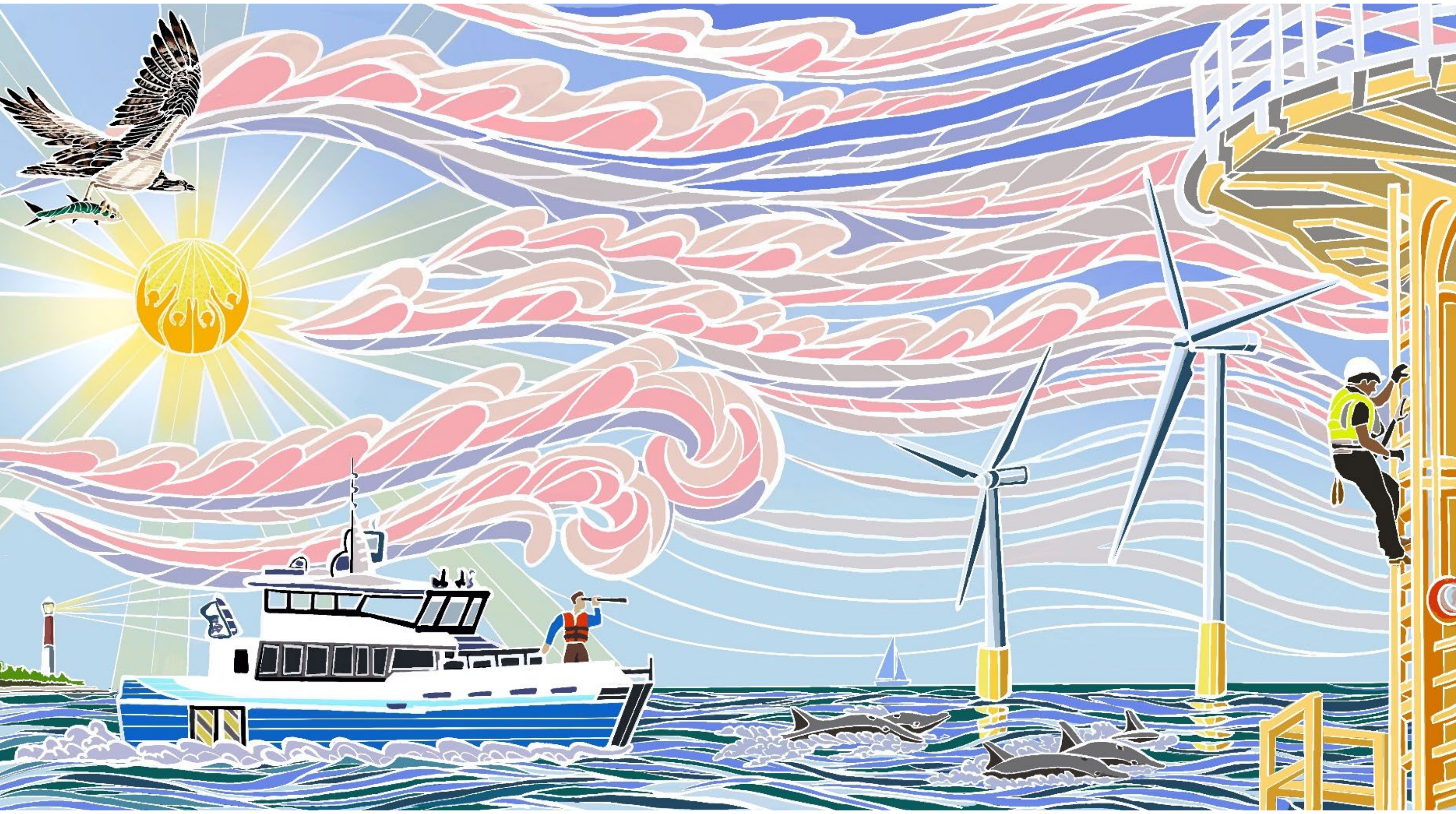

Appendix II-L

Hydroacoustic Modeling Report

March 2024

Underwater Acoustic Assessment of Pile Driving and Related Sound-Producing Construction Activities at the Atlantic Shores Offshore Wind North Project, BOEM Lease Area OCS-A-0549

Prepared For:

Atlantic Shores Offshore Wind

Version 2.3
December 8 , 2023

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Research – Operations – Engineering – Design - Analysis

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ACRONYMS AND ABBREVIATIONS

°	degrees
ρ	density of a medium
λ	lambda (wavelength)
µPa	microPascal(s)
3D	three-dimensional
AIM	Acoustic Integration Model©
Atlantic Shores	Atlantic Shores Offshore Wind, LLC
BOEM	Bureau of Ocean Energy Management
c	speed of sound in a medium
cc	cubic centimeters
C	Celsius (Centigrade)
CPA	closest point of approach
CRM	Coastal Relief Model
dB	decibel(s)
DP	dynamic positioning
DPS	distinct population segment
EFH	essential fish habitat
ESA	Endangered Species Act
F	Fahrenheit
g	gram(s)
GARFO	Greater Atlantic Regional Fisheries Office (NOAA Fisheries)
GPa	gigaPascal(s)
hr	hour(s)
HFC	high-frequency cetaceans
HRG	high resolution geophysical
Hz	Hertz
kHz	kiloHertz
kJ	kiloJoule(s)
km	kilometer(s)

