mid-frequency cetaceans	185	1.23	0.46	0.20	0.08	1.13	0.41	0.17	0.07
High-frequency cetaceans	155	8.78	6.49	5.15	3.69	8.22	6.06	4.75	3.33
Phocid pinnipeds	185	4.76	2.83	1.75	0.89	4.33	2.58	1.54	0.81
Sea turtles	204	3.19	1.68	1.01	0.41	2.73	1.46	0.84	0.40

Table F-92. Ranges ($R_{95\%}$ in km) to cumulative SEL injury thresholds for four 5 m jackets using an IHC S-2,500 hammer with attenuation at two selected modeling locations (L01 and L02), with 2 dB shift for post-piling installation.

Hearing group	Threshold (dB)	L01				L02			
		Attenuation level (dB)				Attenuation level (dB)			
		0	6	10	15	0	6	10	15
Low-frequency cetaceans	183	11.35	8.34	6.57	4.68	10.01	7.40	5.86	4.16
Mid-frequency cetaceans	185	1.57	0.62	0.24	0.10	1.31	0.70	0.23	0.09
High-frequency cetaceans	155	9.61	7.25	5.86	4.27	9.00	6.75	5.41	3.82
Phocid pinnipeds	185	5.48	3.39	2.26	1.26	5.02	3.04	1.99	1.14
Sea turtles	204	3.75	2.14	1.26	0.63	3.21	1.80	1.11	0.55

F.5. Ranges to Thresholds for Fish

Table F-93. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish - 12 m monopiles using a 4,400 kJ hammer with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)									
			L01					L02				
			1,400	1,800	2,000	3,000	4,400	1,400	1,800	2,000	3,000	4,400
Small fish[a]	L_E	183	8.13					7.47				
	L_{pk}	206	0.09	0.10	0.10	0.18	0.21	0.07	0.08	0.09	0.16	0.25
Large fish[a]	L_E	187	6.72					6.24				
	L_{pk}	206	0.09	0.10	0.10	0.18	0.21	0.07	0.08	0.09	0.16	0.25
All fish[b]	L_p	150	6.15	6.68	7.04	7.81	8.59	5.69	6.11	6.50	7.32	7.94
Fish without swim bladder[c]	L_E	216	0.49					0.51				
	L_{pk}	213	0.04	0.05	0.06	0.07	0.08	0.03	0.04	0.05	0.06	0.06
Fish with swim bladder[c]	L_E	203	2.52					2.26				
	L_{pk}	207	0.08	0.09	0.10	0.12	0.20	0.07	0.07	0.08	0.13	0.17
All fish[c]	L_E	186	7.05					6.54				

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa^2·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-94. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish - 12 m monopiles using a 4,400 kJ hammer with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)									
			L01					L02				
			1,400	1,800	2,000	3,000	4,400	1,400	1,800	2,000	3,000	4,400
Small fish[a]	L_E	183	6.72					6.24				
	L_{pk}	206	0.06	0.07	0.08	0.09	0.11	0.05	0.06	0.06	0.08	0.09
Large fish[a]	L_E	187	5.57					5.12				
	L_{pk}	206	0.06	0.07	0.08	0.09	0.11	0.05	0.06	0.06	0.08	0.09
All fish[b]	L_p	150	5.03	5.54	5.83	6.44	7.12	4.62	5.02	5.38	6.10	6.68
Fish without swim bladder[c]	L_E	216	0.22					0.27				
	L_{pk}	213	0.01	0.01	0.01	0.03	0.05	0.01	0.01	0.03	0.04	0.04
Fish with swim bladder[c]	L_E	203	1.68					1.57				
	L_{pk}	207	0.05	0.06	0.07	0.08	0.10	0.05	0.05	0.06	0.07	0.08
All fish[c]	L_E	186	5.83					5.4				

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa^2·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-95. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish - 12 m monopiles using a 4,400 kJ hammer with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)									
			L01					L02				
			1,400	1,800	2,000	3,000	4,400	1,400	1,800	2,000	3,000	4,400
Small fish[a]	L_E	183	5.27					4.85				
	L_{pk}	206	0.01	0.02	0.04	0.05	0.06	0.02	0.03	0.04	0.05	0.05
Large fish[a]	L_E	187	4.20					3.8				
	L_{pk}	206	0.01	0.02	0.04	0.05	0.06	0.02	0.03	0.04	0.05	0.05
All fish[b]	L_p	150	3.73	4.20	4.46	4.99	5.62	3.39	3.73	4.05	4.69	5.24
Fish without swim bladder[c]	L_E	216	0.12					0.12				
	L_{pk}	213	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01
Fish with swim bladder[c]	L_E	203	0.91					0.89				
	L_{pk}	207	0.01	0.01	0.02	0.05	0.06	0.01	0.03	0.03	0.04	0.05
All fish[c]	L_E	186	4.45					4.06				

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa²·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-96. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish - 15 m monopiles using a 4,400 kJ hammer with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)												
			L01							L02							
			480	800	1,600	2,500	3,000	4,000	4,400	480	800	1,600	2,500	3,000	4,000	4,400
Small fish[a]	L_E	183	8.67							7.89						
	L_{pk}	206	0.05	0.06	0.09	0.11	0.16	0.20	0.22	0.04	0.05	0.07	0.09	0.14	0.18	0.25
Large fish[a]	L_E	187	7.22							6.65						
	L_{pk}	206	0.05	0.06	0.09	0.11	0.16	0.20	0.22	0.04	0.05	0.07	0.09	0.14	0.18	0.25
All fish[b]	L_p	150	4.63	5.33	6.25	7.43	7.72	8.22	8.72	4.24	4.72	5.65	6.72	7.09	7.78	8.07
Fish without swim bladder[c]	L_E	216	0.62							0.64						
	L_{pk}	213	0.01	0.01	0.04	0.06	0.07	0.08	0.08	0.01	0.01	0.04	0.05	0.06	0.07	0.07
Fish with swim bladder[c]	L_E	203	2.89							2.57						
	L_{pk}	207	0.04	0.06	0.08	0.10	0.11	0.19	0.21	0.04	0.05	0.07	0.08	0.09	0.16	0.18
All fish[c]	L_E	186	7.56							6.95						

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa²·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-97. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish – 15 m monopiles using a 4,400 kJ hammer with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)												
			L01							L02					
			480	800	1,600	2,500	3,000	4,000	4,400	480	800	1,600	2,500	3,000	4,000	4,400
Small fish[a]	L_E	183	7.22							6.65						
	L_{pk}	206	0.01	0.04	0.06	0.08	0.09	0.10	0.11	0.01	0.03	0.05	0.06	0.07	0.09	0.10
Large fish[a]	L_E	187	5.99							5.51						
	L_{pk}	206	0.01	0.04	0.06	0.08	0.09	0.10	0.11	0.01	0.03	0.05	0.06	0.07	0.09	0.10
All fish[b]	L_p	150	3.69	4.28	5.15	6.20	6.40	6.80	7.23	3.34	3.72	4.62	5.63	5.93	6.52	6.80
Fish without swim bladder[c]	L_E	216	0.32							0.34						
	L_{pk}	213	0.00	0.00	0.01	0.02	0.04	0.05	0.05	0.00	0.01	0.01	0.03	0.04	0.04	0.05
Fish with swim bladder[c]	L_E	203	1.97							1.81						
	L_{pk}	207	0.01	0.02	0.05	0.07	0.08	0.09	0.1	0.01	0.03	0.05	0.06	0.07	0.08	0.09
All fish[c]	L_E	186	6.27							5.79						

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa2·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-98. Expected scenario modeled for monopile acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish – 15 m monopiles using a 4,400 kJ hammer with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)												
			L01							L02					
			480	800	1,600	2,500	3,000	4,000	4,400	480	800	1,600	2,500	3,000	4,000	4,400
Small fish[a]	L_E	183	5.70							5.24						
	L_{pk}	206	0.00	0.01	0.02	0.04	0.05	0.06	0.07	0.01	0.01	0.03	0.04	0.05	0.05	0.06
Large fish[a]	L_E	187	4.6							4.17						
	L_{pk}	206	0.00	0.01	0.02	0.04	0.05	0.06	0.07	0.01	0.01	0.03	0.04	0.05	0.05	0.06
All fish[b]	L_p	150	2.97	3.29	3.90	4.84	5.01	5.32	5.68	2.62	2.84	3.46	4.34	4.58	5.09	5.36
Fish without swim bladder[c]	L_E	216	0.15							0.15						
	L_{pk}	213	0.00	0.00	0.0	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Fish with swim bladder[c]	L_E	203	1.13							1.09						
	L_{pk}	207	0.00	0.01	0.01	0.04	0.05	0.06	0.06	0	0.01	0.01	0.03	0.04	0.05	0.05
All fish[c]	L_E	186	4.86							4.44						

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa2·s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-99. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	9.00				7.87			
	L_{pk}	206	0.10	0.11	0.08	0.06	0.09	0.09	0.06	0.07
Large fish[a]	L_E	187	7.24				6.37			
	L_{pk}	206	0.10	0.11	0.08	0.06	0.09	0.09	0.06	0.07
All fish[b]	L_p	150	7.12	6.98	7.40	5.59	6.73	6.90	6.07	2.35
Fish without swim bladder[c]	L_E	216	0.31				0.30			
	L_{pk}	213	0.06	0.05	0.03	0.02	0.05	0.05	0.02	0.03
Fish with swim bladder[c]	L_E	203	2.22				1.84			
	L_{pk}	207	0.10	0.10	0.07	0.06	0.08	0.08	0.05	0.07
All fish[c]	L_E	186	7.66				6.74			

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa²s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-100. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 6 dB attenuation and with 2 dB shift for post-piling installation (OSS foundation).

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	9.94				8.68			
	L_{pk}	206	0.19	0.19	0.11	0.08	0.16	0.16	0.09	0.10
Large fish[a]	L_E	187	8.13				7.11			
	L_{pk}	206	0.19	0.19	0.11	0.08	0.16	0.16	0.09	0.10
All fish[b]	L_p	150	7.98	7.82	8.28	6.33	7.47	7.64	6.78	2.57
Fish without swim bladder[c]	L_E	216	0.46				0.42			
	L_{pk}	213	0.07	0.07	0.05	0.03	0.06	0.06	0.03	0.04
Fish with swim bladder[c]	L_E	203	2.77				2.26			
	L_{pk}	207	0.17	0.11	0.09	0.07	0.14	0.12	0.07	0.08
All fish[c]	L_E	186	8.56				7.48			

L_{pk}= unweighted peak sound pressure (dB re 1 µPa); L_E= unweighted sound exposure level (dB re 1 µPa²s); L_p= unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-101. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	7.24				6.37			
	L_{pk}	206	0.08	0.08	0.05	0.04	0.07	0.07	0.04	0.05
Large fish[a]	L_E	187	5.72				5			
	L_{pk}	206	0.08	0.08	0.05	0.04	0.07	0.07	0.04	0.05
All fish[b]	L_p	150	5.63	5.54	5.88	4.31	5.34	5.50	4.71	1.88
Fish without swim bladder[c]	L_E	216	0.18				0.16			
	L_{pk}	213	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02
Fish with swim bladder[c]	L_E	203	1.42				1.23			
	L_{pk}	207	0.07	0.07	0.05	0.03	0.06	0.06	0.03	0.04
All fish[c]	L_E	186	6.07				5.34			

Note: L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-102. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 10 dB attenuation and with 2 dB shift for post-piling installation (OSS foundation).

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	8.13				7.11			
	L_{pk}	206	0.09	0.09	0.07	0.05	0.08	0.08	0.05	0.06
Large fish[a]	L_E	187	6.45				5.68			
	L_{pk}	206	0.09	0.09	0.07	0.05	0.08	0.08	0.05	0.06
All fish[b]	L_p	150	6.36	6.23	6.60	4.89	6.01	6.17	5.39	2.15
Fish without swim bladder[c]	L_E	216	0.24				0.21			
	L_{pk}	213	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.02
Fish with swim bladder[c]	L_E	203	1.83				1.49			
	L_{pk}	207	0.09	0.09	0.06	0.04	0.07	0.07	0.04	0.05
All fish[c]	L_E	186	6.84				6.01			

Note: L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-103. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	5.35				4.68			
	L_{pk}	206	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.02
Large fish[a]	L_E	187	4.12				3.49			
	L_{pk}	206	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.02
All fish[b]	L_p	150	4.04	3.96	4.24	3.18	3.78	3.95	3.30	1.16
Fish without swim bladder[c]	L_E	216	0.07				0.06			
	L_{pk}	213	0.0	0.00	0.00	0.01	0.00	0.00	0.01	0.01
Fish with swim bladder[c]	L_E	203	0.66				0.59			
	L_{pk}	207	0.01	0.01	0.02	0.02	0.03	0.02	0.01	0.02
All fish[c]	L_E	186	4.42				3.78			

Note: L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Table F-104. Expected scenario modeled for jacket foundation acoustic radial distances ($R_{95\%}$ in km) to thresholds for fish-5 m jacket piles using a 2,500 kJ hammer with 15 dB attenuation and with 2 dB shift for post-piling installation (OSS foundation).

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)							
			L01				L02			
			1,200	1,400	1,800	2,500	1,200	1,400	1,800	2,500
Small fish[a]	L_E	183	6.07				5.34			
	L_{pk}	206	0.06	0.05	0.03	0.02	0.05	0.05	0.02	0.03
Large fish[a]	L_E	187	4.73				4.07			
	L_{pk}	206	0.06	0.05	0.03	0.02	0.05	0.05	0.02	0.03
All fish[b]	L_p	150	4.62	4.54	4.85	3.53	4.38	4.59	3.81	1.44
Fish without swim bladder[c]	L_E	216	0.11				0.11			
	L_{pk}	213	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Fish with swim bladder[c]	L_E	203	0.88				0.78			
	L_{pk}	207	0.05	0.03	0.03	0.02	0.04	0.04	0.02	0.03
All fish[c]	L_E	186	5.02				4.39			

Note: L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = unweighted sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa). Small fish are defined as having a total mass of less than 2 g.

[a] FHWG (2008), Stadler and Woodbury (2009)

[b] Andersson et al. (2007), Wysocki et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011)

[c] Popper et al. (2014)

Appendix G. Animal Movement and Exposure Modeling

To assess the risk of impacts from anthropogenic sound exposure, an estimate of the received sound levels for individuals of each species known to occur in the Project area during the assessed activities is required. Both sound sources and animals move. The sound fields may be complex, and the sound received by an animal is a function of where the animal is at any given time. To a reasonable approximation, the locations of the Projects' sound sources are known, and acoustic modeling can be used to predict the individual and aggregate 3-D sound fields of the sources. The location and movement of animals within the sound field, however, is unknown. Realistic animal movement within the sound field can be simulated. Repeated random sampling (Monte Carlo method simulating many animals within the operations area) is used to estimate the sound exposure history of the population of simulated animals (animats) during the operation.

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is much higher than the real-world density to ensure good representation of the PDF. The resulting PDF is scaled using the real-world density.

Several models for marine mammal movement have been developed (Ellison et al. 1999, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behavior. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behavior model (3MB; Houser 2006) and used to predict the exposure of animats (virtual marine mammals and sea turtles) to sound arising from sound sources in simulated representative surveys. Within JASMINE simulations, the modeled sound fields are repeated at proposed foundation locations, mimicking the impact pile driving activity throughout the lease area. Animats are programmed to behave like the marine animals likely to be present in the survey area. The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modeled sound exposure levels are summed over the total simulation duration, such as 24 hours or the entire simulation, to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as the 3MB model (Houser 2006) but has been extended to be directly compatible with MONM and FWRAM acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioral states based on time and space dependent modeled variables such as received levels for aversion behavior (Ellison et al. 2016).

G.1. Animal Movement Parameters

JASMINE uses previously measured behavior to forecast behavior in new situations and locations. The parameters used for forecasting realistic behavior are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behavior of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behavior states. The probability of an animat starting out in or transitioning into a given behavior state can in turn be defined in terms of the animat's current behavioral state, depth, and the time of day. In addition, each travel parameter and behavioral state has a termination function that governs how long the parameter value or overall behavioral state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below. JASCO maintains species-specific choices of values for the behavioral parameters used in this study. The parameter values are available for limited distribution upon request.

Travel sub-models

Direction –determines an animat's choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviors with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).

- **Travel rate** –defines an animat's rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate** –defines an animat's rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate** –defines an animat's rate of travel in the vertical plane during the descent portion of a dive.
- **Depth** –defines an animat's maximum dive depth.
- **Bottom following** –determines whether an animat returns to the surface once reaching the ocean floor, or whether it follows the contours of the bathymetry.
- **Reversals** –determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behavior is used to emulate the foraging behavior of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval** –determines the duration an animat spends at, or near, the surface before diving again.

G.1.1. Exposure Integration Time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (SPL) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behavior collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. Therefore, the simulation time should be limited to a few weeks, the approximate scale of the collected data (e.g., marine mammal tag data) (Houser 2006). For this study, one-week simulations (i.e., 7 days) were modeled.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that might be present in the Project area during sound-producing activities is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited in this analysis to a rectangular area enclosing a 70-km (43.5-mile) buffer around the Lease Area (see figures in Appendix G.3). In the simulation, every animat that reaches and leaves a border of the simulation area is replaced by another animat entering at an opposite border—e.g., an animat departing at the northern border of the simulation area is replaced by an animat entering the simulation area at the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition (see Appendix G.3). The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

G.1.2. Aversion

Aversion is a common response of animals 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 same levels elicit response at closer ranges; both proximity and received levels are important factors in aversive responses (Dunlop et al. 2017). As a supplement to this modeling study for comparison purposes only, parameters determining aversion at specified sound levels were implemented for the North Atlantic right whale (NARW), in recognition of its endangered status, and harbor porpoise, a species known to have a strong aversive response to loud sounds.

Aversion is implemented in JASMINE by defining a new behavioral state that an animat may transition in to when a received level is exceeded. There are very few data on which aversive behavior can be based. Because of the dearth of information and to be consistent within this report, aversion probability is based on the Wood et al. (2012) step function that was used to estimate potential behavioral disruption. Animats will be assumed to avert by changing their headings by a fixed amount away from the source, with greater deflections associated with higher received levels (Tables G-1 and G-2). Aversion thresholds for marine mammals are based on the Wood et al. (2012) step function. Animats remain in the aversive state for a specified amount of time, depending on the level of exposure that triggered aversion (Tables G-1 and G-2). During this time, travel parameters are recalculated periodically as with normal behaviors. At the end of the aversion interval, the animat model parameters are changed (see Tables G-1 and G-2),

depending on the current level of exposure and the animat either begins another aversion interval or transitions to a non-aversive behavior; while if aversion begins immediately, transition to a regular behavior occurs at the end of the next surface interval, consistent with regular behavior transitions.

Table G-1. North Atlantic right whales: Aversion parameters for the animal movement simulation based on Wood et al. (2012) behavioral response criteria.

Probability of aversion	Received sound level (L_p, dB re 1 µPa)	Change in course (°)	Duration of aversion(s)
10%	140	10	300
50%	160	20	60
90%	180	30	30

Table G-2. Harbor porpoises: Aversion parameters for the animal movement simulation based on Wood et al. (2012) behavioral response criteria.

Probability of aversion	Received sound level (L_p, dB re 1 µPa)	Change in course (°)	Duration of aversion(s)
50%	120	20	60
90%	140	30	30

G.1.3. Seeding Density and Scaling

The exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 0.5 animats/km^2 over the entire simulation area. Some species have depth preference restrictions, e.g., sperm whales prefer water greater than 1,000 m (Aoki et al. 2007), and the simulation location contained a relatively high portion of shallow water areas. For each species, the local modeling density, that is the density of animats near the construction area, was determined by dividing the simulation seeding density by the proportion of seedable area. To evaluate potential Level B or Level A harassment, threshold exceedance was determined in 24 h time windows for each species. From the numbers of animats exceeding threshold, the numbers of individual animals for each species predicted to exceed threshold were determined by scaling the animat results by the ratio of local real-world density to local modeling density. As described in Section 3, the local density estimates were obtained from the habitat-based models of Roberts et al. (2015, 2016a, 2017, 2018, 2020, 2021b).

G.2. Animal Movement Modeling Supplemental Results

The results in this section are the yearly exposure estimates for construction schedules 1 and 2 , separated by year, and the exposure range estimates for modeled foundation types not included in the proposed construction schedules (Table 3). Construction schedule 3 is not presented in this section because it does not exceed a one year duration, and therefore all animal movement modeling results for construction schedule 3 are included in Sections 4.2 and 4.3.

G.2.1. Exposure Estimates - Full Buildout

This section contains the marine mammals and sea turtle exposure estimates for the proposed yearly construction schedules for the full buildout of the Project as defined in Table G-3 and Table G-4.

Table G-3. Yearly construction schedule 1 – Full buildout: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	8	0	5	0
Jun	20	6	15	6
Jul	25	0	20	0
Aug	19	6	18	6
Sep	18	0	14	0
Oct	16	0	13	0
Nov	5	0	4	0
Dec	1	0	0	0
Total Piling Days	**112**	**12**	**89**	**12**
Total Piles	**112**	**48**	**89**	**48**
Total Foundations	**112**	**2**	**89**	**2**

Table G-4. Yearly construction schedule 2 – Full buildout: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	8	0	5	0
Jun	20	6	15	6
Jul	25	0	20	0
Aug	19	6	18	6
Sep	18	0	14	0
Oct	16	0	13	0
Nov	5	0	4	0
Dec	1	0	0	0
Total Piling Days	**112**	**12**	**89**	**12**
Total Piles	**112**	**48**	**356**	**48**
Total Foundations	**112**	**2**	**89**	**2**

G.2.1.1. Marine Mammals

Table G-5. Construction schedule 1, year 1 – Full buildout : the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-3).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-6. Construction schedule 1, year 2 – Full buildout: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-3).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	5.97	3.66	2.26	0.99	0.05	<0.01	0	0	11.18	8.11	6.53	5.13	9.84	6.68	5.17	3.78
	Minke whale	57.17	22.71	8.06	1.61	0.10	<0.01	0	0	164.01	124.11	101.23	79.52	121.43	88.69	70.51	53.90
	Humpback whale	5.87	3.27	1.74	0.62	0.04	<0.01	0	0	11.93	8.39	6.46	4.76	9.40	6.57	5.04	3.67
	North Atlantic right whale[c] (migrating)	0.55	0.22	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.59	1.13	0.87	0.66	3.03	2.37	1.97	1.56
	Sei whale[c]	0.67	0.41	0.25	0.11	<0.01	<0.01	0	0	1.29	0.94	0.75	0.59	1.13	0.77	0.60	0.44
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	210.78	154.97	124.34	95.66	91.81	62.88	47.06	29.71
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	9.20	2.54	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	697.16	343.93	40.43	0	320.47	150.84	93.93	44.58
	Bottlenose dolphin, offshore	1.76	0	0	0	1.83	0	0	0	4573.44	3326.01	2579.55	1825.49	1933.89	1261.28	899.35	581.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.98	5.11	4.12	3.15	3.03	2.08	1.57	1.01
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	9.07	3.21	1.06	0.32	4.62	2.01	1.00	0.23	44.68	32.62	26.39	20.06	118.22	89.26	72.93	55.55
PPW	Gray seal	8.48	2.21	0.45	0.16	0.30	0	0	0	137.98	92.30	67.38	50.29	86.63	54.98	41.51	28.23
	Harbor seal	25.32	4.97	1.13	0.06	1.59	0.33	0	0	322.87	213.62	160.97	120.36	201.31	129.42	98.02	66.89

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-7. Construction schedule 2, year 1 – Full buildout: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-4).

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p[a]				L_p[b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-8. Construction schedule 2, year 2 – Full buildout: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-4).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	10.24	5.82	3.46	1.51	0.02	<0.01	0	0	15.38	11.03	9.20	6.41	13.57	9.00	6.88	4.74
	Minke whale	107.83	43.81	16.27	2.97	0.10	<0.01	0	0	242.38	174.21	141.72	95.10	173.67	121.73	98.53	70.02
	Humpback whale	11.77	5.89	3.02	1.08	0.02	<0.01	0	0	19.04	12.65	9.82	6.28	14.95	9.93	7.73	5.25
	North Atlantic right whale[c] (migrating)	1.21	0.50	0.24	0.05	<0.01	0	0	0	2.56	1.66	1.31	0.77	5.78	4.34	3.59	2.70
	Sei whale[c]	1.21	0.69	0.41	0.18	<0.01	<0.01	0	0	1.82	1.31	1.09	0.76	1.61	1.07	0.82	0.56
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.15	0.08	0.01	0	0	0	0	0	302.06	207.64	171.37	112.91	167.81	116.91	84.74	52.64
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	19.52	8.41	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	993.20	97.45	0	0	786.04	400.97	250.17	114.08
	Bottlenose dolphin, offshore	7.24	0	0	0	0	0	0	0	6428.45	4331.19	3416.59	2050.28	3530.66	2388.91	1696.19	1049.49
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	10.35	7.24	6.03	4.15	5.99	4.19	3.09	1.97
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	40.51	22.44	12.52	3.17	4.16	1.30	0.33	0.12	69.67	48.24	39.23	26.30	246.01	193.18	161.62	126.90
PPW	Gray seal	35.15	10.26	2.00	0.02	0.16	0	0	0	191.33	117.98	94.34	60.59	139.23	88.26	68.34	41.30
	Harbor seal	84.58	24.21	7.03	0.68	0.66	0.02	0	0	444.49	280.32	213.40	134.64	320.39	205.22	156.16	97.11

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

G.2.1.2. Sea Turtles

The total number of sea turtles predicted to receive sound levels above the injury and behavioral response thresholds are presented in Tables G-9 to G-12 for the yearly construction schedules described in Appendix G.2.

Table G-9. Construction schedule 1, year 1 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table G-10. Construction schedule 1, year 2 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-3).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	17.34	4.37	0.91	0.57	0	0	0	0	60.88	34.07	21.63	9.57
Leatherback turtle[a]	5.87	1.24	0.43	0.21	0	0	0	0	33.33	18.46	11.02	4.23
Loggerhead turtle	115.57	29.98	4.08	4.08	0	0	0	0	1464.13	723.22	377.26	175.02
Green turtle	0.68	0.22	0.05	0.01	<0.01	0	0	0	1.87	1.03	0.61	0.30

[a] Listed as Endangered under the ESA.

Table G-11. Construction schedule 2, year 1 – Full buildout: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-4).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table G-12. Construction schedule 2, year 2 – Full buildout: the mean number of modeled sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-4).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	15.50	2.35	0.91	0.07	0	0	0	0	69.09	32.56	16.10	6.39
Leatherback turtle[a]	5.19	0.94	0.23	0.12	0	0	0	0	38.73	16.40	8.28	3.54
Loggerhead turtle	123.72	17.75	0	0	0	0	0	0	1643.58	690.59	348.71	142.39
Green turtle	0.57	0.10	0.02	0.01	0	0	0	0	1.93	0.79	0.44	0.14

[a] Listed as Endangered under the ESA.

G.2.2. Exposure Estimates – Project 1 Plus Overlap

This section contains the marine mammals and sea turtle exposure estimates for the proposed yearly construction schedules for Project 1 plus overlap as defined in Table G-13 and Table G-14.

Table G-13. Yearly construction schedule 1 - Project 1 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	8	0	0	0
Jun	20	6	0	0
Jul	25	0	0	0
Aug	19	6	0	0
Sep	18	0	0	0
Oct	16	0	0	0
Nov	5	0	0	0
Dec	1	0	0	0
Total Piling Days	**112**	**12**	**0**	**0**
Total Piles	**112**	**48**	**0**	**0**
Total Foundations	**112**	**2**	**0**	**0**

Table G-14. Yearly construction schedule 2 - Project 1 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	8	0	0	0
Jun	20	6	0	0
Jul	25	0	0	0
Aug	19	6	0	0
Sep	18	0	0	0
Oct	16	0	0	0
Nov	5	0	0	0
Dec	1	0	0	0
Total Piling Days	**112**	**12**	**0**	**0**
Total Piles	**112**	**48**	**0**	**0**
Total Foundations	**112**	**2**	**0**	**0**

G.2.2.1. Marine Mammals

Table G-15. Construction schedule 1, year 1 – Project 1 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-13).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-16. Construction schedule 1, year 2 – Project 1 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-13).

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Humpback whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	North Atlantic right whale[c] (migrating)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sei whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PPW	Gray seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Harbor seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-17. Construction schedule 2, year 1 – Project 1 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-14).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale[c] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale[c]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-18. Construction schedule 2, year 2 – Project 1 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-14).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Humpback whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	North Atlantic right whale[c] (migrating)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sei whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PPW	Gray seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Harbor seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

G.2.2.2. Sea Turtles

Table G-19. Construction schedule 1, year 1 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-13).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table G-20. Construction schedule 1, year 2 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-13).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0	0	0	0	0	0	0	0	0	0	0	0
Leatherback turtle[a]	0	0	0	0	0	0	0	0	0	0	0	0
Loggerhead turtle	0	0	0	0	0	0	0	0	0	0	0	0
Green turtle	0	0	0	0	0	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table G-21. Construction schedule 2, year 1 – Project 1 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-14).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	20.25	5.16	1.05	0.68	0	0	0	0	70.86	39.89	25.51	11.29
Leatherback turtle[a]	7.08	1.49	0.52	0.26	0	0	0	0	40.24	22.39	13.40	5.13
Loggerhead turtle	132.54	35.08	4.93	4.93	0	0	0	0	1693.31	839.51	438.38	203.03
Green turtle	0.79	0.26	0.06	0.02	<0.01	0	0	0	2.17	1.21	0.71	0.35

[a] Listed as Endangered under the ESA.

Table G-22. Construction schedule 2, year 2 – Project 1 plus overlap: the mean number of modeled sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-14).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0	0	0	0	0	0	0	0	0	0	0	0
Leatherback turtle[a]	0	0	0	0	0	0	0	0	0	0	0	0
Loggerhead turtle	0	0	0	0	0	0	0	0	0	0	0	0
Green turtle	0	0	0	0	0	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

G.2.3. Exposure Estimates– Project 2 Plus Overlap

This section contains the marine mammals and sea turtle exposure estimates for the proposed yearly construction schedules for Project 2 plus overlap as defined in Table G-23 and

Table G-24Table G-3.

Table G-23. Yearly construction schedule 1 - Project 2 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Monopile 15 m diameter MHU4400S (1 pile/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	0	0	5	0
Jun	0	0	15	6
Jul	0	0	20	0
Aug	0	0	18	6
Sep	0	0	14	0
Oct	0	0	13	0
Nov	5	0	4	0
Dec	1	0	0	0
Total Piling Days	**6**	**0**	**89**	**12**
Total Piles	**6**	**0**	**89**	**48**
Total Foundations	**6**	**0**	**89**	**2**

Table G-24. Yearly construction schedule 2 - Project 2 plus overlap: Total days of piling per month were used to estimate the number of marine mammal and sea turtle acoustic exposures for Atlantic Shores Offshore Wind.

Construction month	Schedule Year One		Schedule Year Two	
	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)	WTG Jacket 5 m diameter IHCS2500 (4 piles/day)	OSS Jacket 5 m diameter IHCS2500 (4 piles/day)
May	0	0	5	0
Jun	0	0	15	6
Jul	0	0	20	0
Aug	0	0	18	6
Sep	0	0	14	0
Oct	0	0	13	0
Nov	5	0	4	0
Dec	1	0	0	0
Total Piling Days	**6**	**0**	**89**	**12**
Total Piles	**24**	**0**	**356**	**48**
Total Foundations	**6**	**0**	**89**	**2**

G.2.3.1. Marine Mammals

Table G-25. Construction schedule 1, year 1 – Project 2 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-23).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	0.37	0.23	0.14	0.06	<0.01	0	0	0	0.74	0.54	0.43	0.34	0.65	0.44	0.34	0.25
	Minke whale	0.52	0.19	0.06	0.01	<0.01	0	0	0	1.66	1.27	1.04	0.83	1.24	0.91	0.72	0.56
	Humpback whale	0.77	0.43	0.23	0.08	<0.01	<0.01	0	0	1.70	1.21	0.93	0.69	1.34	0.95	0.73	0.53
	North Atlantic right whale[c] (migrating)	0.16	0.06	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.49	0.36	0.27	0.21	0.92	0.72	0.60	0.48
	Sei whale[c]	0.19	0.12	0.07	0.03	<0.01	0	0	0	0.39	0.28	0.23	0.18	0.34	0.23	0.18	0.13
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	24.93	18.57	14.93	11.65	9.99	6.82	5.09	3.20
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	2.10	0.46	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	35.55	18.45	2.60	0	12.60	6.19	3.58	1.74
	Bottlenose dolphin, offshore	0	0	0	0	0.12	0	0	0	252.52	186.22	144.42	103.87	99.13	63.52	44.97	29.10
	Risso's dolphin	0	0	0	0	0	0	0	0	2.88	2.12	1.71	1.31	1.19	0.82	0.62	0.39
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	3.24	0.94	0.15	0.03	2.01	0.88	0.44	0.10	18.96	13.89	11.26	8.57	49.02	36.83	29.99	22.75
PPW	Gray seal	1.51	0.30	0.04	0.04	0.08	0	0	0	33.28	22.43	16.34	12.21	20.56	13.06	9.81	6.72
	Harbor seal	4.91	0.67	0.08	0	0.42	0.08	0	0	77.98	51.80	39.24	29.43	47.80	30.77	23.28	16.00

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-26. Construction schedule 1, year 2 – Project 2 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-23).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	5.97	3.66	2.26	0.99	0.05	<0.01	0	0	11.18	8.11	6.53	5.13	9.84	6.68	5.17	3.78
	Minke whale	57.17	22.71	8.06	1.61	0.10	<0.01	0	0	164.01	124.11	101.23	79.52	121.43	88.69	70.51	53.90
	Humpback whale	5.87	3.27	1.74	0.62	0.04	<0.01	0	0	11.93	8.39	6.46	4.76	9.40	6.57	5.04	3.67
	North Atlantic right whale[c] (migrating)	0.55	0.22	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.59	1.13	0.87	0.66	3.03	2.37	1.97	1.56
	Sei whale[c]	0.67	0.41	0.25	0.11	<0.01	<0.01	0	0	1.29	0.94	0.75	0.59	1.13	0.77	0.60	0.44
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	210.78	154.97	124.34	95.66	91.81	62.88	47.06	29.71
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	9.20	2.54	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	697.16	343.93	40.43	0	320.47	150.84	93.93	44.58
	Bottlenose dolphin, offshore	1.76	0	0	0	1.83	0	0	0	4573.44	3326.01	2579.55	1825.49	1933.89	1261.28	899.35	581.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.98	5.11	4.12	3.15	3.03	2.08	1.57	1.01
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	9.07	3.21	1.06	0.32	4.62	2.01	1.00	0.23	44.68	32.62	26.39	20.06	118.22	89.26	72.93	55.55
PPW	Gray seal	8.48	2.21	0.45	0.16	0.30	0	0	0	137.98	92.30	67.38	50.29	86.63	54.98	41.51	28.23
	Harbor seal	25.32	4.97	1.13	0.06	1.59	0.33	0	0	322.87	213.62	160.97	120.36	201.31	129.42	98.02	66.89

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-27. Construction schedule 2, year 1 – Project 2 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-24).

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	0.72	0.41	0.24	0.10	<0.01	<0.01	0	0	1.09	0.78	0.65	0.45	0.96	0.63	0.49	0.33
	Minke whale	1.16	0.46	0.16	0.03	<0.01	0	0	0	2.65	1.90	1.55	1.03	1.90	1.33	1.08	0.76
	Humpback whale	1.81	0.90	0.46	0.16	<0.01	0	0	0	2.95	1.96	1.53	0.96	2.32	1.54	1.20	0.81
	North Atlantic right whale[c] (migrating)	0.40	0.16	0.08	0.02	<0.01	0	0	0	0.85	0.55	0.43	0.25	1.92	1.44	1.19	0.90
	Sei whale[c]	0.38	0.21	0.13	0.05	<0.01	<0.01	0	0	0.57	0.41	0.34	0.23	0.50	0.33	0.26	0.17
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	<0.01	0	0	0	0	0	0	38.62	26.47	21.98	14.24	21.39	14.92	10.74	6.64
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	5.26	2.26	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	54.59	2.60	0	0	42.54	22.27	13.63	6.20
	Bottlenose dolphin, offshore	0.37	0	0	0	0	0	0	0	378.78	254.63	201.39	119.17	207.81	140.27	99.20	60.95
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	4.47	3.12	2.61	1.78	2.58	1.81	1.33	0.85
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	17.64	9.75	5.40	1.33	1.80	0.55	0.14	0.05	30.41	21.04	17.14	11.43	107.56	84.43	70.61	55.43
PPW	Gray seal	8.66	2.46	0.45	0	0.04	0	0	0	47.57	29.31	23.56	14.98	34.65	21.97	17.00	10.23
	Harbor seal	20.78	5.82	1.66	0.17	0.17	0	0	0	110.57	69.67	53.29	33.26	79.71	51.08	38.86	24.09

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

Table G-28. Construction schedule 2, year 2 – Project 2 plus overlap: the mean number of modeled marine mammals estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (

Table G-24).

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	10.24	5.82	3.46	1.51	0.02	<0.01	0	0	15.38	11.03	9.20	6.41	13.57	9.00	6.88	4.74
	Minke whale	107.83	43.81	16.27	2.97	0.10	<0.01	0	0	242.38	174.21	141.72	95.10	173.67	121.73	98.53	70.02
	Humpback whale	11.77	5.89	3.02	1.08	0.02	<0.01	0	0	19.04	12.65	9.82	6.28	14.95	9.93	7.73	5.25
	North Atlantic right whale[c] (migrating)	1.21	0.50	0.24	0.05	<0.01	0	0	0	2.56	1.66	1.31	0.77	5.78	4.34	3.59	2.70
	Sei whale[c]	1.21	0.69	0.41	0.18	<0.01	<0.01	0	0	1.82	1.31	1.09	0.76	1.61	1.07	0.82	0.56
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.15	0.08	0.01	0	0	0	0	0	302.06	207.64	171.37	112.91	167.81	116.91	84.74	52.64
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	19.52	8.41	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	993.20	97.45	0	0	786.04	400.97	250.17	114.08
	Bottlenose dolphin, offshore	7.24	0	0	0	0	0	0	0	6428.45	4331.19	3416.59	2050.28	3530.66	2388.91	1696.19	1049.49
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	10.35	7.24	6.03	4.15	5.99	4.19	3.09	1.97
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	40.51	22.44	12.52	3.17	4.16	1.30	0.33	0.12	69.67	48.24	39.23	26.30	246.01	193.18	161.62	126.90
PPW	Gray seal	35.15	10.26	2.00	0.02	0.16	0	0	0	191.33	117.98	94.34	60.59	139.23	88.26	68.34	41.30
	Harbor seal	84.58	24.21	7.03	0.68	0.66	0.02	0	0	444.49	280.32	213.40	134.64	320.39	205.22	156.16	97.11

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA

G.2.3.2. Sea Turtles

Table G-29. Construction schedule 1, year 1 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-23).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.22	0.06	0.01	<0.01	0	0	0	0	0.76	0.44	0.29	0.13
Leatherback turtle[a]	0.48	0.10	0.04	0.02	0	0	0	0	2.74	1.56	0.94	0.36
Loggerhead turtle	0.06	0.02	<0.01	<0.01	0	0	0	0	0.75	0.38	0.20	0.09
Green turtle	0	0	0	0	0	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table G-30. Construction schedule 1, year 2 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (Table G-23).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	17.34	4.37	0.91	0.57	0	0	0	0	60.88	34.07	21.63	9.57
Leatherback turtle[a]	5.87	1.24	0.43	0.21	0	0	0	0	33.33	18.46	11.02	4.23
Loggerhead turtle	115.57	29.98	4.08	4.08	0	0	0	0	1464.13	723.22	377.26	175.02
Green turtle	0.68	0.22	0.05	0.01	<0.01	0	0	0	1.87	1.03	0.61	0.30

[a] Listed as Endangered under the ESA.

Table G-31. Construction schedule 2, year 1 – Project 2 plus overlap: the mean number of sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (

Table G-24).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.19	0.03	0.01	0	0	0	0	0	0.89	0.42	0.20	0.08
Leatherback turtle[a]	0.41	0.07	0.02	<0.01	0	0	0	0	3.24	1.36	0.68	0.29
Loggerhead turtle	0.06	<0.01	0	0	0	0	0	0	0.88	0.36	0.18	0.07
Green turtle	0	0	0	0	0	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table G-32. Construction schedule 2, year 2 – Project 2 plus overlap: the mean number of modeled sea turtles estimated to experience sound levels above exposure criteria for different sound attenuation levels. The schedule includes the installation of both WTG and OSS foundations (

Table G-24).

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	15.50	2.35	0.91	0.07	0	0	0	0	69.09	32.56	16.10	6.39
Leatherback turtle[a]	5.19	0.94	0.23	0.12	0	0	0	0	38.73	16.40	8.28	3.54
Loggerhead turtle	123.72	17.75	0	0	0	0	0	0	1643.58	690.59	348.71	142.39
Green turtle	0.57	0.10	0.02	0.01	0	0	0	0	1.93	0.79	0.44	0.14

[a] Listed as Endangered under the ESA.

G.2.4. Exposure Range Estimates

The tables in this section include exposure ranges ($ER_{95\%}$) for modeled foundation types not included in the 2-year construction schedules described in Table 3, with broadband attenuation of 0, 6, 10, and 15 dB during the summer season.

G.2.4.1. Marine Mammals

Tables G-33 to G-34 contain exposure-based ranges foundation types not included in the 2-year construction schedules described in Table 3.

Table G-33. Monopile foundation (12 m diameter, one pile per day) exposure ranges ($ER_{95\%}$) in km to marine mammal thresholds with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c] (sei whale[c,d])	3.24	2.04	1.09	0.35	0.03	<0.01	0	0	6.38	4.60	3.52	2.80	6.55	4.75	3.64	2.82
	Minke whale	1.93	0.89	0.33	0.04	0.02	0	0	0	5.75	4.30	3.37	2.69	6.00	4.43	3.42	2.69
	Humpback whale	3.30	1.84	1.08	0.39	0.05	<0.01	<0.01	0	6.30	4.58	3.48	2.90	6.42	4.69	3.50	2.90
	North Atlantic right whale[c] (migrating)	2.45	1.13	0.56	0.21	0.02	0	0	0	6.13	4.57	3.60	2.64	14.61	11.88	9.96	7.95
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	6.03	4.38	3.37	2.71	3.28	2.36	1.73	0.87
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	5.32	4.24	3.79	0	3.76	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	5.88	4.30	3.41	2.67	3.27	2.29	1.54	0.80
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	6.08	4.59	3.53	2.69	3.43	2.42	1.78	0.89
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	1.54	0.70	0.39	0.02	0.59	0.24	0.16	0.05	6.28	4.52	3.59	2.72	20.78	17.22	14.72	12.00
PPW	Gray seal	0.87	0.17	0.01	0.02	0.03	0.02	0	0	6.34	4.64	3.72	2.94	5.15	3.35	2.85	1.89
	Harbor seal	0.83	0.14	<0.01	0	<0.01	<0.01	0	0	6.35	4.71	3.73	2.92	5.20	3.54	2.92	1.96

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] fin whale used as a surrogate for sei whale behavioral definition

Table G-34. Monopile foundation (12 m diameter, two piles per day) exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p[a]				L_p[b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c] (sei whale[c,d])	3.21	1.98	1.30	0.33	0.04	0.01	0	0	6.28	4.54	3.62	2.83	6.51	4.68	3.65	2.86
	Minke whale	1.98	0.85	0.38	0.07	0.04	<0.01	0	0	5.69	4.20	3.37	2.66	5.95	4.31	3.39	2.66
	Humpback whale	3.35	1.87	1.01	0.37	0.03	0	0	0	6.14	4.64	3.62	2.75	6.31	4.73	3.64	2.75
	North Atlantic right whale[c] (migrating)	2.45	1.19	0.67	0.33	0.04	0	0	0	6.02	4.41	3.48	2.75	14.65	11.67	9.96	7.88
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	6.01	4.36	3.50	2.77	3.35	2.41	1.72	0.84
	Short-beaked common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	5.31	4.27	3.82	0	3.69	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	<0.01	<0.01	0	0	5.85	4.23	3.28	2.52	3.23	2.22	1.52	0.76
	Risso's dolphin	0	0	0	0	0	0	0	0	6.05	4.40	3.55	2.71	3.40	2.47	1.63	0.87
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	1.54	0.73	0.32	0.03	0.56	0.24	0.16	0.06	6.01	4.58	3.49	2.79	20.58	16.87	14.52	11.77
PPW	Gray seal	0.72	0.11	0	0	0.04	0	0	0	6.26	4.67	3.73	2.85	5.20	3.59	2.84	1.96
	Harbor seal	0.62	0.09	<0.01	<0.01	0.03	<0.01	0	0	6.24	4.64	3.66	2.92	5.13	3.52	2.84	2.08

[a] NOAA (2005), [b] Wood et al. (2012), [c] Listed as Endangered under the ESA, [d] fin whale used as a surrogate for sei whale behavioral definition

G.2.4.2. Sea Turtles

Similar to the results presented for marine mammals (see Appendix G.2.1.1), Tables G-35 to G-36 contain the exposure ranges ($ER_{95\%}$) for sea turtles to injury and behavioral criteria thresholds for monopile and jacket foundations considering broadband mitigation of 0, 6, 10, and 15 dB attenuation. The tables in this section are for foundation types not included in the 2-year construction schedules described in Table 3.

Table G-35. Monopile foundation (12 m diameter, one pile per day) exposure ranges ($ER_{95\%}$) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.84	0.26	0.02	<0.01	0	0	0	0	2.91	1.89	1.24	0.49
Leatherback turtle[a]	0.93	0.28	0.02	0.02	0	0	0	0	2.57	1.67	0.92	0.47
Loggerhead turtle	0.45	<0.01	0	0	0	0	0	0	2.39	1.55	0.94	0.47
Green turtle	1.32	0.35	0.07	<0.01	0	0	0	0	2.97	1.88	1.34	0.67

[a] Listed as Endangered under the ESA.

Table G-36. Monopile foundation (12 m diameter, two piles per day) exposure ranges ($ER_{95\%}$) in km to sea turtle injury and behavioral thresholds with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.85	0.28	0.03	<0.01	0	0	0	0	2.80	1.90	1.23	0.63
Leatherback turtle[a]	0.88	0.13	0.03	0.02	0	0	0	0	2.66	1.71	1.14	0.43
Loggerhead turtle	0.30	0.02	0	0	0	0	0	0	2.46	1.50	1.01	0.65
Green turtle	1.32	0.35	0.09	<0.01	0	0	0	0	2.94	2.00	1.36	0.68

[a] Listed as Endangered under the ESA.

G.3. Animat Seeding Area

Exposure modeling seeding areas are set using each species' preferred depth range. The following maps show seeding areas for each species, overlaid on a density map, if available, displaying the highest density month for that species. If density surfaces are unavailable for a particular species, a surrogate may be used, and for some species, the density data source shown in the image may not coincide with the data source used in predicting exposures. Please refer to Section 3.2 for a detailed description of density sources and calculations.

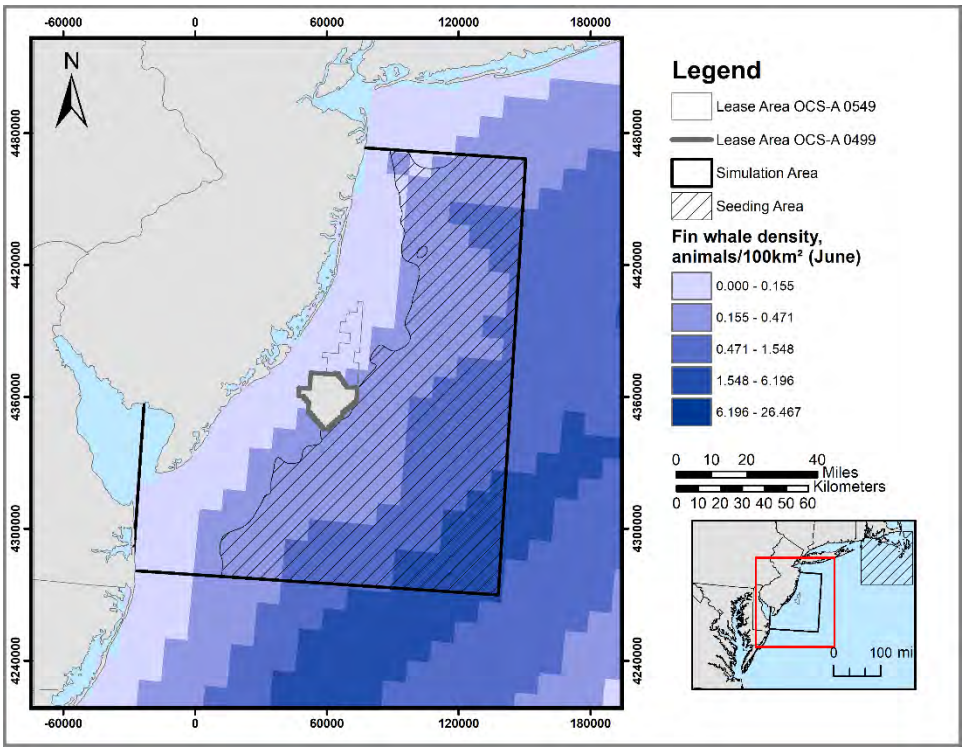

Figure G-1. Map of fin whale animat seeding range.

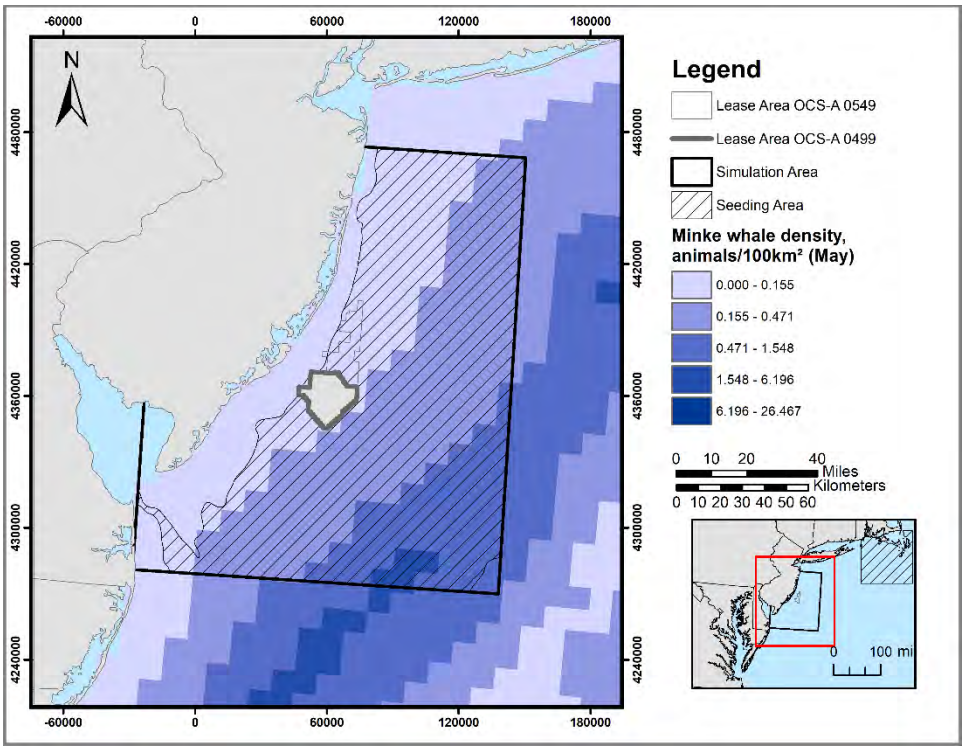

Figure G-2. Map of minke whale animat seeding range.

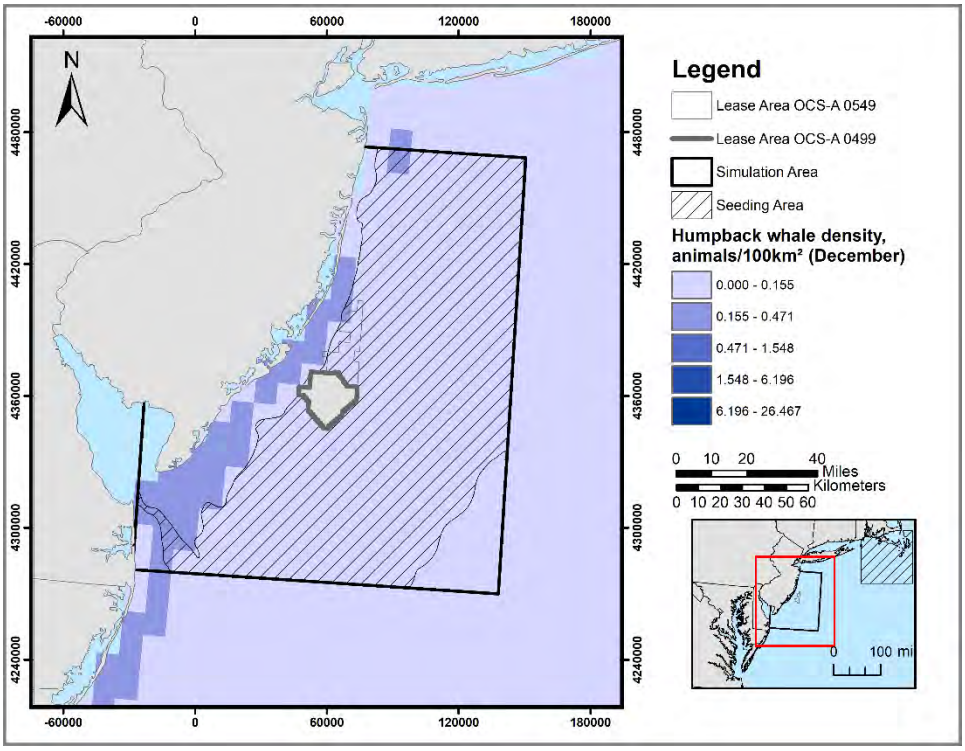

Figure G-3. Map of humpback whale animat seeding range.

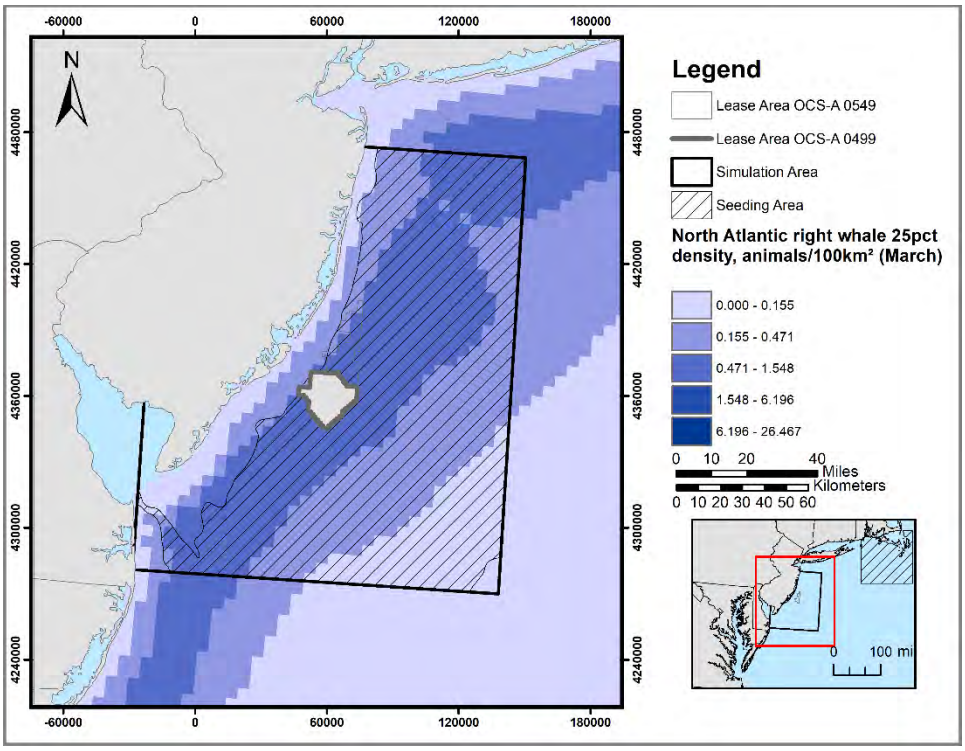

Figure G-4. Map of North Atlantic right whale (25% foraging, 75% migrating) animat seeding range.

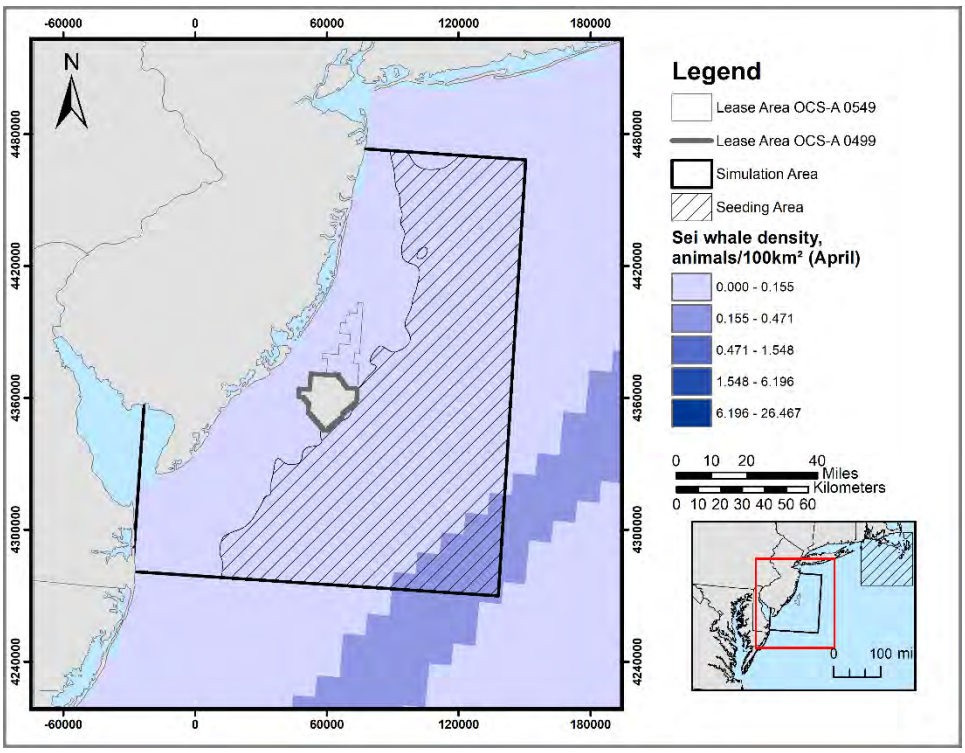

Figure G-5. Map of sei whale animat seeding range.

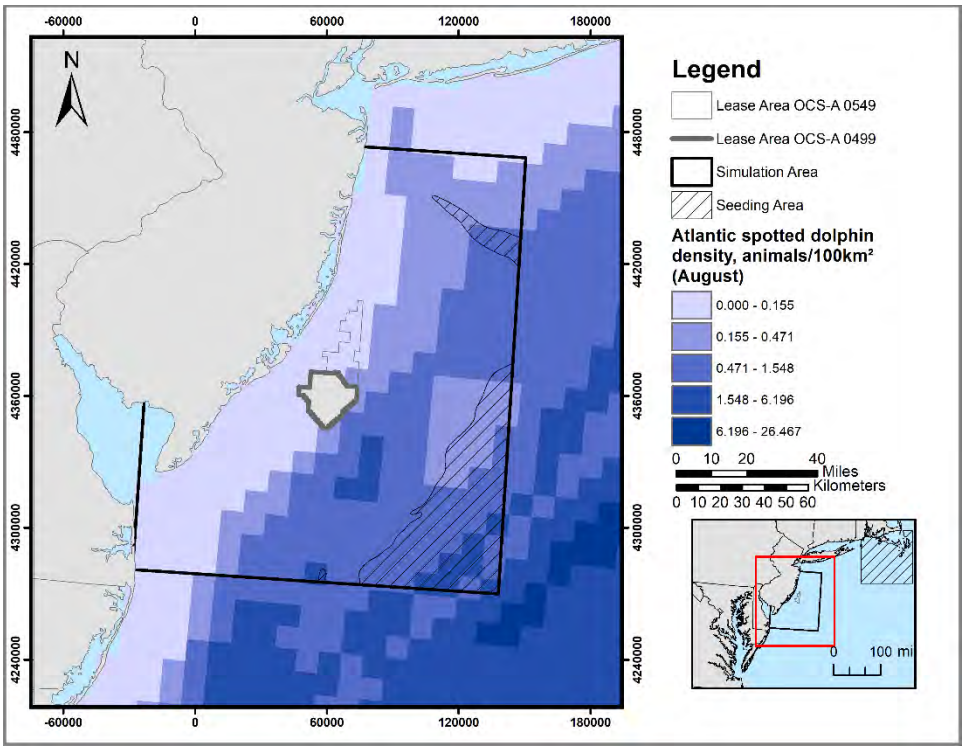

Figure G-6. Map of Atlantic spotted dolphin animat seeding range.

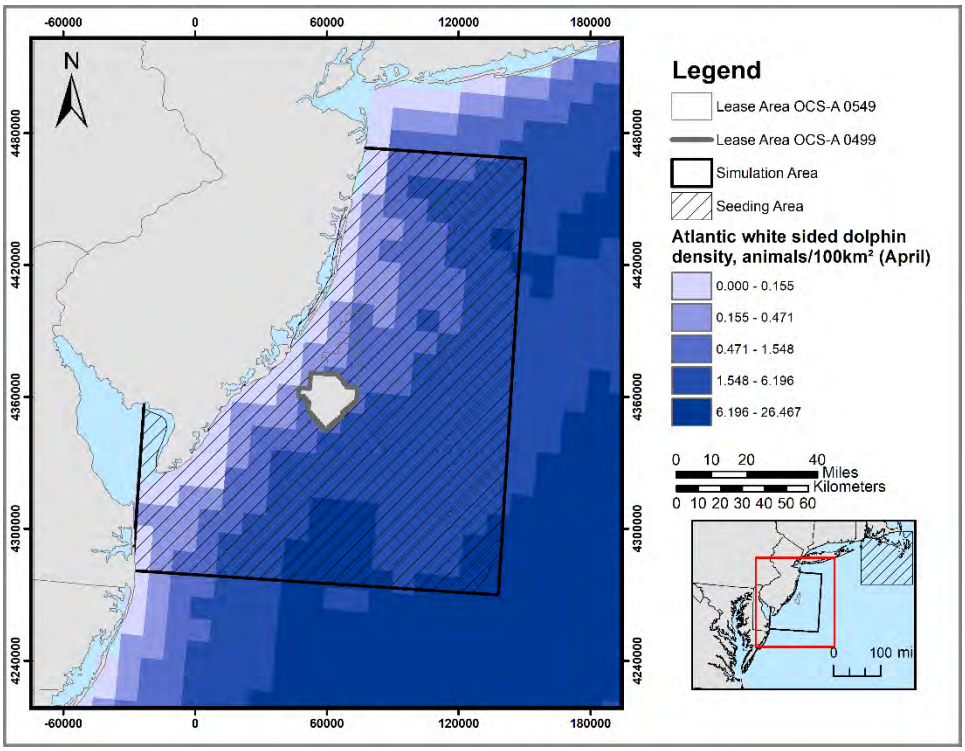

Figure G-7. Map of Atlantic white-sided dolphin animat seeding range.

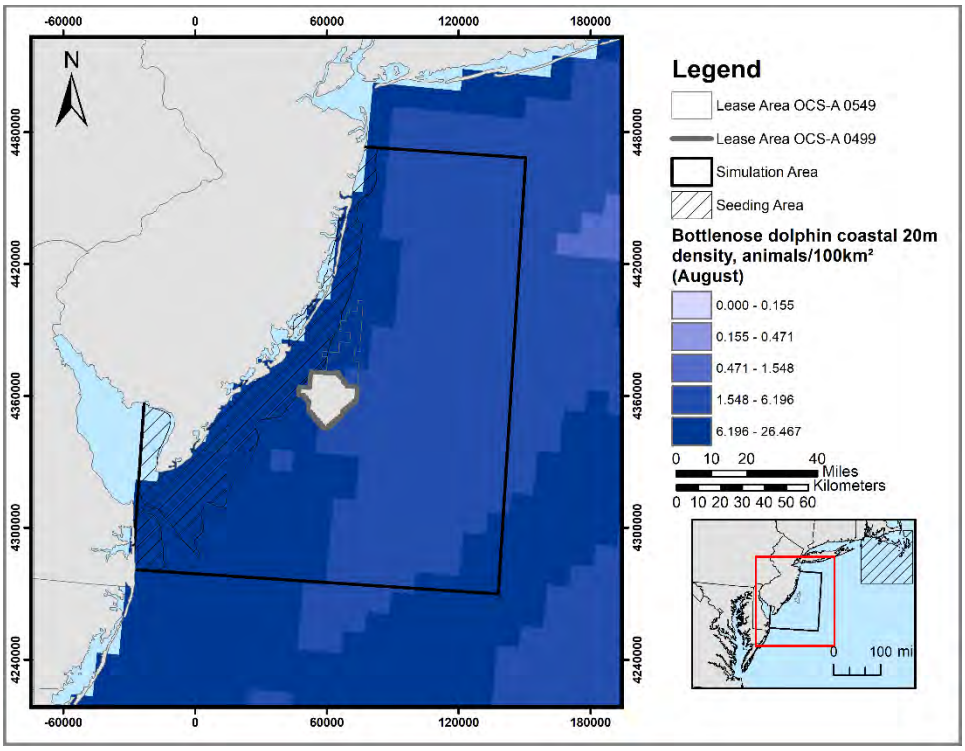

Figure G-8. Map of coastal bottlenose dolphin animat seeding range.

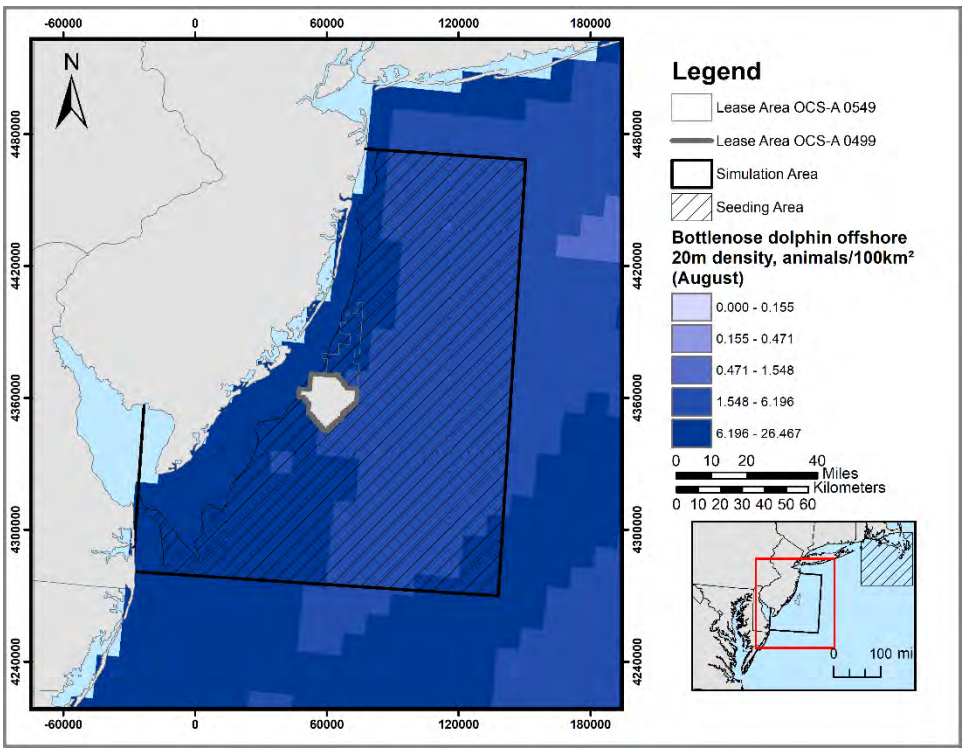

Figure G-9. Map of offshore bottlenose dolphin animat seeding range.

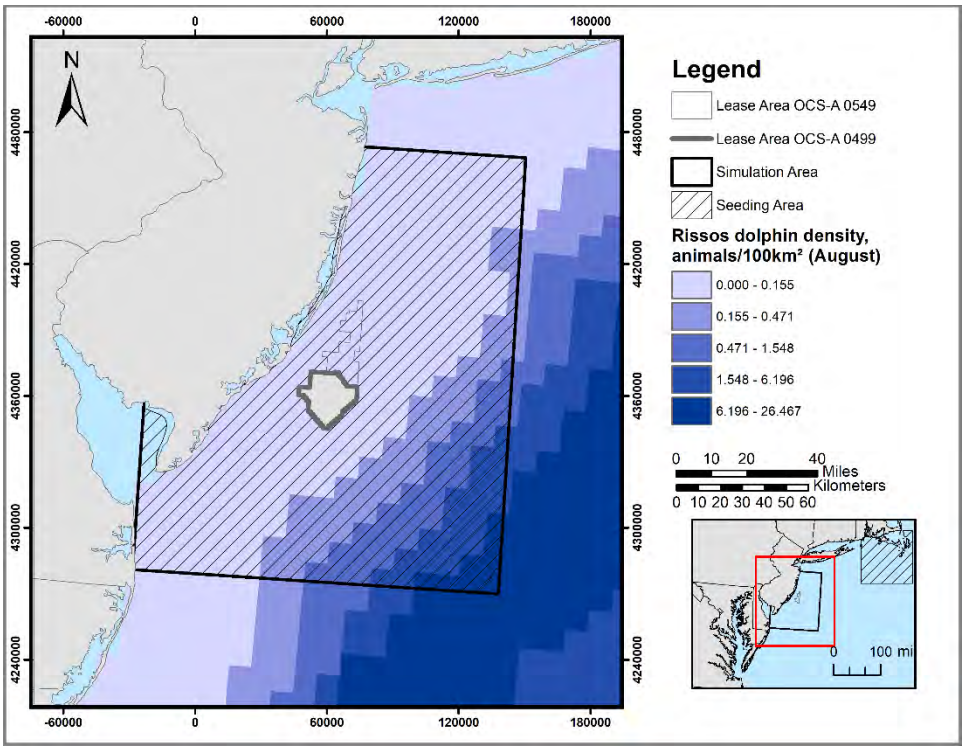

Figure G-10. Map of Risso's dolphin animat seeding range.

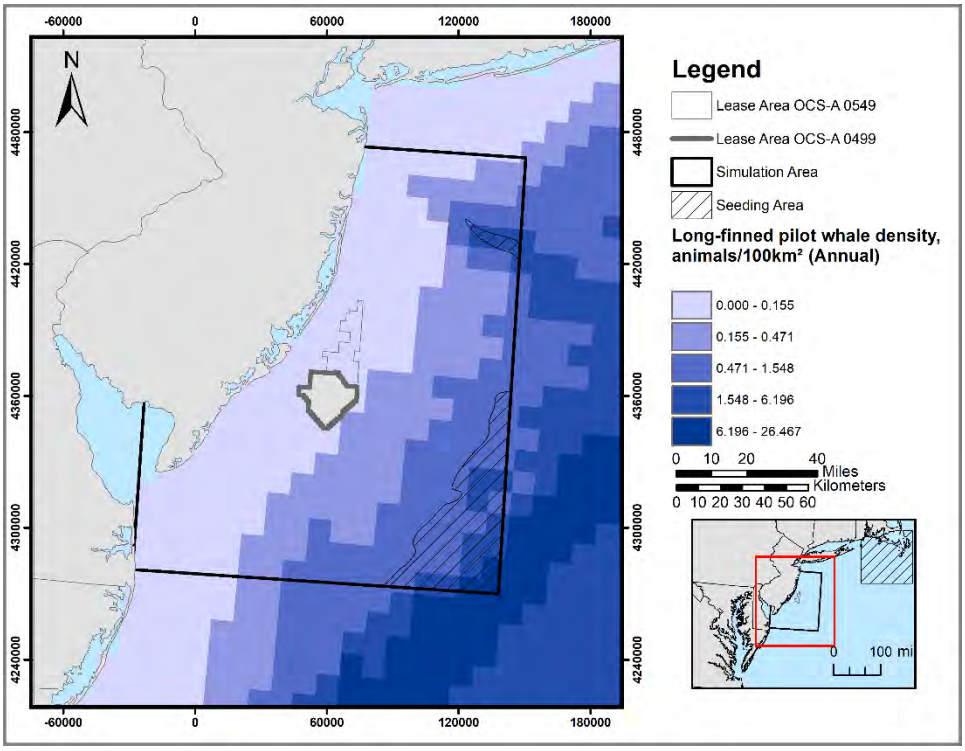

Figure G-11. Map of Long-finned pilot whales animat seeding range.

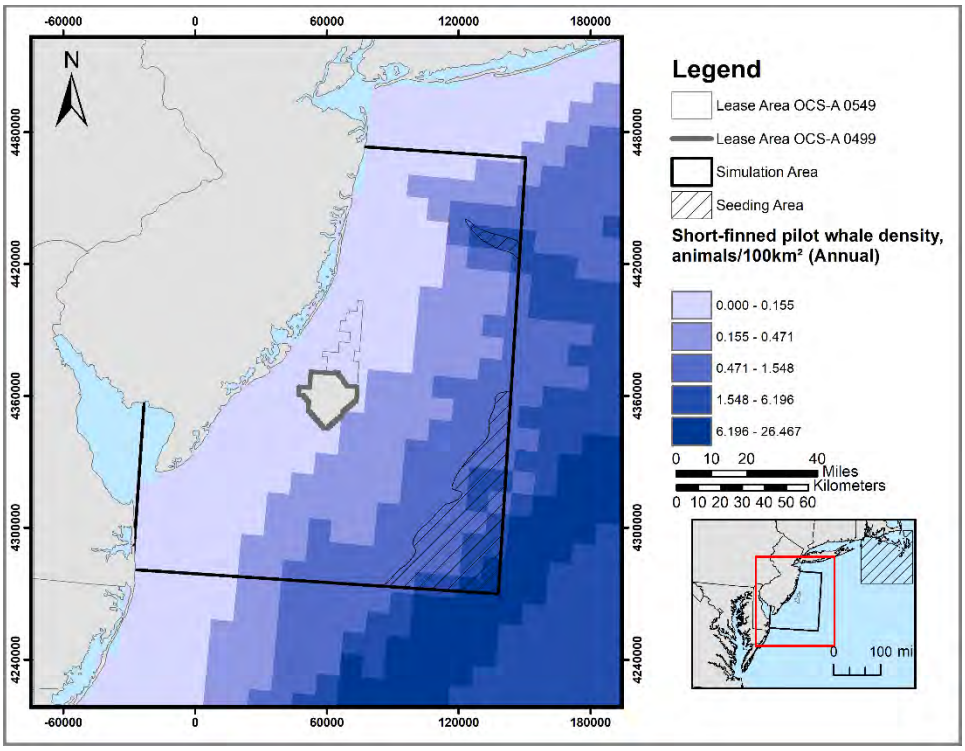

Figure G-12. Map of Short-finned pilot whales animat seeding range.

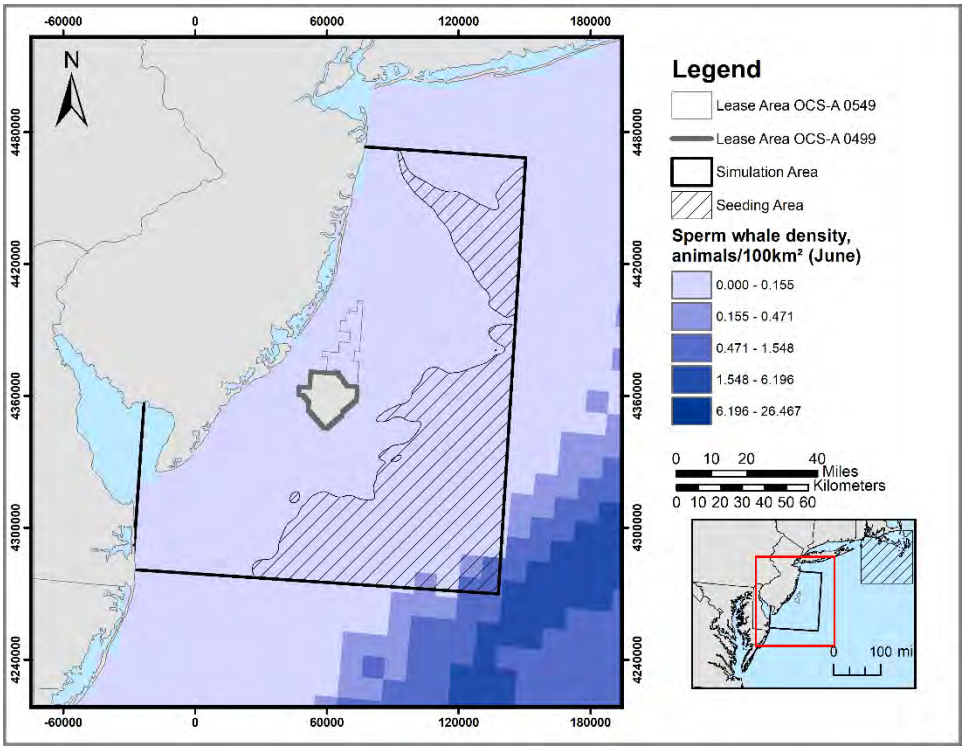

Figure G-13. Map of sperm whale seeding range.

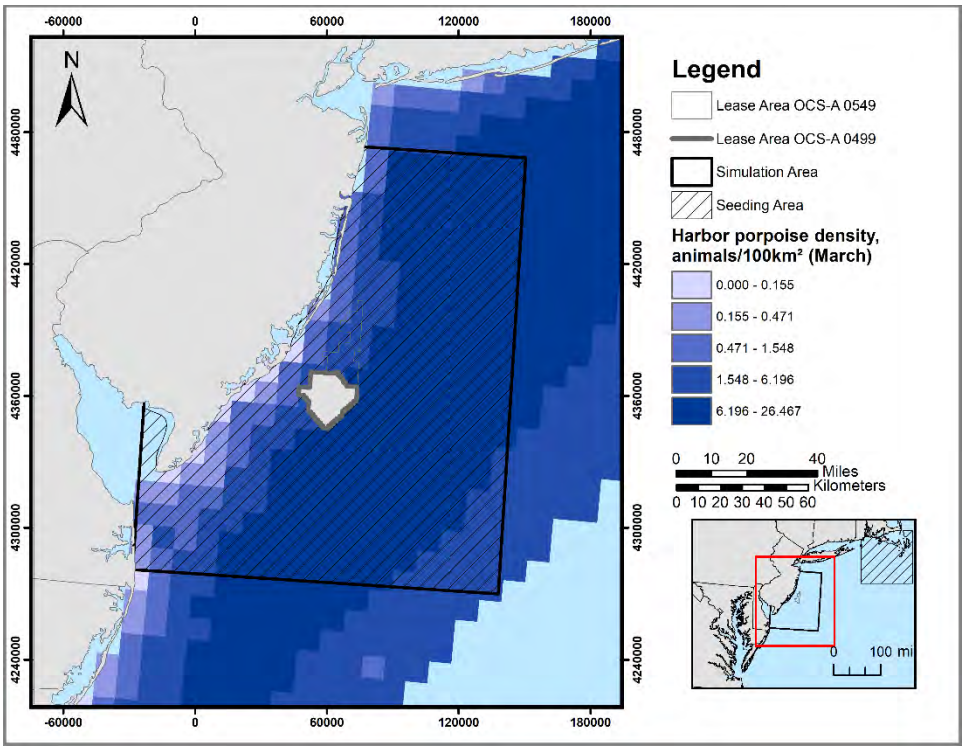

Figure G-14. Map of harbor porpoise animat seeding range.

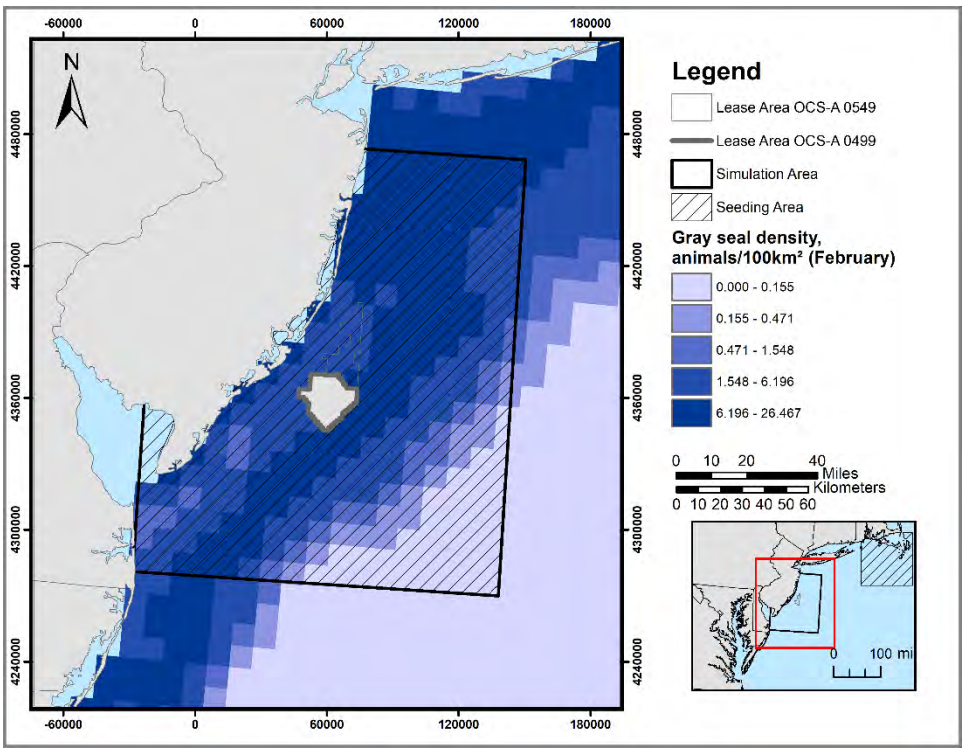

Figure G-15. Map of gray seal animat seeding range.

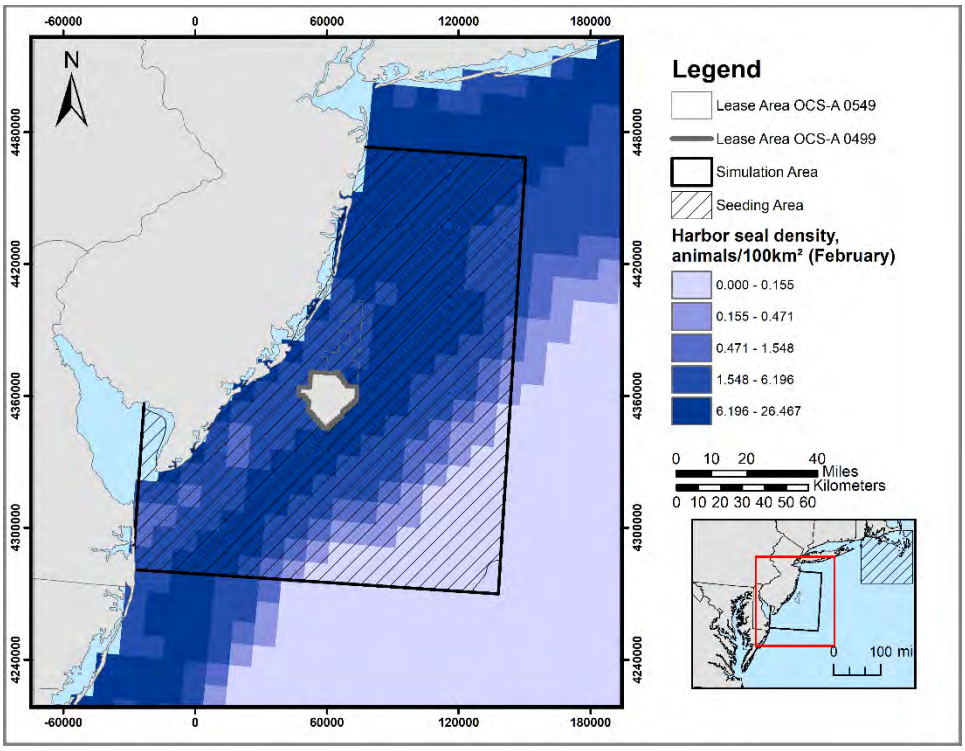

Figure G-16. Map of harbor seal animat seeding range.

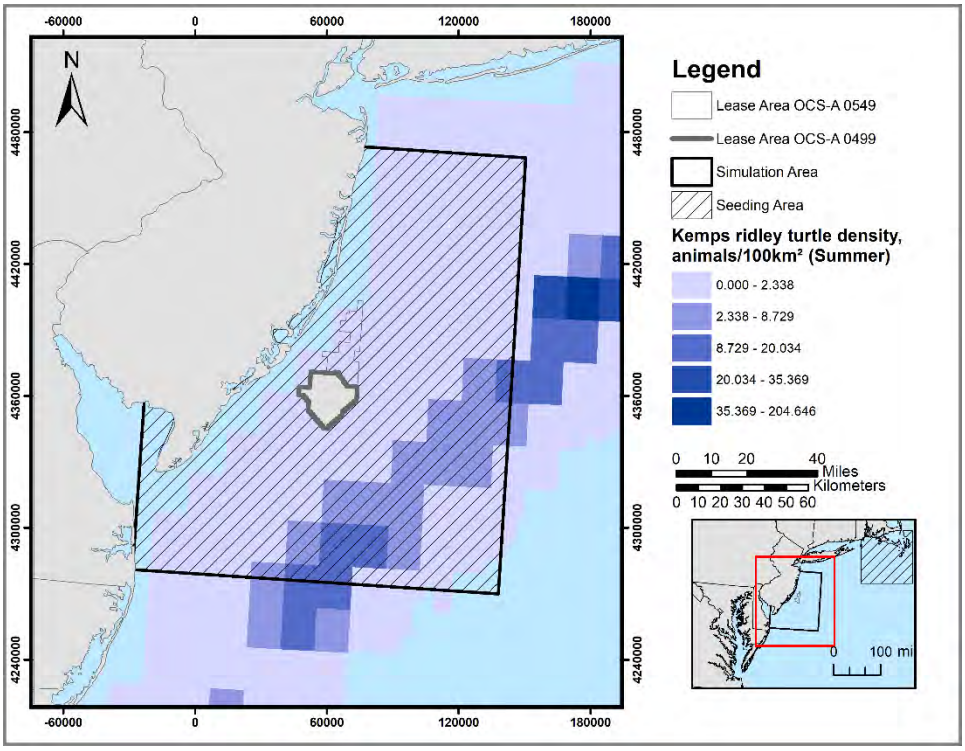

Figure G-17. Map of Kemps ridley turtle seeding range.

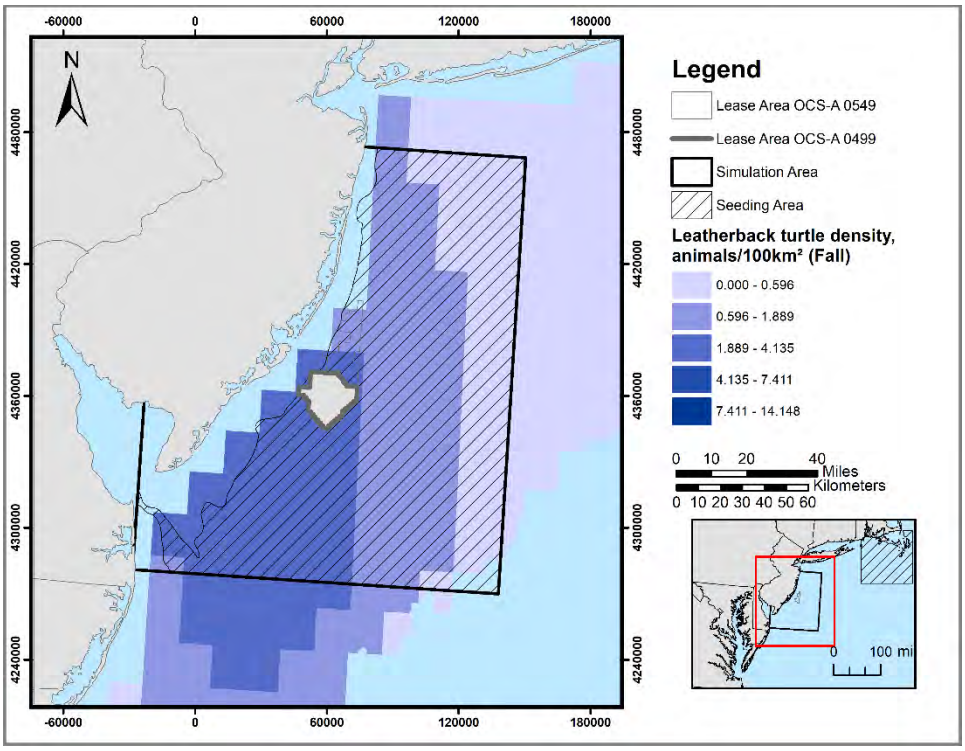

Figure G-18. Map of leatherback turtle seeding range.

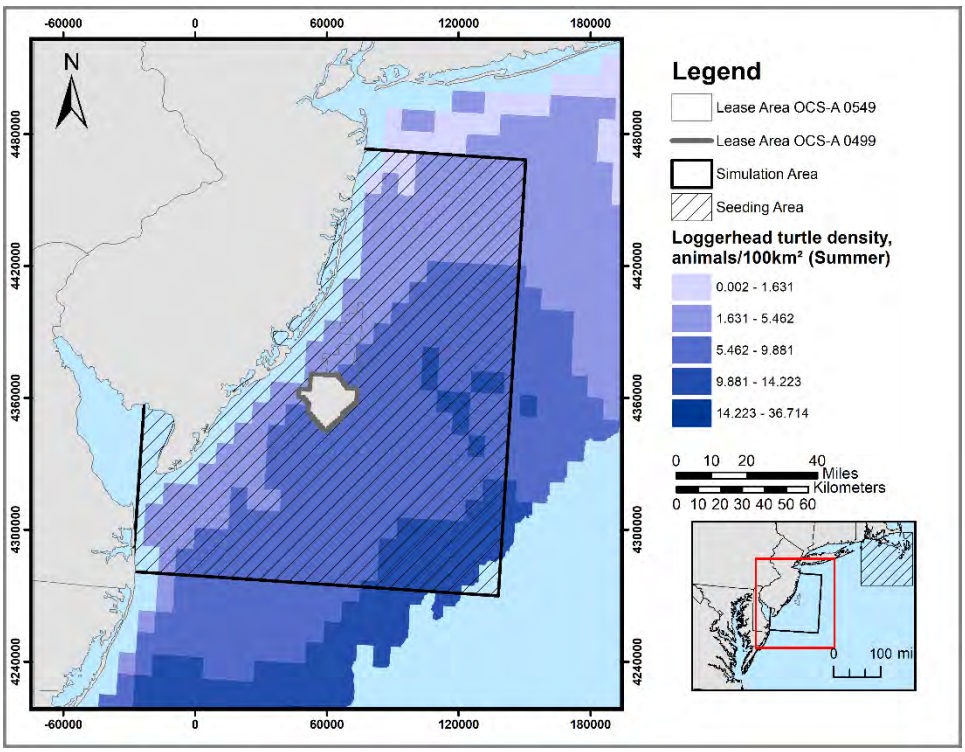

Figure G-19. Map of loggerhead turtle seeding range.

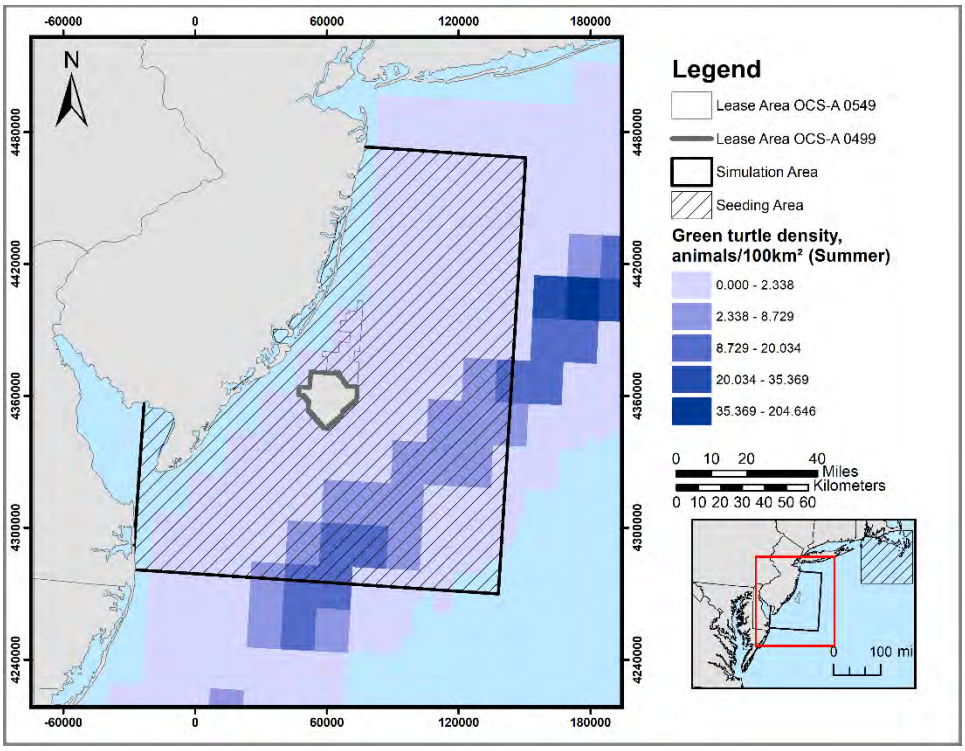

Figure G-20. Map of green turtle seeding range.

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Atlantic Shores Offshore Wind

Updates to the Application for Marine Mammal Protection Act (MMPA) Rulemaking and Letter of Authorization

DATE: 28 March 2023

FROM: JASCO Applied Sciences (USA) Inc.

TO: Atlantic Shores Offshore Wind, LLC

VERSION: 3.0

This document contains updates to the *Atlantic Shores Offshore Wind Application for Marine Mammal Protection Act (MMPA) Rulemaking and Letter of Authorization* (hereafter, the Application), which was deemed Adequate and Complete by NMFS on August 25, 2022. Included are updates to the proposed construction schedules for foundation installation and to the exposure and take estimates based on these new construction schedules and on updated animal density and abundance estimates.

Update to the Construction Schedules

Atlantic Shores Offshore Wind has revised its proposed Projects covered in the Application such that wind turbine generator (WTG) foundations installed during the first year of the buildout will all be monopile foundations. WTG foundations installed during the second year of the buildout could be either monopile or jacket foundations. There are still three potential construction schedules under the revision. Construction Schedules 1 and 3, which use monopile foundations for all WTGs, are unchanged. Construction Schedule 2, which formerly used jacket foundations for all WTGs, now uses a combination of monopile (year 1) and jacket (year 2) foundations. Construction Schedule 2 is used as the basis for the take estimates for impact pile driving. Offshore service station (OSS) foundations are all jacket foundations, which is unchanged from the Application.

Updates to the Take Estimates

This update to the exposure and take estimates provided in the Application uses the 2022 Duke University Marine Geospatial Ecology Laboratory (MGEL) Habitat-based Marine Mammal Density Models for the US Atlantic (Roberts et al. 2016, 2022), which were recently updated for all species, as well as the latest stock abundance estimate for the North Atlantic right whale from the 2022 draft stock assessment reports (SARs) (NOAA Fisheries 2023). All other stock sizes remain unchanged in the 2022 draft SARs. Updated exposure and take estimates for impact pile driving in Sections 3.1 and 4.1 use revised Construction Schedule 2.

Included in the take estimate update are:

- Roberts et al. (2022) marine mammal density updates (see Section 1) for:
  - Impact pile driving,
  - Vibratory pile driving for cofferdam installation and removal, and
  - HRG surveys.
- Updated exposures (see Section 2) for the following sound-producing activities:
  - Impact pile driving for 1) the Full Buildout of the Project, 2) Project 1 plus the overlap, and 3) Project 2 plus the overlap;
  - Vibratory pile driving for cofferdam installation and removal; and
  - HRG surveys.
- Updated take estimates (see Section 3) for the following sound-producing activities:
  - Impact pile driving for 1) the Full Buildout of the Project, 2) Project 1 plus the overlap, and 3) Project 2 plus the overlap;
  - Vibratory pile driving for cofferdam installation and removal; and
  - HRG surveys for 1) the Full Buildout of the Project, 2) Project 1 plus the overlap, and 3) for Project 2 plus the overlap.
- Updated take request (see Section 4) for all activities combined, assuming Construction Schedule 2, for:
  - The full project buildout,
  - Project 1, and
  - Project 2.
- Alternate take estimates (see Section 5) calculated using two proposed alternate construction schedules:
  - Schedule 1 and
  - Schedule 3.
- Supplemental figures (see Section 7) showing:
  - Monthly density differences for the North Atlantic right whale resulting from updating from the Roberts et al. (2021a, 2021b) right whale model (version 11) to the Roberts et al. (2022) right whale model.
  - How the zone of Influence diverged for coastal and offshore bottlenose dolphins to calculate densities and estimate take resulting from cofferdam installation/removal at the Monmouth site (see next paragraph).

Changes to methodology:

- When calculating exposures and takes for bottlenose dolphins for cofferdam installation/removal in the Application, it was assumed that the offshore stock would not be present in the near-shore waters where cofferdam activities would occur, so exposures and takes for this stock were assumed to be zero. This is true for the Atlantic cofferdam site where depth within the zone of influence (ZOI) does not exceed 20 m. However, the ZOI at the Monmouth site extends into waters >20 m deep. Therefore, for this document, the area used to calculate bottlenose dolphin density as well as the ZOI were split at the 20 m isobath for the Monmouth site (see Supplemental Figure 3). The areas <20 m deep and >20 m deep were used to calculate exposures and takes for the coastal and offshore stocks of these species, respectively, at the Monmouth site. For the Atlantic cofferdam site, only the coastal stock of

bottlenose dolphins is likely to occur so the total area and total density were used, which is unchanged from the Application.

- The time required for cofferdam installation/removal at the Atlantic site was reduced from 16 days (8 for installation and 8 for removal) to 12 days (6 for installation and 6 for removal) to reduce some of the conservatism that was used in the Application. Cofferdam installation at the Atlantic site is expected to require less time than at the Monmouth site because of the shallower water depths off Atlantic City.
- For the Project 1 and Project 2 breakdown, as a conservative measure, the estimated takes for cofferdam installation/removal at the Monmouth landfall site were used for both projects because these were higher for most species. For Project 1, it was assumed these takes would occur in year 1 (expected to be 2025) and for Project 2 it was assumed these takes would occur in year 2 (expected to be 2026). After the Roberts et al. (2022) density update was applied, take estimates for the Monmouth site were no longer conservative for coastal bottlenose dolphins because the estimated density for this species increased substantially near the Atlantic site. Therefore, takes for cofferdam installation/removal from the Atlantic Site were used for Project 1 in year 1 and estimated takes from the Monmouth site were used for Project 2 in year 2 to be more reflective of actual construction activities.
- When calculating exposures and takes from HRG surveys for pilot whales and seals, the densities provided by Roberts et al. (2016, 2022) were scaled by the relative abundances of the two species in each guild to get species-specific density estimates.
- All other methodology remains the same as in the Application.

The tables provided in this document are intended as replacement tables for those in the Application where data have been updated. All other tables in the application remain unchanged and thus are not included here. For ease of comparison, the tables and figures provided below use the same numbering as in the Application. For all details on the modeling and take calculation methodology, please refer to the Application.

Additional analyses:

After submission of the Application, the Proponent conducted an analysis of underwater sound transmission of aircraft used during construction of the Project (see Volume II of the COP Section 4.7.2 and Appendix II-L). Underwater sound transmission of aircraft is highly variable, and the majority of aircraft sound is reflected off the surface of the water. While research on the marine mammal behavioral responses to aircraft is limited, existing research suggests that the impact of aircraft sound on the behavioral responses of marine mammals is low. Therefore, although temporary behavioral response to aircraft at low altitudes may be exhibited by some species of cetaceans, due to the intermittent nature of aircraft use and the limited propagation of the sound source in the water column, the risk of aircraft impact to marine mammals is expected to be negligible, and therefore is not included herein.

Contents

Figures

Tables

1. Construction Schedule Update

Per Atlantic Shores South revised PDE, Construction Schedule 2 is updated for the full buildout (Table 8) and for Project 1 plus the overlap area (Table 9) and Project 2 plus the overlap area (Table 10) as follows:

Table 8. Atlantic Shores Construction Schedule 2 – Full Buildout: Used to estimate marine mammal exposures above threshold criteria. Shown are the number of piling days (number of piles) for each construction month and year.

Construction Month	Construction Schedule 2: 2 Year Schedule[a] Combined Monopile and Jacket						
	Year 1 # Days (# Piles)		Year 2 # Days (# Piles)		Total # Days (# Piles)b		
	WTG Monopile 15 m (1 pile/d)	OSS Jacket 5 m (4 piles/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)	WTG Monopile 15 m (1 pile/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)
May	8 (8)	0 (0)	5 (20)	0 (0)	8 (8)	5 (20)	0 (0)
Jun	20 (20)	6 (24)	15 (60)	6 (24)	20 (20)	15 (60)	12 (48)
Jul	25 (25)	0 (0)	20 (80)	0 (0)	25 (25)	20 (80)	0 (0)
Aug	19 (19)	6 (24)	18 (72)	6 (24)	19 (19)	18 (72)	12 (48)
Sep	18 (18)	0 (0)	14 (56)	0 (0)	18 (18)	14 (56)	0 (0)
Oct	16 (16)	0 (0)	13 (52)	0 (0)	16 (16)	13 (52)	0 (0)
Nov	5 (5)	0 (0)	4 (16)	0 (0)	5 (5)	4 (16)	0 (0)
Dec	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)
Total Piling Days	**112**	**12**	**89**	**12**	**201**		**24**
Total Piles	**112**	**48**	**356**	**48**	**468**		**96**
Total Foundations	**112**	**2**	**89**	**2**	**201[c]**		**4**

[a] The schedules assume a start year of 2026 for WTG foundation installation. Construction Schedule 2 is used in the take estimation.

[b] Modeling assumed 201 WTG foundations and 4 large OSSs.

[c] The PDE is inclusive of 200 WTG foundations and 1 Met tower on a WTG foundation.

Table 9. Atlantic Shores Construction Schedule 2 – Project 1 plus Overlap: Used to estimate marine mammal exposures above threshold criteria. Shown are the number of piling days (number of piles) for each construction month and year.

Construction Month	Construction Schedule 2: 2 Year Schedule[a] Combined Monopile and Jacket						
	Year 1 # Days (# Piles)		Year 2 # Days (# Piles)		Total # Days (# Piles)b		
	WTG Monopile 15 m (1 pile/d)	OSS Jacket 5 m (4 piles/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)	WTG Monopile 15 m (1 pile/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)
May	8 (8)	0 (0)	0 (0)	0 (0)	8 (8)	0 (0)	0 (0)
Jun	20 (20)	6 (24)	0 (0)	0 (0)	20 (20)	0 (0)	6 (24)
Jul	25 (25)	0 (0)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)
Aug	19 (19)	6 (24)	0 (0)	0 (0)	19 (19)	0 (0)	6 (24)
Sep	18 (18)	0 (0)	0 (0)	0 (0)	18 (18)	0 (0)	0 (0)
Oct	16 (16)	0 (0)	0 (0)	0 (0)	16 (16)	0 (0)	0 (0)
Nov[c]	5 (5)	0 (0)	0 (0)	0 (0)	5 (5)	0 (0)	0 (0)
Dec[c]	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)
Total Piling Days	**112**	**12**	**0**	**0**	**112**		**12**
Total Piles	**112**	**48**	**0**	**0**	**112**		**48**
Total Foundations	**112**	**2**	**0**	**0**	**112**		**2**

[a] The schedules assume a start year of 2026 for foundation installation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles. Construction Schedule 2 is used in the take request.

[b] Modeling assumed 106 WTG foundations (105 WTGs + 1 Met Tower) installed during May–October in the Project 1 Area plus an additional 6 WTG foundations installed during November–December in the Overlap Area as well as 2 large OSSs installed during June and August in the Project 1 Area. All foundation installation for Project 1 plus Overlap would occur during year 1.

[c] The 6 WTG foundations installed during November–December are part of the Overlap Area and are counted in both the Project 1 plus Overlap and Project 2 plus Overlap exposure and take estimates.

Table 10. Atlantic Shores Construction Schedule 2 – Project 2 plus Overlap: Used to estimate marine mammal exposures above threshold criteria. Shown are the number of piling days (number of piles) for each construction month and year.

Construction Month	Construction Schedule 2: 2 Year Schedulea Combined Monopile and Jacket						
	Year 1 # Days (# Piles)		Year 2 # Days (# Piles)		Total # Days (# Piles)b		
	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)	WTG Monopile 15 m (1 pile/d)	WTG Jacket 5 m (4 piles/d)	OSS Jacket 5 m (4 piles/d)
May	0 (0)	0 (0)	5 (20)	0 (0)	0 (0)	5 (20)	0 (0)
Jun	0 (0)	0 (0)	15 (60)	6 (24)	0 (0)	15 (60)	6 (24)
Jul	0 (0)	0 (0)	20 (80)	0 (0)	0 (0)	20 (80)	0 (0)
Aug	0 (0)	0 (0)	18 (72)	6 (24)	0 (0)	18 (72)	6 (24)
Sep	0 (0)	0 (0)	14 (56)	0 (0)	0 (0)	14 (56)	0 (0)
Oct	0 (0)	0 (0)	13 (52)	0 (0)	0 (0)	13 (52)	0 (0)
Nov[c]	5 (20)	0 (0)	4 (16)	0 (0)	0 (0)	9 (36)	0 (0)
Dec[c]	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)
Total Piling Days	**6**	**0**	**89**	**12**	**95**		**12**
Total Piles	**24**	**0**	**356**	**48**	**380**		**48**
Total Foundations	**6**	**0**	**89**	**2**	**95**		**2**

[a] The schedules assume a start year of 2026 for foundation installation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles. Construction Schedule 2 is used in the take request.

[b] Modeling assumed 6 WTG foundations installed during November–December of year 1 in the Overlap Area as well as 89 WTG foundations installed during May–December of year 2 plus two large OSSs installed during June and August of year 2 in the Project 2 Area.

[c] The 6 WTG foundations installed during November–December of year 1 are part of the Overlap Area and are counted in both the Project 1 plus Overlap and Project 2 plus Overlap exposure and take estimates.

2. Density Estimates

The 2022 MGEL models (Roberts et al. 2016, 2022) provide monthly marine mammal density estimates (animals per 100 square kilometers [animals/100 km^2]) for all 5 × 5 km grid cells within the US Atlantic Exclusive Economic Zone. This is an increase in resolution from the former models, which used 10 × 10 km grid cells for all species except the North Atlantic right whale (NARW), with an unchanged 5 × 5 km spatial resolution for this species. The 2022 updated NARW model (v12) provides model predictions for three eras, 2003–2019, 2003–2009, and 2010–2019, to reflect the apparent shift in NARW distribution around 2010. The modeling reported herein used the 2010–2019 density predictions as recommended by Roberts et al. (2022). Similarly, the 2022 updated humpback whale model (v11) provides model predictions for three eras, 2002–2019, 2002–2008, and 2009–2019. The modeling reported herein used the 2009–2019 density predictions as recommended by Roberts et al. (2022). Details on how density is calculated can be found in the Application.

2.1. Densities Used for Impact Pile Driving Analysis

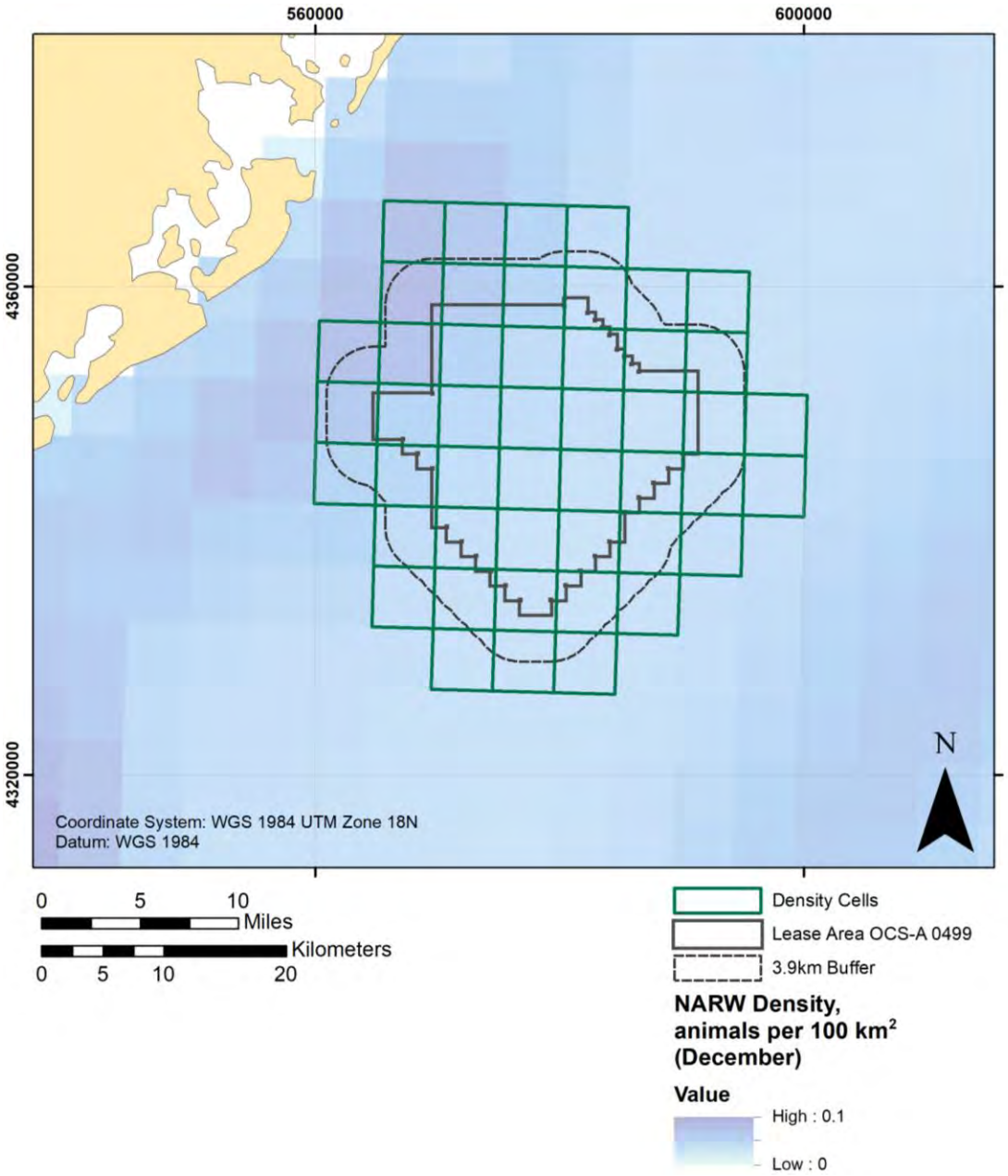


Figure 12. Marine mammal (e.g., NARW) density map showing highlighted grid cells used to calculate mean monthly species estimates within a 3.9 km buffer around the OCS-A 0499 lease area (Roberts et al. 2016, 2022).

Table 12. Mean monthly marine mammal density estimates for all modeled species within a 3.9 km buffer around the Atlantic Shores OCS-A 0499 Lease Area.

Species		Monthly density (animals/100 km²) [a]												Annual mean	May to Dec mean
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
LF	Fin whale [b]	0.178	0.123	0.098	0.099	0.088	0.075	0.047	0.028	0.029	0.031	0.038	0.141	0.081	0.060
	Minke whale	0.051	0.049	0.049	0.737	0.810	0.202	0.054	0.026	0.015	0.066	0.016	0.042	0.176	0.154
	Humpback whale	0.093	0.065	0.084	0.101	0.091	0.058	0.011	0.006	0.020	0.065	0.086	0.121	0.067	0.057
	North Atlantic right whale [b]	0.069	0.074	0.062	0.046	0.010	0.003	0.001	0.001	0.002	0.004	0.010	0.042	0.027	0.009
	Sei whale [b]	0.026	0.016	0.034	0.074	0.027	0.006	0.001	0.001	0.002	0.008	0.026	0.042	0.022	0.014
MF	Atlantic spotted dolphin	0.001	0.000	0.001	0.003	0.006	0.012	0.028	0.133	0.109	0.147	0.113	0.008	0.047	0.070
	Atlantic white-sided dolphin	0.355	0.225	0.221	0.673	0.755	0.605	0.018	0.004	0.059	0.556	0.591	0.601	0.389	0.399
	Common dolphin	2.754	1.139	1.347	2.751	3.431	1.695	0.939	0.507	0.085	1.006	5.315	5.876	2.237	2.357
	Bottlenose dolphin, coastal [c]	2.917	1.024	2.053	8.290	20.869	27.429	29.272	31.415	32.096	29.744	30.414	16.667	19.349	27.238
	Bottlenose dolphin, offshore [c]	1.409	0.489	0.732	2.460	6.311	8.449	9.350	9.485	8.613	8.335	9.468	5.944	5.920	8.244
	Risso's dolphin	0.015	0.002	0.003	0.031	0.029	0.008	0.006	0.006	0.006	0.013	0.074	0.115	0.026	0.032
	Long-finned pilot whale [d]	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
	Short-finned pilot whale [d]	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
	Sperm whale [b]	0.004	0.002	0.001	0.007	0.010	0.005	0.003	0.000	0.000	0.000	0.003	0.004	0.003	0.003
HF	Harbor porpoise	3.968	3.756	3.091	4.161	1.025	0.033	0.023	0.016	0.003	0.007	0.029	2.891	1.584	0.503
PPW	Gray seal [e]	4.881	3.521	2.352	2.866	4.508	0.492	0.080	0.054	0.120	0.639	1.731	4.588	2.153	1.527
	Harbor seal [e]	10.967	7.911	5.285	6.439	10.127	1.106	0.180	0.122	0.271	1.437	3.889	10.308	4.837	3.430

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] For bottlenose dolphins, the 3.9 km buffer was split at the 20 m isobath: coastal, <20 m; offshore >20 m.
[d] Long- and short-finned pilot whale densities are the annual pilot whale guild density scaled by their relative abundances.
[e] Gray and harbor seal densities are the Roberts et al. (2016, 2022) seals guild density scaled by their relative abundances.

2.2. Densities Used for Vibratory Pile Driving for Cofferdam Installation and Removal

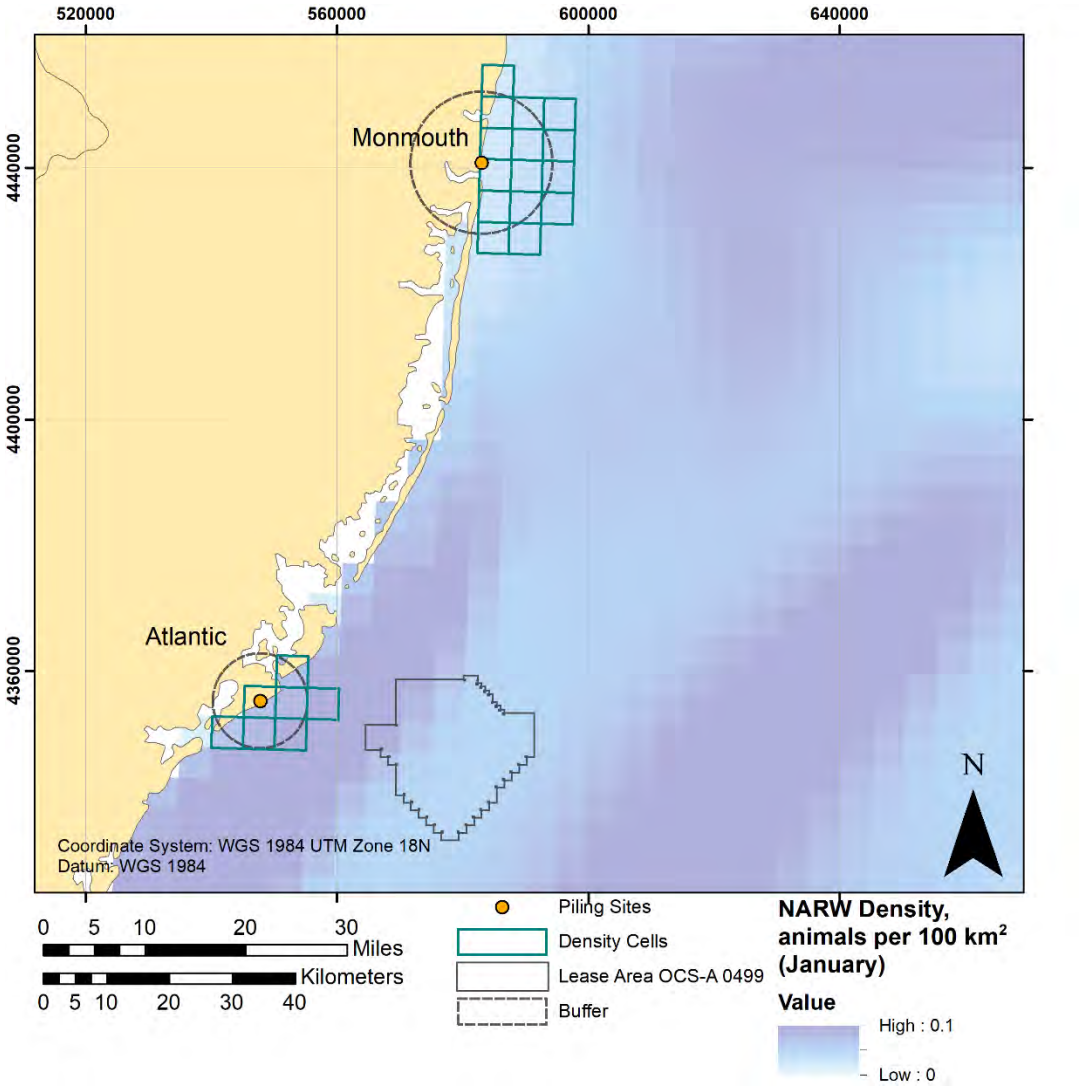


Figure 13. Marine mammal (e.g., NARW) density map showing highlighted grid cells used to calculate maximum seasonal species densities at each vibratory piling location (Roberts et al. 2016, 2022).

Table 13. Maximum annual density [a] (animals per 100 km^2), estimated from September to May, at each of the two vibratory piling sites.

Species		Monmouth	Atlantic
LF	Fin whale [b]	0.117	0.052
	Minke whale	0.526	0.136
	Humpback whale	0.132	0.114
	North Atlantic right whale [b]	0.035	0.092
	Sei whale [b]	0.046	0.018
MF	Atlantic spotted dolphin	0.033	0.014
	Atlantic white-sided dolphin	0.206	0.051
	Common dolphin	2.058	0.524
	Bottlenose dolphin, coastal [c]	27.795	146.614
	Bottlenose dolphin, offshore [c]	22.530	0.000
	Risso's dolphin	0.020	0.002
	Long-finned pilot whale [d]	0.000	0.000
	Short-finned pilot whale [d]	0.000	0.000
	Sperm whale [b]	0.008	0.002
HF	Harbor porpoise	2.768	0.821
PPW	Gray seal [e]	4.477	9.029
	Harbor seal [e]	10.059	20.287

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] For bottlenose dolphins, the impact area was split at the 20 m isobath: coastal, <20 m; offshore >20 m.
[d] Long- and short-finned pilot whale densities are the Roberts et al. (2016, 2022) annual pilot whale guild density scaled by species relative abundances.
[e] Gray and harbor seal densities are the Roberts et al. (2016, 2022) seal guild density scaled by species relative abundances.

2.3. Densities Used for HRG Survey Analysis

Table 14. Maximum monthly densities [a] used to estimate Level B exposures from HRG surveys.

Species		Maximum monthly density [a] (animals/100 km²)
LF	Fin whale [b]	0.114
	Minke whale	0.401
	Humpback whale	0.090
	North Atlantic right whale [b]	0.056
	Sei whale [b]	0.031
MF	Atlantic spotted dolphin	0.033
	Atlantic white-sided dolphin	0.278
	Common dolphin	1.473
	Bottlenose dolphin (coastal and offshore) [c]	36.269
	Risso's dolphin	0.017
	Pilot whale, long-finned [d]	0.004
	Pilot whale, short-finned [d]	0.003
	Sperm whale [b]	0.005
HF	Harbor porpoise	2.506
PPW	Gray seal [e]	4.319
	Harbor seal [e]	9.704

[a] Density is from Roberts et al. (2016, 2022) calculated for the entire HRG survey area.
[b] Listed as Endangered under the ESA.
[c] Bottlenose dolphin density is for the species as a whole, not delineated by stocks.
[d] The density estimate provided by Roberts et al. (2016, 2022) for the pilot whale guild was scaled by the relative abundance of the two species.
[e] The density estimate provided by Roberts et al. (2016, 2022) for the seals guild was scaled by the relative abundance of the two species.

3. Exposure Estimates

3.1. Exposure Estimates – Impact Pile Driving

3.1.1. Full Buildout

Table 24. Construction Schedule 2, Year 1 – Full Buildout: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale [d] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale [d]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table 25. Construction Schedule 2, Year 2 – Full Buildout: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	10.24	5.82	3.46	1.51	0.02	<0.01	0	0	15.38	11.03	9.20	6.41	13.57	9.00	6.88	4.74
	Minke whale	107.83	43.81	16.27	2.97	0.10	<0.01	0	0	242.38	174.21	141.72	95.10	173.67	121.73	98.53	70.02
	Humpback whale	11.77	5.89	3.02	1.08	0.02	<0.01	0	0	19.04	12.65	9.82	6.28	14.95	9.93	7.73	5.25
	North Atlantic right whale [d] (migrating)	1.21	0.50	0.24	0.05	<0.01	0	0	0	2.56	1.66	1.31	0.77	5.78	4.34	3.59	2.70
	Sei whale [d]	1.21	0.69	0.41	0.18	<0.01	<0.01	0	0	1.82	1.31	1.09	0.76	1.61	1.07	0.82	0.56
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.15	0.08	0.01	0	0	0	0	0	302.06	207.64	171.37	112.91	167.81	116.91	84.74	52.64
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	19.52	8.41	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	993.20	97.45	0	0	786.04	400.97	250.17	114.08
	Bottlenose dolphin, offshore	7.24	0	0	0	0	0	0	0	6428.45	4331.19	3416.59	2050.28	3530.66	2388.91	1696.19	1049.49
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	10.35	7.24	6.03	4.15	5.99	4.19	3.09	1.97
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	40.51	22.44	12.52	3.17	4.16	1.30	0.33	0.12	69.67	48.24	39.23	26.30	246.01	193.18	161.62	126.90
PPW	Gray seal	35.15	10.26	2.00	0.02	0.16	0	0	0	191.33	117.98	94.34	60.59	139.23	88.26	68.34	41.30
	Harbor seal	84.58	24.21	7.03	0.68	0.66	0.02	0	0	444.49	280.32	213.40	134.64	320.39	205.22	156.16	97.11

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table 26. Construction Schedule 2, Years 1 and 2 combined – Full Buildout: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	17.65	10.36	6.26	2.74	0.09	<0.01	0	0	29.45	21.25	17.43	12.88	25.95	17.41	13.40	9.50
	Minke whale	182.08	72.83	26.34	4.96	0.22	<0.01	0	0	460.94	340.02	277.09	201.85	335.72	240.32	192.84	142.19
	Humpback whale	19.18	10.03	5.22	1.85	0.07	0.01	0	0	34.37	23.45	18.15	12.43	27.03	18.40	14.23	9.98
	North Atlantic right whale [d] (migrating)	1.96	0.80	0.39	0.09	<0.01	<0.01	<0.01	<0.01	4.80	3.27	2.54	1.72	10.02	7.66	6.35	4.89
	Sei whale [d]	2.13	1.25	0.75	0.33	0.01	<0.01	0	0	3.60	2.60	2.14	1.58	3.18	2.13	1.64	1.17
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.17	0.09	0.02	0	0	0	0	0	572.29	406.89	331.31	236.36	283.45	196.06	143.94	89.99
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	31.21	11.49	1.35	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1825.67	511.58	50.32	0	1154.48	575.37	357.73	165.27
	Bottlenose dolphin, offshore	9.00	0	0	0	2.28	0	0	0	11913.17	8329.22	6517.32	4250.61	5822.29	3879.40	2757.82	1735.93
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	19.76	14.15	11.61	8.42	10.04	6.97	5.18	3.31
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	56.32	27.61	13.91	3.54	12.98	5.13	2.26	0.56	153.85	109.80	89.08	64.21	466.34	359.16	297.00	229.83
PPW	Gray seal	46.51	13.05	2.52	0.25	0.60	0	0	0	392.52	252.87	192.76	134.08	264.91	168.05	128.50	82.30
	Harbor seal	119.22	30.44	8.32	0.74	3.04	0.51	0	0	915.50	592.33	448.91	310.91	612.51	393.09	298.40	194.39

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

3.1.2. Project 1 Plus Overlap

Table 27. Construction Schedule 2, Year 1 – Project 1 plus Overlap: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale [d] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale [d]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

3.1.3. Project 2 Plus Overlap

Table 28. Construction Schedule 2, Year 1 – Project 2 plus Overlap: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	0.72	0.41	0.24	0.10	<0.01	<0.01	0	0	1.09	0.78	0.65	0.45	0.96	0.63	0.49	0.33
	Minke whale	1.16	0.46	0.16	0.03	<0.01	0	0	0	2.65	1.90	1.55	1.03	1.90	1.33	1.08	0.76
	Humpback whale	1.81	0.90	0.46	0.16	<0.01	0	0	0	2.95	1.96	1.53	0.96	2.32	1.54	1.20	0.81
	North Atlantic right whale [d] (migrating)	0.40	0.16	0.08	0.02	<0.01	0	0	0	0.85	0.55	0.43	0.25	1.92	1.44	1.19	0.90
	Sei whale [d]	0.38	0.21	0.13	0.05	<0.01	<0.01	0	0	0.57	0.41	0.34	0.23	0.50	0.33	0.26	0.17
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	<0.01	0	0	0	0	0	0	38.62	26.47	21.98	14.24	21.39	14.92	10.74	6.64
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	5.26	2.26	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	54.59	2.60	0	0	42.54	22.27	13.63	6.20
	Bottlenose dolphin, offshore	0.37	0	0	0	0	0	0	0	378.78	254.63	201.39	119.17	207.81	140.27	99.20	60.95
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	4.47	3.12	2.61	1.78	2.58	1.81	1.33	0.85
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	17.64	9.75	5.40	1.33	1.80	0.55	0.14	0.05	30.41	21.04	17.14	11.43	107.56	84.43	70.61	55.43
PPW	Gray seal	8.66	2.46	0.45	0	0.04	0	0	0	47.57	29.31	23.56	14.98	34.65	21.97	17.00	10.23
	Harbor seal	20.78	5.82	1.66	0.17	0.17	0	0	0	110.57	69.67	53.29	33.26	79.71	51.08	38.86	24.09

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table 29. Construction Schedule 2, Year 2 – Project 2 plus Overlap: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	10.24	5.82	3.46	1.51	0.02	<0.01	0	0	15.38	11.03	9.20	6.41	13.57	9.00	6.88	4.74
	Minke whale	107.83	43.81	16.27	2.97	0.10	<0.01	0	0	242.38	174.21	141.72	95.10	173.67	121.73	98.53	70.02
	Humpback whale	11.77	5.89	3.02	1.08	0.02	<0.01	0	0	19.04	12.65	9.82	6.28	14.95	9.93	7.73	5.25
	North Atlantic right whale [d] (migrating)	1.21	0.50	0.24	0.05	<0.01	0	0	0	2.56	1.66	1.31	0.77	5.78	4.34	3.59	2.70
	Sei whale [d]	1.21	0.69	0.41	0.18	<0.01	<0.01	0	0	1.82	1.31	1.09	0.76	1.61	1.07	0.82	0.56
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.15	0.08	0.01	0	0	0	0	0	302.06	207.64	171.37	112.91	167.81	116.91	84.74	52.64
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	19.52	8.41	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	993.20	97.45	0	0	786.04	400.97	250.17	114.08
	Bottlenose dolphin, offshore	7.24	0	0	0	0	0	0	0	6428.45	4331.19	3416.59	2050.28	3530.66	2388.91	1696.19	1049.49
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	10.35	7.24	6.03	4.15	5.99	4.19	3.09	1.97
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	40.51	22.44	12.52	3.17	4.16	1.30	0.33	0.12	69.67	48.24	39.23	26.30	246.01	193.18	161.62	126.90
PPW	Gray seal	35.15	10.26	2.00	0.02	0.16	0	0	0	191.33	117.98	94.34	60.59	139.23	88.26	68.34	41.30
	Harbor seal	84.58	24.21	7.03	0.68	0.66	0.02	0	0	444.49	280.32	213.40	134.64	320.39	205.22	156.16	97.11

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table 30. Construction Schedule 2, Years 1 and 2 combined – Project 2 plus Overlap: The mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 2 assumes all WTGs and the met tower are installed on jacket foundations each with four 5-m pin piles and OSSs are installed on jacket foundations each with twenty-four 5-m pin piles.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	10.96	6.23	3.70	1.62	0.02	<0.01	0	0	16.47	11.82	9.86	6.86	14.53	9.63	7.37	5.07
	Minke whale	108.99	44.27	16.44	3.00	0.10	<0.01	0	0	245.03	176.11	143.27	96.13	175.57	123.05	99.60	70.78
	Humpback whale	13.58	6.79	3.47	1.23	0.02	<0.01	0	0	21.99	14.60	11.35	7.25	17.27	11.47	8.93	6.06
	North Atlantic right whale [d] (migrating)	1.60	0.66	0.32	0.07	<0.01	0	0	0	3.41	2.21	1.74	1.03	7.70	5.78	4.79	3.60
	Sei whale [d]	1.59	0.90	0.53	0.23	<0.01	<0.01	0	0	2.39	1.72	1.44	0.99	2.11	1.40	1.07	0.73
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.17	0.09	0.01	0	0	0	0	0	340.68	234.11	193.35	127.15	189.20	131.84	95.48	59.29
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	24.78	10.66	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1047.78	100.05	0	0	828.58	423.24	263.79	120.29
	Bottlenose dolphin, offshore	7.61	0	0	0	0	0	0	0	6807.23	4585.82	3617.98	2169.45	3738.47	2529.17	1795.39	1110.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	14.81	10.36	8.64	5.93	8.58	6.00	4.42	2.82
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	58.15	32.19	17.93	4.50	5.96	1.85	0.47	0.17	100.08	69.28	56.37	37.73	353.56	277.62	232.23	182.33
PPW	Gray seal	43.81	12.72	2.46	0.02	0.20	0	0	0	238.90	147.29	117.90	75.57	173.88	110.23	85.34	51.52
	Harbor seal	105.36	30.03	8.69	0.85	0.83	0.02	0	0	555.06	349.99	266.69	167.89	400.10	256.30	195.02	121.20

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Listed as Endangered under the ESA.
[d] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.

3.2. Exposure Estimates – Vibratory Pile Driving for Cofferdam Installation and Removal

Table 31. Vibratory pile driving for cofferdam installation and removal, injury: maximum estimated exposures above the injury acoustic criteria from cofferdam installation and removal during Years 1 and 2. The vibratory sheet pile driving activities are expected to occur during a single year at each location.

Species		Year 1 (Atlantic)	Year 2 (Monmouth)	Maximum total exposures
LF	Fin whale [a]	<0.01	<0.01	<0.01
	Minke whale	<0.01	<0.01	<0.01
	Humpback whale	<0.01	<0.01	<0.01
	North Atlantic right whale [a]	<0.01	<0.01	<0.01
	Sei whale [a]	<0.01	<0.01	<0.01
MF	Atlantic spotted dolphin	0	0	0
	Atlantic white-sided dolphin	0	0	0
	Common dolphin	0	0	0
	Bottlenose dolphin, coastal	0	0	0
	Bottlenose dolphin, offshore	0	0	0
	Risso's dolphin	0	0	0
	Pilot whale, long-finned	0	0	0
	Pilot whale, short-finned	0	0	0
	Sperm whale [a]	0	0	0
HF	Harbor porpoise	0.09	0.28	0.37
PPW	Gray seal	<0.01	<0.01	<0.01
	Harbor seal	<0.01	<0.01	0.01

[a] Listed as Endangered under the ESA.

Table 32. Vibratory pile driving for cofferdam installation and removal, behavior: maximum estimated exposures above the behavioral acoustic criterion from cofferdam installation and removal during Years 1 and 2. The vibratory sheet pile driving activities are expected to occur during a single year at each location.

Species		Year 1 (Atlantic)	Year 2 (Monmouth)	Maximum total exposures
LF	Fin whale [a]	0.65	4.14	4.79
	Minke whale	1.70	18.66	20.36
	Humpback whale	1.43	4.70	6.13
	North Atlantic right whale [a]	1.15	1.23	2.38
	Sei whale [a]	0.23	1.62	1.85
MF	Atlantic spotted dolphin	0.17	1.16	1.33
	Atlantic white-sided dolphin	0.63	7.31	7.94
	Common dolphin	6.56	73.01	79.58
	Bottlenose dolphin, coastal	1835.52	607.13	2442.65
	Bottlenose dolphin, offshore	0.00	307.29	307.29
	Risso's dolphin	0.02	0.70	0.72
	Pilot whale, long-finned	0.00	<0.01	0.01
	Pilot whale, short-finned	0.00	<0.01	<0.01
	Sperm whale [a]	0.02	0.28	0.30
HF	Harbor porpoise	10.28	98.23	108.51
PPW	Gray seal	113.04	158.86	271.91
	Harbor seal	253.98	356.92	610.90

[a] Listed as Endangered under the ESA.

3.3. Exposure Estimates – HRG Surveys

Table 33. Maximum yearly and maximum total estimated exposures above the behavioral acoustic criterion from HRG surveys.

Species		Maximum yearly exposures	Maximum total exposures for all 5 years of surveys
LF	Fin whale [a]	2	10
	Minke whale	4	20
	Humpback whale	1	5
	North Atlantic right whale [a]	1	5
	Sei whale [a]	1	5
MF	Atlantic spotted dolphin	1	5
	Atlantic white-sided dolphin	3	15
	Common dolphin	14	70
	Bottlenose dolphin, coastal [b]	113	565
	Bottlenose dolphin, offshore [b]	225	1125
	Risso's dolphin	1	5
	Pilot whale, long-finned	1	5
	Pilot whale, short-finned	1	5
	Sperm whale [a]	1	5
HF	Harbor porpoise	24	120
PPW	Gray seal	41	205
	Harbor seal	91	455

[a] Listed as Endangered under the ESA.
[b] Assumes 33 % of bottlenose dolphins are from the coastal stock because ~33 % of the survey area is in waters ≤20 m deep.

4. Take Estimates

4.1. Take Estimates – Impact Pile Driving

4.1.1. Full Buildout

Table 34. Level A and Level B take estimates for impact pile driving – Full Buildout.

Species		Stock size	ITA Request Year 2 [e]			ITA request Year 3			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	3	9	0.18	4	10	0.21	7	18	0.37
	Minke whale	21,968	11	136	0.67	17	142	0.72	27	278	1.39
	Humpback whale	1,396	3	9	0.86	4	10	1.00	6	19	1.79
	North Atlantic right whale [a,b]	338	0	4	1.18	0	4	1.18	0	8	2.37
	Sei whale [a,b]	6,292	1	3	0.06	1	3	0.06	1	6	0.11
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	100	0.25	0	200	0.50
	Atlantic white-sided dolphin	93,233	1	160	0.17	1	172	0.19	1	332	0.36
	Common dolphin [c]	172,974	0	193	0.11	0	157	0.09	0	349	0.20
	Bottlenose dolphin, coastal [b]	6,639	0	51	0.77	0	14	0.21	0	51	0.77
	Bottlenose dolphin, offshore	62,851	0	3101	4.93	0	3417	5.44	0	6518	10.37
	Risso's dolphin [b]	35,215	1	30	0.09	1	30	0.09	1	60	0.17
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	20	0.05	0	40	0.10
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	6	0.02	0	12	0.04
	Sperm whale [a,b]	4,349	0	2	0.05	0	2	0.05	0	4	0.09
HF	Harbor porpoise	95,543	2	50	0.05	13	40	0.06	14	90	0.11
PPW	Gray seal	27,300	1	99	0.37	2	95	0.36	3	193	0.72
	Harbor seal	61,336	2	236	0.39	8	214	0.36	9	449	0.75

[a] Listed as Endangered under the ESA.

[b] Level B take estimate rounded up to one average group size for yearly take and to two average group sizes for total take estimates.

[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.

[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

[e] Pile driving activities are planned to occur during Year 2 and Year 3 (expected to be 2026 and 2027) of the 5-year period of the ITA request. Thus, ITA request Year 2 and Year 3 in take tables are equivalent to Construction Schedule Year 1 and Year 2 for impact pile driving activities.

4.1.2. Project 1 Plus Overlap

Table 35. Level A and Level B take estimates for impact pile driving – Project 1 plus Overlap.

Species		Stock size	ITA request Year 2 [e]			ITA request Year 3			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	3	9	0.18	0	0	0.00	3	9	0.18
	Minke whale	21,968	11	136	0.67	0	0	0.00	11	136	0.67
	Humpback whale	1,396	3	9	0.86	0	0	0.00	3	9	0.86
	North Atlantic right whale [a,b]	338	0	4	1.18	0	0	0.00	0	4	1.18
	Sei whale [a,b]	6,292	1	3	0.06	0	0	0.00	1	3	0.06
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	0	0.00	0	100	0.25
	Atlantic white-sided dolphin	93,233	1	160	0.17	0	0	0.00	1	160	0.17
	Common dolphin [c]	172,974	0	193	0.11	0	0	0.00	0	193	0.11
	Bottlenose dolphin, coastal	6,639	0	51	0.77	0	0	0.00	0	51	0.77
	Bottlenose dolphin, offshore	62,851	0	3101	4.93	0	0	0.00	0	3101	4.93
	Risso's dolphin [b]	35,215	1	30	0.09	0	0	0.00	1	30	0.09
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	0	0.00	0	20	0.05
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	0	0.00	0	6	0.02
	Sperm whale [a,b]	4,349	0	2	0.05	0	0	0.00	0	2	0.05
HF	Harbor porpoise	95,543	2	50	0.05	0	0	0.00	2	50	0.05
PPW	Gray seal	27,300	1	99	0.37	0	0	0.00	1	99	0.37
	Harbor seal	61,336	2	236	0.39	0	0	0.00	2	236	0.39

[a] Listed as Endangered under the ESA.

[b] Take estimate rounded up to one average group size for ITA request Year 2 and total Level B take estimates.

[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.

[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

[e] Pile driving activities are planned to occur during Year 2 and Year 3 (expected to be 2026 and 2027) of the 5-year period of the ITA request. Thus, ITA request Year 2 and Year 3 in take tables are equivalent to Construction Schedule Year 1 and Year 2 for impact pile driving activities. Project 1 is expected to be installed completely during ITA request Year 2 (Construction Schedule Year 1), therefore there is no take requested for Project 1 plus Overlap for ITA request Year 3.

4.1.3. Project 2 Plus Overlap

Table 36. Level A and Level B take estimates for impact pile driving – Project 2 plus Overlap.

Species		Stock size	ITA request Year 2 [e]			ITA request Year 3			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale [a,b]	6,802	1	2	0.04	4	10	0.21	4	10	0.21
	Minke whale	21,968	1	2	0.01	17	142	0.72	17	144	0.73
	Humpback whale	1,396	1	2	0.21	4	10	1.00	4	12	1.15
	North Atlantic right whale [a,b]	338	0	4	1.18	0	4	1.18	0	8	2.37
	Sei whale [a,b]	6,292	1	3	0.06	1	3	0.06	1	6	0.11
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	100	0.25	0	200	0.50
	Atlantic white-sided dolphin	93,233	0	22	0.02	1	172	0.19	1	194	0.21
	Common dolphin [c]	172,974	0	10	0.01	0	157	0.09	0	166	0.10
	Bottlenose dolphin, coastal [b]	6,639	0	14	0.21	0	14	0.21	0	28	0.42
	Bottlenose dolphin, offshore	62,851	0	202	0.32	0	3417	5.44	0	3618	5.76
	Risso's dolphin [b]	35,215	1	30	0.09	1	30	0.09	1	60	0.17
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	20	0.05	0	40	0.10
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	6	0.02	0	12	0.04
	Sperm whale [a,b]	4,349	0	2	0.05	0	2	0.05	0	4	0.09
HF	Harbor porpoise	95,543	6	18	0.03	13	40	0.06	18	57	0.08
PPW	Gray seal	27,300	1	24	0.09	2	95	0.36	3	118	0.44
	Harbor seal	61,336	2	54	0.09	8	214	0.36	9	267	0.45

[a] Listed as Endangered under the ESA.

[b] Level B take estimates rounded up to one average group size for yearly takes and to two average group sizes for total take estimates. For fin whales Level B take was only rounded up to one group size for Year 2.

[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.

[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

[e] Pile driving activities are planned to occur during Year 2 and Year 3 (expected to be 2026 and 2027) of the 5-year period of the ITA request. Thus, ITA request Year 2 and Year 3 in take tables are equivalent to Construction Schedule Year 1 and Year 2 for impact pile driving activities.

4.2. Take Estimates – Vibratory Pile Driving for Cofferdam Installation and Removal

Table 37. Yearly and total Level B take estimates for vibratory pile driving from cofferdam installation and removal.

Species		ITA request Year 1 [d] (Atlantic)	ITA request Year 2 (Monmouth)	Total
LF	Fin whale [a]	2 [b]	5	6 [b]
	Minke whale	2	19	21
	Humpback whale	2	5	7
	North Atlantic right whale [a]	4 [b]	4 [b]	8 [b]
	Sei whale [a]	3 [b]	3 [b]	5 [b]
MF	Atlantic spotted dolphin	100 [b]	100 [b]	200 [b]
	Atlantic white-sided dolphin	22 [b]	22 [b]	43 [b]
	Common dolphin [c]	19	74	93
	Bottlenose dolphin, coastal	1836	608	2444
	Bottlenose dolphin, offshore	0	308	308
	Risso's dolphin	30 [b]	30 [b]	60 [b]
	Long-finned pilot whale	20 [b]	20 [b]	40 [b]
	Short-finned pilot whale	6 [b]	6 [b]	12 [b]
	Sperm whale [a]	2 [b]	2 [b]	4 [b]
HF	Harbor porpoise	11	99	109
PPW	Gray seal	114	159	272
	Harbor seal	254	357	611

[a] Listed as Endangered under the ESA.

[b] Level B take request increased to one average group size, which is not a whole number so is rounded up to an integer; total is the average group size multiplied by 2 and then rounded up to a whole number.

[c] The take estimate for common dolphins for Year 1 is the average daily sighting rate from site characterization surveys multiplied by the number of survey days, which is then rounded up to a whole number. For Year 2 and for the 2 years combined, the estimated exposures were higher than the sighting rate so the exposure estimates were used as a conservative estimate. The exposure estimates provided in the previous section are not whole numbers so they were rounded up to a whole number.

[d] Cofferdam installation/removal is planned to occur during ITA request Year 1 and Year 2 (expected to be 2025 and 2026) of the 5-year period of the ITA request.

4.3. Take Estimates – HRG Surveys

4.3.1. Full Buildout

Table 38. Maximum yearly and maximum total Level B takes calculated for HRG surveys.

Species		Maximum yearly Level B takes	Maximum total Level B takes
LF	Fin whale [a]	2	10
	Minke whale	4	20
	Humpback whale	1	5
	North Atlantic right whale [a]	1	5
	Sei whale [a,b]	2	10
MF	Atlantic spotted dolphin [c]	100	500
	Atlantic white-sided dolphin	3	15
	Common dolphin [d]	93	465
	Bottlenose dolphin, coastal	113	565
	Bottlenose dolphin, offshore	225	1125
	Risso's dolphin [c]	30	150
	Pilot whale, long-finned [c]	20	100
	Pilot whale, short-finned [c]	6	30
	Sperm whale [a]	1	5
HF	Harbor porpoise	24	120
PPW	Gray seal	41	205
	Harbor seal	91	455

[a] Listed as Endangered under the ESA.
[b] Take estimate for sei whales based on a 2020 sighting of 2 animals during site characterization surveys.
[c] Take estimates for these species were rounded up to one group size.
[d] Take estimate for common dolphins uses the daily sighting rate from site characterization surveys multiplied by the number of survey days.

4.3.2. Project 1

Table 39. Maximum yearly and maximum total Level B takes for HRG surveys – Project 1.

Species		Maximum yearly Level B takes	Maximum total Level B takes
LF	Fin whale [a]	1	5
	Minke whale	2	10
	Humpback whale	1	5
	North Atlantic right whale [a]	1	5
	Sei whale [a]	1	5
MF	Atlantic spotted dolphin [b]	50	250
	Atlantic white-sided dolphin	2	10
	Common dolphin [c]	47	235
	Bottlenose dolphin, coastal	57	285
	Bottlenose dolphin, offshore	113	565
	Risso's dolphin [b]	15	75
	Pilot whale, long-finned [b]	10	50
	Pilot whale, short-finned [b]	3	15
	Sperm whale [a]	1	5
HF	Harbor porpoise	12	60
PPW	Gray seal	21	105
	Harbor seal	46	230

[a] Listed as Endangered under the ESA.
[b] Take estimates for these species were rounded up to one group size before splitting into Project 1 and Project 2.
[c] Take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of survey days.

4.3.3. Project 2

Table 40. Maximum yearly and maximum total Level B takes for HRG surveys – Project 2.

Species		Maximum yearly Level B takes	Maximum total Level B takes
LF	Fin whale [a]	1	5
	Minke whale	2	10
	Humpback whale	0	0
	North Atlantic right whale [a]	0	0
	Sei whale [a]	1	5
MF	Atlantic spotted dolphin [b]	50	250
	Atlantic white-sided dolphin	1	5
	Common dolphin [c]	46	230
	Bottlenose dolphin, coastal	56	280
	Bottlenose dolphin, offshore	112	560
	Risso's dolphin [b]	15	75
	Pilot whale, long-finned [b]	10	50
	Pilot whale, short-finned [b]	3	15
	Sperm whale [a]	0	0
HF	Harbor porpoise	12	60
PPW	Gray seal	20	100
	Harbor seal	45	225

[a] Listed as Endangered under the ESA.
[b] Take estimates for these species were rounded up to one group size before splitting into Project 1 and Project 2.
[c] Take estimate for common dolphins uses the daily sighting rate from site characterization surveys multiplied by the number of survey days.

5. Number of Takes Requested – All Activities

5.1. Full Buildout

Table 41. Requested Level A and Level B takes by year for all activities conducted during construction of Atlantic Shores – Full Buildout.

Species		Stock size	ITA request Year 1 [g]			ITA request Year 2			ITA request Year 3			ITA request Year 4			ITA request Year 5		
			Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]
LF	Fin whale [b,e]	6,802	0	4	0.06	3	16	0.28	4	12	0.24	0	2	0.03	0	2	0.03
	Minke whale	21,968	0	6	0.03	11	159	0.77	17	146	0.74	0	4	0.02	0	4	0.02
	Humpback whale	1,396	0	3	0.21	3	15	1.29	4	11	1.07	0	1	0.07	0	1	0.07
	North Atlantic right whale [b,c,e]	338	0	5	1.48	0	9	2.66	0	5	1.48	0	1	0.3	0	1	0.3
	Sei whale [b,c,e]	6,292	0	5	0.08	1	8	0.14	1	5	0.1	0	2	0.03	0	2	0.03
MF	Atlantic spotted dolphin [c,d,e]	39,921	0	200	0.5	0	300	0.75	0	200	0.5	0	100	0.25	0	100	0.25
	Atlantic white-sided dolphin [e]	93,233	0	25	0.03	1	185	0.2	1	175	0.19	0	3	0	0	3	0
	Common dolphin [f]	172,974	0	112	0.06	0	360	0.21	0	250	0.14	0	93	0.05	0	93	0.05
	Bottlenose dolphin, coastal [c]	6,639	0	1949	29.36	0	772	11.63	0	127	1.91	0	113	1.7	0	113	1.7
	Bottlenose dolphin, offshore	62,851	0	225	0.36	0	3634	5.78	0	3642	5.79	0	225	0.36	0	225	0.36
	Risso's dolphin [c,d,e]	35,215	0	60	0.17	1	90	0.26	1	60	0.17	0	30	0.09	0	30	0.09
	Long-finned pilot whale [c,d,e]	39,215	0	40	0.1	0	60	0.15	0	40	0.1	0	20	0.05	0	20	0.05
	Short-finned pilot whale [c,d,e]	28,924	0	12	0.04	0	18	0.06	0	12	0.04	0	6	0.02	0	6	0.02
	Sperm whale [b,c,e]	4,349	0	3	0.07	0	5	0.11	0	3	0.07	0	1	0.02	0	1	0.02
HF	Harbor porpoise	95,543	0	35	0.04	2	173	0.18	13	64	0.08	0	24	0.03	0	24	0.03
PPW	Gray seal	27,300	0	155	0.57	1	299	1.1	2	136	0.51	0	41	0.15	0	41	0.15
	Harbor seal	61,336	0	345	0.56	2	684	1.12	8	305	0.51	0	91	0.15	0	91	0.15

[a] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken annually, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Level B take estimate for impact pile driving rounded up to one average group size; impact pile driving scheduled to occur during Year 2 and Year 3.
[d] Level B take estimate for HRG surveys rounded up to one group size; HRG surveys occur during all 5 years.
[e] Level B take estimate for cofferdam vibratory piling rounded up to one group size; cofferdam installation scheduled to occur during Year 1 and Year 2.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.
[g] Years 1–5 are expected to be in 2025–2029.

Table 42. Summary of total Level A and Level B takes for all activities conducted during construction of Atlantic Shores – Full Buildout.

Species		Stock size	5 Year total		
			Level A	Level B	Max. % [a]
LF	Fin whale [b,e]	6,802	7	35	0.62
	Minke whale	21,968	27	319	1.58
	Humpback whale	1,396	6	31	2.65
	North Atlantic right whale [b,c,e]	338	0	21	6.21
	Sei whale [b,c,e]	6,292	1	22	0.37
MF	Atlantic spotted dolphin [c,d,e]	39,921	0	900	2.25
	Atlantic white-sided dolphin [e]	93,233	1	391	0.42
	Common dolphin [f]	172,974	0	907	0.52
	Bottlenose dolphin, coastal [c]	6,639	0	3060	46.09
	Bottlenose dolphin, offshore	62,851	0	7951	12.65
	Risso's dolphin [c,d,e]	35,215	1	270	0.77
	Long-finned pilot whale [c,d,e]	39,215	0	180	0.46
	Short-finned pilot whale [c,d,e]	28,924	0	54	0.19
	Sperm whale [b,c,e]	4,349	0	13	0.3
HF	Harbor porpoise	95,543	14	320	0.35
PPW	Gray seal	27,300	3	671	2.47
	Harbor seal	61,336	9	1515	2.48

[a] Max percent is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken over the 5-year duration of the LOA, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Total Level B take estimate for impact pile driving rounded up to two average group sizes.
[d] Level B take estimate for HRG surveys rounded up to one group size per year; HRG surveys occur during all 5 years.
[e] Level B take estimate for cofferdam vibratory piling rounded up to two group sizes, except for fin whale, which was only rounded up in Year 1.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.

5.2. Project 1 Plus Overlap

Table 43. Requested Level A and Level B takes by year for all activities conducted during construction of Atlantic Shores – Project 1 plus Overlap.

Species		Stock size	ITA request Year 1[g]			ITA request Year 2			ITA request Year 3			ITA request Year 4			ITA request Year 5		
			Level A	Level B	Max %[a]	Level A	Level B	Max %[a]	Level A	Level B	Max %[a]	Level A	Level B	Max %[a]	Level A	Level B	Max %[a]
LF	Fin whale [b]	6,802	0	3	0.04	3	10	0.19	0	1	0.01	0	1	0.01	0	1	0.01
	Minke whale	21,968	0	4	0.02	11	138	0.68	0	2	0.01	0	2	0.01	0	2	0.01
	Humpback whale	1,396	0	3	0.21	3	10	0.93	0	1	0.07	0	1	0.07	0	1	0.07
	North Atlantic right whale [b,c,e]	338	0	5	1.48	0	5	1.48	0	1	0.3	0	1	0.3	0	1	0.3
	Sei whale [b,c,e]	6,292	0	4	0.06	1	4	0.08	0	1	0.02	0	1	0.02	0	1	0.02
MF	Atlantic spotted dolphin [c,d,e]	39,921	0	150	0.38	0	150	0.38	0	50	0.13	0	50	0.13	0	50	0.13
	Atlantic white-sided dolphin [e]	93,233	0	24	0.03	1	162	0.17	0	2	0	0	2	0	0	2	0
	Common dolphin [f]	172,974	0	66	0.04	0	240	0.14	0	47	0.03	0	47	0.03	0	47	0.03
	Bottlenose dolphin, coastal [c]	6,639	0	1893	28.51	0	108	1.63	0	57	0.86	0	57	0.86	0	57	0.86
	Bottlenose dolphin, offshore	62,851	0	113	0.18	0	3214	5.11	0	113	0.18	0	113	0.18	0	113	0.18
	Risso's dolphin [c,d,e]	35,215	0	45	0.13	1	45	0.13	0	15	0.04	0	15	0.04	0	15	0.04
	Long-finned pilot whale [c,d,e]	39,215	0	30	0.08	0	30	0.08	0	10	0.03	0	10	0.03	0	10	0.03
	Short-finned pilot whale [c,d,e]	28,924	0	9	0.03	0	9	0.03	0	3	0.01	0	3	0.01	0	3	0.01
	Sperm whale [b,c,e]	4,349	0	3	0.07	0	3	0.07	0	1	0.02	0	1	0.02	0	1	0.02
HF	Harbor porpoise	95,543	0	23	0.02	2	62	0.07	0	12	0.01	0	12	0.01	0	12	0.01
PPW	Gray seal	27,300	0	135	0.49	1	120	0.44	0	21	0.08	0	21	0.08	0	21	0.08
	Harbor seal	61,336	0	300	0.49	2	282	0.46	0	46	0.07	0	46	0.07	0	46	0.07

[a] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken annually, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Level B take estimate for impact pile driving rounded up to one average group size; impact pile driving scheduled to occur during Year 2 only.
[d] Level B take estimate for HRG surveys rounded up to one group size; HRG surveys occur during all 5 years.
[e] Level B take estimate for cofferdam vibratory piling rounded up to one group size; cofferdam installation assumed to occur during Year 1.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.
[g] Years 1–5 are expected to be in 2025–2029.

Table 44. Summary of total Level A and Level B takes for all activities conducted during construction of Atlantic Shores – Project 1 plus Overlap.

Species		Stock size	5 year total		
			Level A	Level B	Max. % [a]
LF	Fin whale [b]	6,802	3	16	0.28
	Minke whale	21,968	11	148	0.72
	Humpback whale	1,396	3	16	1.36
	North Atlantic right whale [b,c,e]	338	0	13	3.85
	Sei whale [b,c,e]	6,292	1	11	0.19
MF	Atlantic spotted dolphin [c,d,e]	39,921	0	450	1.13
	Atlantic white-sided dolphin [e]	93,233	1	192	0.21
	Common dolphin [f]	172,974	0	447	0.26
	Bottlenose dolphin, coastal [c]	6,639	0	2172	32.72
	Bottlenose dolphin, offshore	62,851	0	3666	5.83
	Risso's dolphin [c,d,e]	35,215	1	135	0.39
	Long-finned pilot whale [c,d,e]	39,215	0	90	0.23
	Short-finned pilot whale [c,d,e]	28,924	0	27	0.09
	Sperm whale [b,c,e]	4,349	0	9	0.21
HF	Harbor porpoise	95,543	2	121	0.13
PPW	Gray seal	27,300	1	318	1.17
	Harbor seal	61,336	2	720	1.18

[a] Max percent is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken over the 5-year duration of the LOA, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Total Level B take estimate for impact pile driving rounded up to one average group size.
[d] Level B take estimate for HRG surveys rounded up to one group size per year; HRG surveys occur during all 5 years.
[e] Level B take estimate for cofferdam vibratory piling rounded up to one group size; cofferdam installation/removal to occur during Year 1.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.

5.3. Project 2 Plus Overlap

Table 45. Requested Level A and Level B takes by year for all activities conducted during construction of Atlantic Shores – Project 2 plus Overlap.

Species		Stock size	ITA request Year 1 [g]			ITA request Year 2			ITA request Year 3			ITA request Year 4			ITA request Year 5		
			Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]	Level A	Level B	Max % [a]
LF	Fin whale [b,c]	6,802	0	1	0.01	1	8	0.13	4	11	0.22	0	1	0.01	0	1	0.01
	Minke whale	21,968	0	2	0.01	1	23	0.11	17	144	0.73	0	2	0.01	0	2	0.01
	Humpback whale	1,396	0	0	0.00	1	7	0.57	4	10	1.00	0	0	0.00	0	0	0.00
	North Atlantic right whale [b,c,e]	338	0	0	0.00	0	8	2.37	0	4	1.18	0	0	0.00	0	0	0.00
	Sei whale [b,c,e]	6,292	0	1	0.02	1	7	0.13	1	4	0.08	0	1	0.02	0	1	0.02
MF	Atlantic spotted dolphin [c,d,e]	39,921	0	50	0.13	0	250	0.63	0	150	0.38	0	50	0.13	0	50	0.13
	Atlantic white-sided dolphin [e]	93,233	0	1	0.00	0	45	0.05	1	173	0.19	0	1	0.00	0	1	0.00
	Common dolphin [f]	172,974	0	46	0.03	0	130	0.08	0	203	0.12	0	46	0.03	0	46	0.03
	Bottlenose dolphin, coastal [c]	6,639	0	56	0.84	0	678	10.21	0	70	1.05	0	56	0.84	0	56	0.84
	Bottlenose dolphin, offshore	62,851	0	112	0.18	0	622	0.99	0	3529	5.61	0	112	0.18	0	112	0.18
	Risso's dolphin [c,d,e]	35,215	0	15	0.04	1	75	0.22	1	45	0.13	0	15	0.04	0	15	0.04
	Long-finned pilot whale [c,d,e]	39,215	0	10	0.03	0	50	0.13	0	30	0.08	0	10	0.03	0	10	0.03
	Short-finned pilot whale [c,d,e]	28,924	0	3	0.01	0	15	0.05	0	9	0.03	0	3	0.01	0	3	0.01
	Sperm whale [b,c,e]	4,349	0	0	0.00	0	4	0.09	0	2	0.05	0	0	0.00	0	0	0.00
HF	Harbor porpoise	95,543	0	12	0.01	6	129	0.14	13	52	0.07	0	12	0.01	0	12	0.01
PPW	Gray seal	27,300	0	20	0.07	1	203	0.75	2	115	0.43	0	20	0.07	0	20	0.07
	Harbor seal	61,336	0	45	0.07	2	456	0.75	8	259	0.44	0	45	0.07	0	45	0.07

[a] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken annually, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Level B take estimate for impact pile driving rounded up to one average group size; impact pile driving scheduled to occur during Year 2 and Year 3.
[d] Level B take estimate for HRG surveys rounded up to one group size; HRG surveys occur during all 5 years.
[e] Level B take estimate for cofferdam vibratory piling rounded up to one group size; cofferdam installation/removal to occur during Year 2.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.
[g] Years 1–5 are expected to be in 2025–2029.

Table 46. Summary of total Level A and Level B takes for all activities conducted during construction of Atlantic Shores – Project 2 plus Overlap.

Species		Stock size	5 year total		
			Level A	Level B	Max % [a]
LF	Fin whale [b]	6,802	4	20	0.35
	Minke whale	21,968	17	173	0.86
	Humpback whale	1,396	4	17	1.50
	North Atlantic right whale [b]	338	0	12	3.55
	Sei whale [b]	6,292	1	14	0.24
MF	Atlantic spotted dolphin [d]	39,921	0	550	1.38
	Atlantic white-sided dolphin	93,233	1	221	0.24
	Common dolphin [f]	172,974	0	470	0.27
	Bottlenose dolphin, coastal	6,639	0	916	13.80
	Bottlenose dolphin, offshore	62,851	0	4486	7.14
	Risso's dolphin [d]	35,215	1	165	0.47
	Long-finned pilot whale [d]	39,215	0	110	0.28
	Short-finned pilot whale [d]	28,924	0	33	0.11
	Sperm whale [b]	4,349	0	6	0.14
HF	Harbor porpoise	95,543	18	216	0.24
PPW	Gray seal	27,300	3	377	1.39
	Harbor seal	61,336	9	849	1.40

[a] Max percent is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken over the 5-year duration of the LOA, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.
[b] Listed as Endangered under the ESA.
[c] Level B take estimate for impact pile driving rounded up to one average group size.
[d] Level B take estimate for HRG surveys rounded up to one group size.
[e] Level B take estimate for cofferdam vibratory piling rounded up to one group size; cofferdam installation/removal to occur during Year 2.
[f] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of HRG survey or pile driving days.

6. Alternate Take Estimates for Impact Pile Driving Using Construction Schedules 1 and 3

6.1. Full Buildout

6.1.1. Alternate Exposure Estimates – Impact Pile Driving

Table A-3. Construction Schedule 1, year 1 – Full Buildout: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale [d] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale [d]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-4. Construction Schedule 1, year 2 – Full Buildout: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	5.97	3.66	2.26	0.99	0.05	<0.01	0	0	11.18	8.11	6.53	5.13	9.84	6.68	5.17	3.78
	Minke whale	57.17	22.71	8.06	1.61	0.10	<0.01	0	0	164.01	124.11	101.23	79.52	121.43	88.69	70.51	53.90
	Humpback whale	5.87	3.27	1.74	0.62	0.04	<0.01	0	0	11.93	8.39	6.46	4.76	9.40	6.57	5.04	3.67
	North Atlantic right whale [d] (migrating)	0.55	0.22	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.59	1.13	0.87	0.66	3.03	2.37	1.97	1.56
	Sei whale [d]	0.67	0.41	0.25	0.11	<0.01	<0.01	0	0	1.29	0.94	0.75	0.59	1.13	0.77	0.60	0.44
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	210.78	154.97	124.34	95.66	91.81	62.88	47.06	29.71
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	9.20	2.54	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	697.16	343.93	40.43	0	320.47	150.84	93.93	44.58
	Bottlenose dolphin, offshore	1.76	0	0	0	1.83	0	0	0	4573.44	3326.01	2579.55	1825.49	1933.89	1261.28	899.35	581.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.98	5.11	4.12	3.15	3.03	2.08	1.57	1.01
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	9.07	3.21	1.06	0.32	4.62	2.01	1.00	0.23	44.68	32.62	26.39	20.06	118.22	89.26	72.93	55.55
PPW	Gray seal	8.48	2.21	0.45	0.16	0.30	0	0	0	137.98	92.30	67.38	50.29	86.63	54.98	41.51	28.23
	Harbor seal	25.32	4.97	1.13	0.06	1.59	0.33	0	0	322.87	213.62	160.97	120.36	201.31	129.42	98.02	66.89

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-5. Construction Schedule 1, years 1 and 2 combined – Full Buildout: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	13.38	8.20	5.06	2.22	0.13	<0.01	0	0	25.25	18.32	14.76	11.60	22.21	15.09	11.69	8.54
	Minke whale	131.42	51.72	18.13	3.60	0.22	<0.01	0	0	382.56	289.91	236.61	186.27	283.48	207.28	164.82	126.06
	Humpback whale	13.28	7.40	3.93	1.40	0.09	0.02	0	0	27.26	19.20	14.79	10.91	21.48	15.03	11.54	8.39
	North Atlantic right whale [d] (migrating)	1.31	0.53	0.25	0.06	<0.01	<0.01	<0.01	<0.01	3.83	2.74	2.11	1.61	7.28	5.69	4.72	3.75
	Sei whale [d]	1.59	0.97	0.60	0.26	0.02	<0.01	0	0	3.07	2.23	1.80	1.41	2.70	1.83	1.43	1.04
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.04	0.02	0.02	0	0	0	0	0	481.01	354.22	284.27	219.12	207.45	142.02	106.26	67.06
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	20.89	5.62	1.35	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1529.64	758.06	90.75	0	688.91	325.24	201.49	95.76
	Bottlenose dolphin, offshore	3.52	0	0	0	4.10	0	0	0	10058.16	7324.04	5680.28	4025.82	4225.52	2751.77	1960.99	1267.89
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	16.39	12.02	9.70	7.42	7.08	4.86	3.67	2.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	24.89	8.38	2.45	0.69	13.44	5.84	2.93	0.67	128.86	94.18	76.24	57.97	338.56	255.23	208.32	158.48
PPW	Gray seal	19.84	5.00	0.97	0.39	0.75	0	0	0	339.18	227.19	165.80	123.78	212.32	134.77	101.67	69.23
	Harbor seal	59.96	11.21	2.42	0.12	3.97	0.82	0	0	793.88	525.63	396.48	296.64	493.43	317.29	240.26	164.17

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-6. Construction Schedule 3, year 1 – Full Buildout: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	13.01	7.72	4.67	2.03	0.11	0.01	0	0	23.53	17.53	14.36	11.35	20.31	13.92	10.93	8.11
	Minke whale	127.66	48.74	16.20	3.41	0.56	0.02	0	0	371.22	285.86	235.02	186.49	273.38	202.07	161.54	123.99
	Humpback whale	11.96	6.42	3.40	1.21	0.10	0.02	<0.01	<0.01	24.27	17.14	13.32	9.94	18.88	13.21	10.23	7.52
	North Atlantic right whale [d] (migrating)	1.24	0.52	0.24	0.06	<0.01	<0.01	<0.01	<0.01	3.57	2.56	2.00	1.50	6.61	5.19	4.36	3.47
	Sei whale [d]	1.44	0.86	0.52	0.22	0.01	<0.01	0	0	2.70	2.00	1.64	1.29	2.34	1.60	1.26	0.93
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	412.93	309.91	251.58	195.61	175.95	121.34	90.81	57.22
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	18.28	4.72	0.99	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	1459.21	745.16	80.00	0	654.84	321.84	195.58	96.95
	Bottlenose dolphin, offshore	3.52	0	0	0	2.48	1.62	1.62	0	9354.05	6799.51	5330.67	3920.78	3956.25	2666.46	1907.97	1196.28
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	14.12	10.53	8.58	6.69	6.16	4.28	3.25	2.11
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	25.79	7.38	2.11	0.54	13.74	5.54	2.55	0.68	136.99	101.33	81.88	62.80	336.58	256.56	210.94	163.28
PPW	Gray seal	17.15	3.64	0.60	0.21	1.01	0.09	0	0	322.34	217.39	161.06	118.79	196.20	126.68	96.20	65.28
	Harbor seal	53.73	9.70	1.91	0.28	4.19	0.82	0	0	751.38	502.70	378.76	279.21	456.17	296.70	224.52	153.13

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

6.1.2. Alternate Take Estimates - Impact Pile Driving

Table A-7. Level A and Level B Take estimates for impact pile driving – Construction Schedule 1, Full Buildout.

Species		Stock size	ITA request Year 2			ITA request Year 3			Total		
			Level A	Level B	Max. %[d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale[a]	6,802	3	9	0.18	3	7	0.15	6	15	0.31
	Minke whale	21,968	11	136	0.67	9	102	0.51	19	237	1.17
	Humpback whale	1,396	3	9	0.86	2	7	0.64	4	15	1.36
	North Atlantic right whale[a,b]	338	0	4	1.18	0	4	1.18	0	8	2.37
	Sei whale[a,b]	6,292	1	3	0.06	1	3	0.06	1	6	0.11
MF	Atlantic spotted dolphin[b]	39,921	0	100	0.25	0	100	0.25	0	200	0.50
	Atlantic white-sided dolphin	93,233	1	160	0.17	1	125	0.14	1	285	0.31
	Common dolphin[c]	172,974	0	193	0.11	0	157	0.09	0	349	0.20
	Bottlenose dolphin, coastal	6,639	0	51	0.77	0	41	0.62	0	91	1.37
	Bottlenose dolphin, offshore	62,851	0	3101	4.93	0	2580	4.10	0	5681	9.04
	Risso's dolphin[b]	35,215	1	30	0.09	1	30	0.09	1	60	0.17
	Long-finned pilot whale[b]	39,215	0	20	0.05	0	20	0.05	0	40	0.10
	Short-finned pilot whale[b]	28,924	0	6	0.02	0	6	0.02	0	12	0.04
	Sperm whale[a,b]	4,349	0	2	0.05	0	2	0.05	0	4	0.09
HF	Harbor porpoise	95,543	2	50	0.05	2	27	0.03	3	77	0.08
PPW	Gray seal	27,300	1	99	0.37	1	68	0.25	1	166	0.61
	Harbor seal	61,336	2	236	0.39	2	161	0.27	3	397	0.65

[a] Listed as Endangered under the ESA.
[b] Level B take estimate rounded up to one average group size for yearly take and to two average group sizes for total take estimates.
[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

Table A-8. Level A and Level B Take estimates for impact pile driving – Construction Schedule 3, Full Buildout.

Species		Stock size	ITA request Year 2			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	5	15	0.29	5	15	0.29
	Minke whale	21,968	17	236	1.15	17	236	1.15
	Humpback whale	1,396	4	14	1.29	4	14	1.29
	North Atlantic right whale [a,b]	338	0	4	1.18	0	4	1.18
	Sei whale [a,b]	6,292	1	3	0.06	1	3	0.06
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	100	0.25
	Atlantic white-sided dolphin	93,233	1	252	0.27	1	252	0.27
	Common dolphin [c]	172,974	0	228	0.13	0	228	0.13
	Bottlenose dolphin, coastal	6,639	0	80	1.21	0	80	1.21
	Bottlenose dolphin, offshore	62,851	2	5331	8.49	2	5331	8.49
	Risso's dolphin [b]	35,215	1	30	0.09	1	30	0.09
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	20	0.05
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	6	0.02
	Sperm whale [a,b]	4,349	0	2	0.05	0	2	0.05
HF	Harbor porpoise	95,543	3	82	0.09	3	82	0.09
PPW	Gray seal	27,300	1	162	0.60	1	162	0.60
	Harbor seal	61,336	2	379	0.62	2	379	0.62

[a] Listed as Endangered under the ESA.
[b] Level B take estimate rounded up to one average group size for yearly and total take estimates.
[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

6.2. Project 1 Plus Overlap

6.2.1. Alternate Exposure Estimates – Impact Pile Driving

Table A-11. Construction Schedule 1, year 1 – Project 1 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale [d] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale [d]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-12. Construction Schedule 1, year 2 – Project 1 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day. No exposures are attributed to Project 1 during year 2 because buildout of Project 1 is completed during year 1 of this schedule.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Humpback whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	North Atlantic right whale [d] (migrating)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sei whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PPW	Gray seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Harbor seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-13. Construction Schedule 1, years 1 and 2 combined – Project 1 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	7.41	4.54	2.80	1.22	0.07	<0.01	0	0	14.07	10.21	8.23	6.47	12.38	8.41	6.52	4.76
	Minke whale	74.25	29.02	10.07	1.99	0.12	<0.01	0	0	218.56	165.81	135.38	106.75	162.05	118.59	94.31	72.17
	Humpback whale	7.41	4.14	2.20	0.78	0.05	<0.01	0	0	15.33	10.81	8.33	6.15	12.08	8.46	6.49	4.73
	North Atlantic right whale [d] (migrating)	0.76	0.31	0.14	0.03	<0.01	<0.01	<0.01	<0.01	2.24	1.60	1.24	0.94	4.24	3.32	2.76	2.19
	Sei whale [d]	0.92	0.56	0.35	0.15	<0.01	<0.01	0	0	1.78	1.29	1.04	0.82	1.57	1.06	0.83	0.61
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	270.23	199.25	159.94	123.45	115.64	79.14	59.20	37.35
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.69	3.08	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	832.48	414.14	50.32	0	368.44	174.40	107.56	51.18
	Bottlenose dolphin, offshore	1.76	0	0	0	2.28	0	0	0	5484.72	3998.03	3100.73	2200.33	2291.63	1490.49	1061.63	686.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.42	6.91	5.58	4.27	4.04	2.78	2.10	1.34
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	15.81	5.17	1.38	0.37	8.82	3.84	1.93	0.44	84.18	61.55	49.85	37.91	220.33	165.97	135.39	102.93
PPW	Gray seal	11.35	2.79	0.52	0.23	0.44	0	0	0	201.20	134.89	98.42	73.49	125.68	79.79	60.16	41.00
	Harbor seal	34.64	6.24	1.29	0.06	2.38	0.49	0	0	471.01	312.01	235.51	176.27	292.12	187.87	142.24	97.28

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-14. Construction Schedule 3, year 1 – Project 1 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	9.14	5.42	3.28	1.43	0.08	<0.01	0	0	16.57	12.34	10.11	7.99	14.30	9.81	7.70	5.71
	Minke whale	112.30	42.85	14.23	2.99	0.48	0.02	0	0	327.21	251.95	207.12	164.38	241.03	178.15	142.40	109.31
	Humpback whale	7.39	3.96	2.10	0.75	0.06	<0.01	<0.01	<0.01	14.82	10.45	8.12	6.06	11.52	8.05	6.24	4.58
	North Atlantic right whale [d] (migrating)	0.70	0.29	0.13	0.03	<0.01	<0.01	<0.01	<0.01	2.00	1.43	1.12	0.84	3.69	2.90	2.44	1.94
	Sei whale [d]	0.91	0.54	0.33	0.14	<0.01	<0.01	0	0	1.69	1.25	1.02	0.81	1.46	1.00	0.79	0.58
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	281.73	211.10	171.42	132.96	121.99	84.21	63.05	39.75
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	12.92	3.42	0.81	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	758.59	388.98	42.66	0	333.28	164.36	99.34	49.34
	Bottlenose dolphin, offshore	1.75	0	0	0	1.40	0.86	0.86	0	5067.93	3688.24	2890.97	2127.78	2130.65	1433.67	1025.29	643.04
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.97	5.20	4.24	3.31	3.05	2.13	1.61	1.05
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	20.95	5.84	1.64	0.41	11.20	4.48	2.03	0.55	112.11	83.04	67.10	51.51	273.05	208.40	171.49	133.01
PPW	Gray seal	12.62	2.70	0.45	0.15	0.74	0.07	0	0	235.44	158.76	117.66	86.75	143.30	92.56	70.31	47.69
	Harbor seal	39.48	7.20	1.44	0.21	3.06	0.60	0	0	548.73	367.15	276.57	203.80	333.18	216.74	164.02	111.83

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

6.2.2. Alternate Take Estimates - Impact Pile Driving

Table A-15. Level A and Level B Take estimates for impact pile driving – Construction Schedule 1, Project 1 plus Overlap.

Species		Stock size	ITA request Year 2			ITA request Year 3			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	3	9	0.18	0	0	0.00	3	9	0.18
	Minke whale	21,968	11	136	0.67	0	0	0.00	11	136	0.67
	Humpback whale	1,396	3	9	0.86	0	0	0.00	3	9	0.86
	North Atlantic right whale [a,b]	338	0	4	1.18	0	0	0.00	0	4	1.18
	Sei whale [a,b]	6,292	1	3	0.06	0	0	0.00	1	3	0.06
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	0	0.00	0	100	0.25
	Atlantic white-sided dolphin	93,233	1	160	0.17	0	0	0.00	1	160	0.17
	Common dolphin [c]	172,974	0	193	0.11	0	0	0.00	0	193	0.11
	Bottlenose dolphin, coastal	6,639	0	51	0.77	0	0	0.00	0	51	0.77
	Bottlenose dolphin, offshore	62,851	0	3101	4.93	0	0	0.00	0	3101	4.93
	Risso's dolphin [b]	35,215	1	30	0.09	0	0	0.00	1	30	0.09
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	0	0.00	0	20	0.05
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	0	0.00	0	6	0.02
	Sperm whale [a,b]	4,349	0	2	0.05	0	0	0.00	0	2	0.05
HF	Harbor porpoise	95,543	2	50	0.05	0	0	0.00	2	50	0.05
PPW	Gray seal	27,300	1	99	0.37	0	0	0.00	1	99	0.37
	Harbor seal	61,336	2	236	0.39	0	0	0.00	2	236	0.39

[a] Listed as Endangered under the ESA.
[b] Year 2 and total Level B take estimates rounded up to one average group size. Project 1 is expected to be installed completely during Year 2.
[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

Table A-16. Level A and Level B Take estimates for impact pile driving – Construction Schedule 3, Project 1 plus Overlap.

Species		Stock size	ITA request Year 2			Total		
			Level A	Level B	Max. %[d]	Level A	Level B	Max. %
LF	Fin whale[a]	6,802	4	11	0.22	4	11	0.22
	Minke whale	21,968	15	208	1.02	15	208	1.02
	Humpback whale	1,396	3	9	0.86	3	9	0.86
	North Atlantic right whale[a,b]	338	0	4	1.18	0	4	1.18
	Sei whale[a,b]	6,292	1	3	0.06	1	3	0.06
MF	Atlantic spotted dolphin[b]	39,921	0	100	0.25	0	100	0.25
	Atlantic white-sided dolphin	93,233	1	172	0.19	1	172	0.19
	Common dolphin[c]	172,974	0	128	0.07	0	128	0.07
	Bottlenose dolphin, coastal	6,639	0	43	0.65	0	43	0.65
	Bottlenose dolphin, offshore	62,851	1	2891	4.60	1	2891	4.60
	Risso's dolphin[b]	35,215	1	30	0.09	1	30	0.09
	Long-finned pilot whale[b]	39,215	0	20	0.05	0	20	0.05
	Short-finned pilot whale[b]	28,924	0	6	0.02	0	6	0.02
	Sperm whale[a,b]	4,349	0	2	0.05	0	2	0.05
HF	Harbor porpoise	95,543	3	68	0.07	3	68	0.07
PPW	Gray seal	27,300	1	118	0.44	1	118	0.44
	Harbor seal	61,336	2	277	0.45	2	277	0.45

[a] Listed as Endangered under the ESA.
[b] Yearly and total Level B take estimates rounded up to one average group size.
[c] Take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

6.3. Project 2 Plus Overlap

6.3.1. Alternate Exposure Estimates – Impact Pile Driving

Table A-19. Construction Schedule 1, year 1 – Project 2 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	0.37	0.23	0.14	0.06	<0.01	0	0	0	0.74	0.54	0.43	0.34	0.65	0.44	0.34	0.25
	Minke whale	0.52	0.19	0.06	0.01	<0.01	0	0	0	1.66	1.27	1.04	0.83	1.24	0.91	0.72	0.56
	Humpback whale	0.77	0.43	0.23	0.08	<0.01	<0.01	0	0	1.70	1.21	0.93	0.69	1.34	0.95	0.73	0.53
	North Atlantic right whale [d] (migrating)	0.16	0.06	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.49	0.36	0.27	0.21	0.92	0.72	0.60	0.48
	Sei whale [d]	0.19	0.12	0.07	0.03	<0.01	0	0	0	0.39	0.28	0.23	0.18	0.34	0.23	0.18	0.13
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	24.93	18.57	14.93	11.65	9.99	6.82	5.09	3.20
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	2.10	0.46	0	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	35.55	18.45	2.60	0	12.60	6.19	3.58	1.74
	Bottlenose dolphin, offshore	0	0	0	0	0.12	0	0	0	252.52	186.22	144.42	103.87	99.13	63.52	44.97	29.10
	Risso's dolphin	0	0	0	0	0	0	0	0	2.88	2.12	1.71	1.31	1.19	0.82	0.62	0.39
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	3.24	0.94	0.15	0.03	2.01	0.88	0.44	0.10	18.96	13.89	11.26	8.57	49.02	36.83	29.99	22.75
PPW	Gray seal	1.51	0.30	0.04	0.04	0.08	0	0	0	33.28	22.43	16.34	12.21	20.56	13.06	9.81	6.72
	Harbor seal	4.91	0.67	0.08	0	0.42	0.08	0	0	77.98	51.80	39.24	29.43	47.80	30.77	23.28	16.00

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-20. Construction Schedule 1, year 2 – Project 2 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	5.97	3.66	2.26	0.99	0.05	<0.01	0	0	11.18	8.11	6.53	5.13	9.84	6.68	5.17	3.78
	Minke whale	57.17	22.71	8.06	1.61	0.10	<0.01	0	0	164.01	124.11	101.23	79.52	121.43	88.69	70.51	53.90
	Humpback whale	5.87	3.27	1.74	0.62	0.04	<0.01	0	0	11.93	8.39	6.46	4.76	9.40	6.57	5.04	3.67
	North Atlantic right whale [d] (migrating)	0.55	0.22	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.59	1.13	0.87	0.66	3.03	2.37	1.97	1.56
	Sei whale [d]	0.67	0.41	0.25	0.11	<0.01	<0.01	0	0	1.29	0.94	0.75	0.59	1.13	0.77	0.60	0.44
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	210.78	154.97	124.34	95.66	91.81	62.88	47.06	29.71
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	9.20	2.54	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	697.16	343.93	40.43	0	320.47	150.84	93.93	44.58
	Bottlenose dolphin, offshore	1.76	0	0	0	1.83	0	0	0	4573.44	3326.01	2579.55	1825.49	1933.89	1261.28	899.35	581.44
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	6.98	5.11	4.12	3.15	3.03	2.08	1.57	1.01
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	9.07	3.21	1.06	0.32	4.62	2.01	1.00	0.23	44.68	32.62	26.39	20.06	118.22	89.26	72.93	55.55
PPW	Gray seal	8.48	2.21	0.45	0.16	0.30	0	0	0	137.98	92.30	67.38	50.29	86.63	54.98	41.51	28.23
	Harbor seal	25.32	4.97	1.13	0.06	1.59	0.33	0	0	322.87	213.62	160.97	120.36	201.31	129.42	98.02	66.89

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-21. Construction Schedule 1, years 1 and 2 combined – Project 2 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	6.34	3.88	2.40	1.05	0.06	<0.01	0	0	11.92	8.65	6.97	5.47	10.49	7.13	5.51	4.03
	Minke whale	57.69	22.90	8.12	1.62	0.10	<0.01	0	0	165.67	125.38	102.27	80.35	122.66	89.60	71.23	54.45
	Humpback whale	6.64	3.70	1.97	0.70	0.04	<0.01	0	0	13.63	9.60	7.40	5.45	10.74	7.51	5.77	4.20
	North Atlantic right whale [d] (migrating)	0.71	0.29	0.13	0.03	<0.01	<0.01	<0.01	<0.01	2.08	1.49	1.15	0.87	3.95	3.09	2.57	2.04
	Sei whale [d]	0.86	0.53	0.33	0.14	<0.01	<0.01	0	0	1.68	1.22	0.98	0.77	1.47	1.00	0.78	0.57
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	0.02	0.01	0.01	0	0	0	0	0	235.71	173.53	139.26	107.31	101.80	69.70	52.15	32.91
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	11.30	3.00	0.67	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	732.72	362.37	43.03	0	333.07	157.03	97.51	46.31
	Bottlenose dolphin, offshore	1.76	0	0	0	1.95	0	0	0	4825.96	3512.23	2723.97	1929.36	2033.02	1324.80	944.32	610.54
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	9.85	7.23	5.84	4.47	4.22	2.90	2.19	1.40
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	12.31	4.15	1.22	0.34	6.64	2.89	1.44	0.33	63.64	46.51	37.65	28.63	167.24	126.09	102.91	78.29
PPW	Gray seal	9.99	2.52	0.49	0.20	0.38	0	0	0	171.26	114.72	83.72	62.50	107.19	68.04	51.33	34.95
	Harbor seal	30.23	5.64	1.22	0.06	2.01	0.41	0	0	400.85	265.41	200.21	149.80	249.12	160.19	121.30	82.89

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

Table A-22. Construction Schedule 3, year 1 – Project 2 plus Overlap: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction Schedule 1 assumes all WTGs and the met tower are installed on 15 m monopile foundations at a rate of one installation per day, and all OSSs are installed on jacket foundations. OSS jacket foundations use twenty-four 5 m pin piles and pin piles are installed at a rate of 4 pin piles per day.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB) [c]								Attenuation (dB) [c]							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale [d]	4.05	2.40	1.45	0.63	0.03	<0.01	0	0	7.31	5.45	4.46	3.53	6.30	4.32	3.39	2.52
	Minke whale	16.00	6.13	2.05	0.44	0.08	<0.01	0	0	46.00	35.46	29.17	23.13	33.82	25.02	20.01	15.36
	Humpback whale	4.62	2.49	1.32	0.46	0.04	<0.01	<0.01	<0.01	9.55	6.76	5.25	3.93	7.43	5.21	4.03	2.97
	North Atlantic right whale [d] (migrating)	0.56	0.23	0.11	0.03	<0.01	<0.01	<0.01	<0.01	1.61	1.16	0.90	0.68	2.98	2.34	1.96	1.57
	Sei whale [d]	0.54	0.32	0.20	0.08	<0.01	<0.01	0	0	1.02	0.76	0.62	0.49	0.88	0.60	0.48	0.35
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic white-sided dolphin	<0.01	<0.01	<0.01	0	0	0	0	0	131.38	98.94	80.26	62.73	54.03	37.18	27.79	17.49
	Common dolphin	0	0	0	0	0	0	0	0	0	0	0	0	5.55	1.34	0.18	0
	Bottlenose dolphin, coastal	0	0	0	0	0	0	0	0	738.40	376.44	39.96	0	334.62	164.26	100.05	49.57
	Bottlenose dolphin, offshore	1.77	0	0	0	1.18	0.80	0.80	0	4536.56	3295.82	2584.39	1901.05	1924.10	1298.28	929.25	582.35
	Risso's dolphin	<0.01	<0.01	<0.01	0	<0.01	0	0	0	7.35	5.48	4.46	3.48	3.18	2.21	1.68	1.09
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale [d]	0	0	0	0	0	0	0	0	0	0	0	0	<0.01	0	0	0
HF	Harbor porpoise (sensitive)	4.93	1.57	0.48	0.13	2.60	1.09	0.52	0.13	25.46	18.72	15.13	11.56	64.86	49.18	40.30	30.93
PPW	Gray seal	4.56	0.95	0.15	0.06	0.27	0.02	0	0	87.69	59.16	43.79	32.32	53.36	34.43	26.13	17.74
	Harbor seal	14.36	2.52	0.48	0.07	1.14	0.22	0	0	204.46	136.78	103.11	76.08	124.06	80.66	61.03	41.66

[a] NOAA (2005).
[b] Wood et al. (2012).
[c] Different levels of broadband sound attenuation are shown for comparison; Atlantic Shores is committing to a sound level attenuation of 10 dB.
[d] Listed as Endangered under the ESA.

6.3.2. Alternate Take Estimates - Impact Pile Driving

Table A-23. Level A and Level B Take estimates for impact pile driving – Construction Schedule 1, Project 2 plus overlap.

Species		Stock size	ITA request Year 2			ITA request Year 3			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	1	2	0.04	3	7	0.15	3	7	0.15
	Minke whale	21,968	1	2	0.01	9	102	0.51	9	103	0.51
	Humpback whale	1,396	1	2	0.21	2	7	0.64	2	8	0.72
	North Atlantic right whale [a,b]	338	0	4	1.18	0	4	1.18	0	8	2.37
	Sei whale [a,b]	6,292	1	3	0.06	1	3	0.06	1	6	0.11
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	100	0.25	0	200	0.50
	Atlantic white-sided dolphin	93,233	0	22	0.02	1	125	0.14	1	140	0.15
	Common dolphin [c]	172,974	0	10	0.01	0	157	0.09	0	166	0.10
	Bottlenose dolphin, coastal	6,639	0	14	0.21	0	41	0.62	0	44	0.66
	Bottlenose dolphin, offshore	62,851	0	145	0.23	0	2580	4.10	0	2724	4.33
	Risso's dolphin [b]	35,215	0	30	0.09	1	30	0.09	1	60	0.17
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	20	0.05	0	40	0.10
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	6	0.02	0	12	0.04
	Sperm whale [a,b]	4,349	0	2	0.05	0	2	0.05	0	4	0.09
HF	Harbor porpoise	95,543	1	12	0.01	2	27	0.03	2	38	0.04
PPW	Gray seal	27,300	1	17	0.07	1	68	0.25	1	84	0.31
	Harbor seal	61,336	1	40	0.07	2	161	0.27	2	201	0.33

[a] Listed as Endangered under the ESA.

[b] Level B take estimates rounded up to one average group size for Year 3 and to two average group sizes for total take estimates. For Year 2 take, because of the limited amount of pile driving, Level B takes for all species except minke whales, offshore bottlenose dolphins, harbor porpoise, and seals were estimated as zero. As a conservative measure, Level B takes for these species were rounded up to one average group size.

[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.

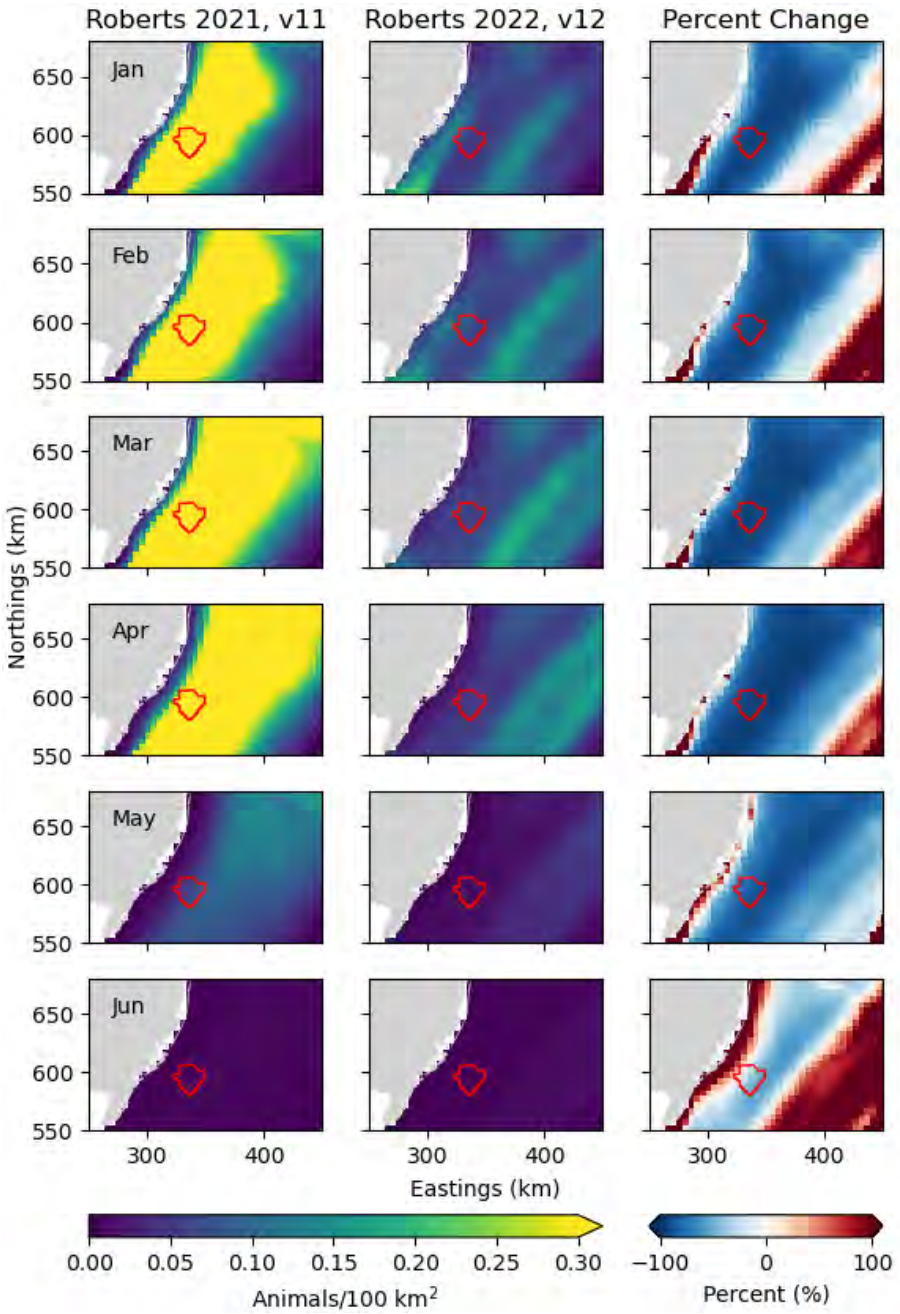
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

Table A-24. Level A and Level B Take estimates for impact pile driving – Construction Schedule 3, Project 2 plus Overlap.

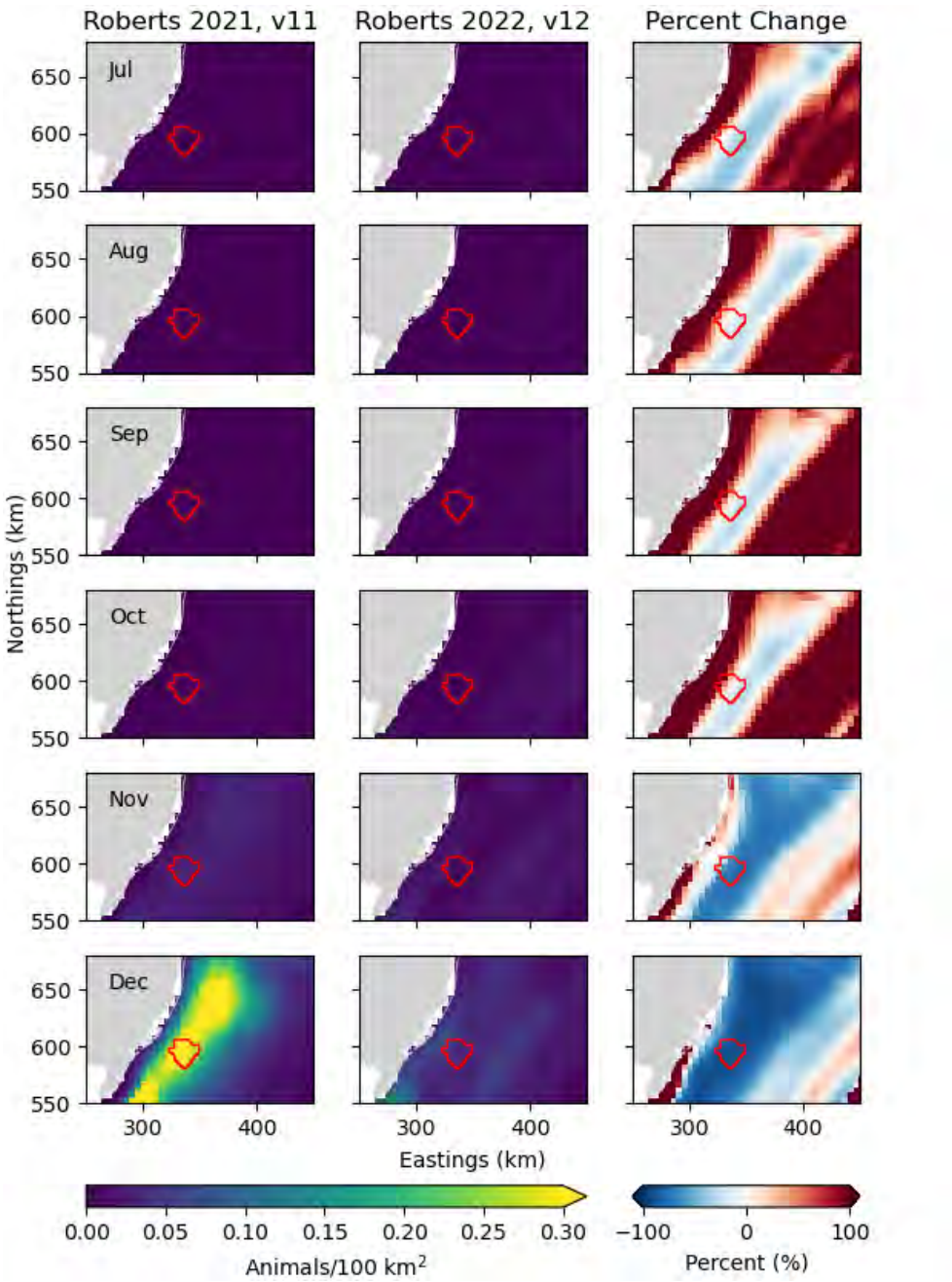
Species		Stock size	ITA request Year 2			Total		
			Level A	Level B	Max. % [d]	Level A	Level B	Max. %
LF	Fin whale [a]	6,802	2	5	0.10	2	5	0.10
	Minke whale	21,968	3	30	0.15	3	30	0.15
	Humpback whale	1,396	2	6	0.57	2	6	0.57
	North Atlantic right whale [a,b]	338	0	4	1.18	0	4	1.18
	Sei whale [a,b]	6,292	1	3	0.06	1	3	0.06
MF	Atlantic spotted dolphin [b]	39,921	0	100	0.25	0	100	0.25
	Atlantic white-sided dolphin	93,233	1	81	0.09	1	81	0.09
	Common dolphin [c]	172,974	0	107	0.06	0	107	0.06
	Bottlenose dolphin, coastal	6,639	0	40	0.60	0	40	0.60
	Bottlenose dolphin, offshore	62,851	1	2585	4.11	1	2585	4.11
	Risso's dolphin [b]	35,215	1	30	0.09	1	30	0.09
	Long-finned pilot whale [b]	39,215	0	20	0.05	0	20	0.05
	Short-finned pilot whale [b]	28,924	0	6	0.02	0	6	0.02
	Sperm whale [a,b]	4,349	0	2	0.05	0	2	0.05
HF	Harbor porpoise	95,543	1	16	0.02	1	16	0.02
PPW	Gray seal	27,300	1	44	0.16	1	44	0.16
	Harbor seal	61,336	1	104	0.17	1	104	0.17

[a] Listed as Endangered under the ESA.
[b] Level B take estimate rounded up to one average group size for yearly take estimates.
[c] Level B take estimate for common dolphins is the daily sighting rate from site characterization surveys multiplied by the number of pile driving days.
[d] Max % is the maximum percentage of the species' stock from NMFS 2022 draft SARs (NOAA Fisheries 2023) that could be taken, calculated as Level A take plus Level B take divided by stock size, multiplied by 100.

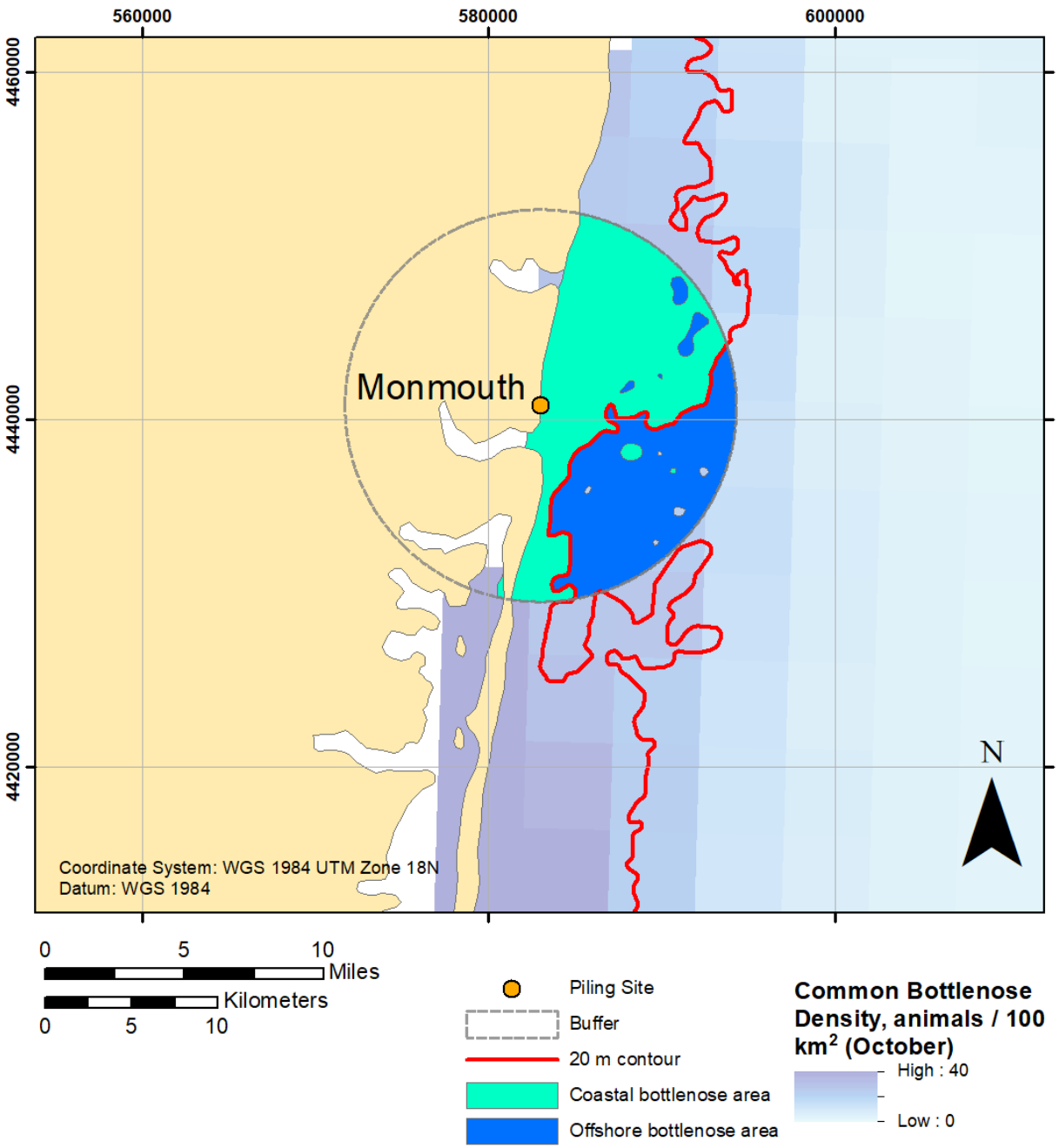
7. Supplemental Figures



Supplemental Figure 1. North Atlantic right whale (NARW) density changes, January through June. Shown are monthly densities for NARWs for January through June in the vicinity of the Atlantic Shores South lease area from the Roberts et al. (2021a, 2021b) right whale model (version 11, left panel) and the Roberts et al. (2022) right whale model (version 12, middle panel). The panel on the right shows the percent change when updating from the 2021 to the 2022 model.



Supplemental Figure 2. North Atlantic right whale (NARW) density changes, July through December. Shown are monthly densities for NARWs for July through December in the vicinity of the Atlantic Shores South lease area from the Roberts et al. (2021a, 2021b) right whale model (version 11, left panel) and the Roberts et al. (2022) right whale model (version 12, middle panel). The panel on the right shows the percent change when updating from the 2021 to the 2022 model.



Supplemental Figure 3. Map showing areas used to calculate density and the zone of influence for the coastal and offshore bottlenose dolphin stocks, used to estimate exposures for vibratory piling for cofferdam installation and removal.

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