kph	kilometers per hour
I	acoustic intensity
L_E	sound exposure level (same as SEL)
$L_{E,24h}$	cumulative sound exposure level over a 24-hour period
$L_{E,cum}$	cumulative sound exposure level
$L_{E,ss}$	single strike sound exposure level
$L_{p,rms}$	root-mean-square sound pressure level
L_{pk}	peak sound pressure level
LF	low frequency
LFC	low-frequency cetaceans
L_p	sound pressure level (same as SPL)
MAI	Marine Acoustics, Inc.
MFC	mid-frequency cetaceans
MGEL	Marine Geospatial Ecology Laboratory (Duke University)
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
MSFCMA	Magnuson-Stevens Fishery Conservation Management Act
MW	megawatt(s)
m^3	cubic meters
m	meter(s)
ms	millisecond(s)
N	Number of Samples (Sample Size)
NARW	North Atlantic right whale(s)
NJWEA	New Jersey Wind Energy Area
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSPE	Navy Standard Parabolic Equation
OCS	outer continental shelf
OSS	offshore substation
OW	otariid pinnipeds in water
p	pressure

p_o	reference pressure
p(t)	squared sound pressure time series
PE	parabolic equation
PTS	permanent threshold shift
PW	phocid pinnipeds in water
RAM	range-dependent acoustic model
RL	received level
RMS	root-mean-square
s	second(s)
SD	standard deviation
SEL	sound exposure level (same as L_E)
SL	source level
SPL	sound pressure level
spp.	species
SVP	sound velocity profile
t	time
T	time interval
TL	transmission loss
TOL	third-octave level
TTS	temporary threshold shift
TU	Sea turtle
U.S.	United States of America
WEA	wind energy areas
WTG	wind turbine generator
ZOI	zone of influence

1 INTRODUCTION

Atlantic Shores Offshore Wind, LLC (Atlantic Shores) is a 50/50 joint venture between EDF-RE Offshore Development, LLC (an indirect, wholly owned subsidiary of EDF Renewables, Inc. [EDF Renewables]) and Shell New Energies US LLC (Shell). Atlantic Shores has submitted a Construction and Operations Plan (COP) to the Bureau of Ocean Energy Management (BOEM) for the development of offshore wind energy generation known as the Atlantic Shores North Project (the Project) within the Lease Area OCS-A 0549 (Lease Area). The purpose of the Project is to develop offshore wind energy generation facilities within BOEM Lease Area OCS-A 0549 to provide clean, renewable energy to the Northeastern U.S. by the mid-to-late 2020s.

Atlantic Shores' proposed offshore wind energy generation facilities will be located in Lease Area OCS-A 0549, which is 81,129 acres (328.3 square kilometers [km^2]) in area (Figure 1). Lease Area OCS-A 0549 is located north of and is adjacent to Atlantic Shores' Lease Area OCS-A 0499. At its closest point, the Lease Area is approximately 8.4 miles (mi) (13.5 kilometers [km]) from the New Jersey coast and approximately 60 mi (96.6 km) from the New York State coast. Multiple proposed landfall sites where the cables from the offshore wind farm come to shore have been proposed along the New Jersey and New York shorelines (Figure 2).

The construction and operation of the Project has the potential to cause acoustic harassment to marine species, in particular marine mammals, sea turtles, and fish populations. Marine Acoustics, Inc. (MAI) was contracted by Atlantic Shores to model and assess the sources of underwater noise generated during the construction and installation of the Project and the effect of sound attenuation methods as a means of mitigation. The objective of this modeling study was to predict the ranges to acoustic thresholds of marine mammals, sea turtles, and fish and the potential injury and behavioral acoustic exposures of marine mammals and sea turtles during construction of the Project. This report includes information relevant to the assessment of specific noise-producing construction related activities and their potential to affect protected marine animals that may occur in the Project area.

1.1 PROJECT SUMMARY

Atlantic Shores' Lease Area is located on the Outer Continental Shelf (OCS) within the New Jersey Wind Energy Area (NJWEA), which was identified by BOEM as suitable for offshore renewable energy development through a multi-year, public environmental review process. Atlantic Shores' proposed offshore wind energy generation facilities will be located in Lease Area OCS-A 0549. Lease Area OCS-A 0549 is located north of and is adjacent to Atlantic Shores' Lease Area OCS-A 0499. The construction activities covered in this report include impact pile driving of monopiles and pin piles for jackets within the lease area and of conductor barrel piles at nearshore locations as well as vibratory pile driving of sheet piles for cofferdams and steel piles for goal posts at nearshore locations. The lease area is located in federal waters of the Atlantic Ocean that range in depth from 20.2 to 29.7 meters (m).

ASOW may potentially install up to 157 wind turbine generators (WTGs), eight offshore substations (OSSs) (three large, four medium, or eight small OSSs), and one Meteorological Tower (Met Tower) within the OCS0-A-0549 Lease Area over a two-year construction period. ASOW is also considering installing up to six cofferdams at nearshore landing sites in New

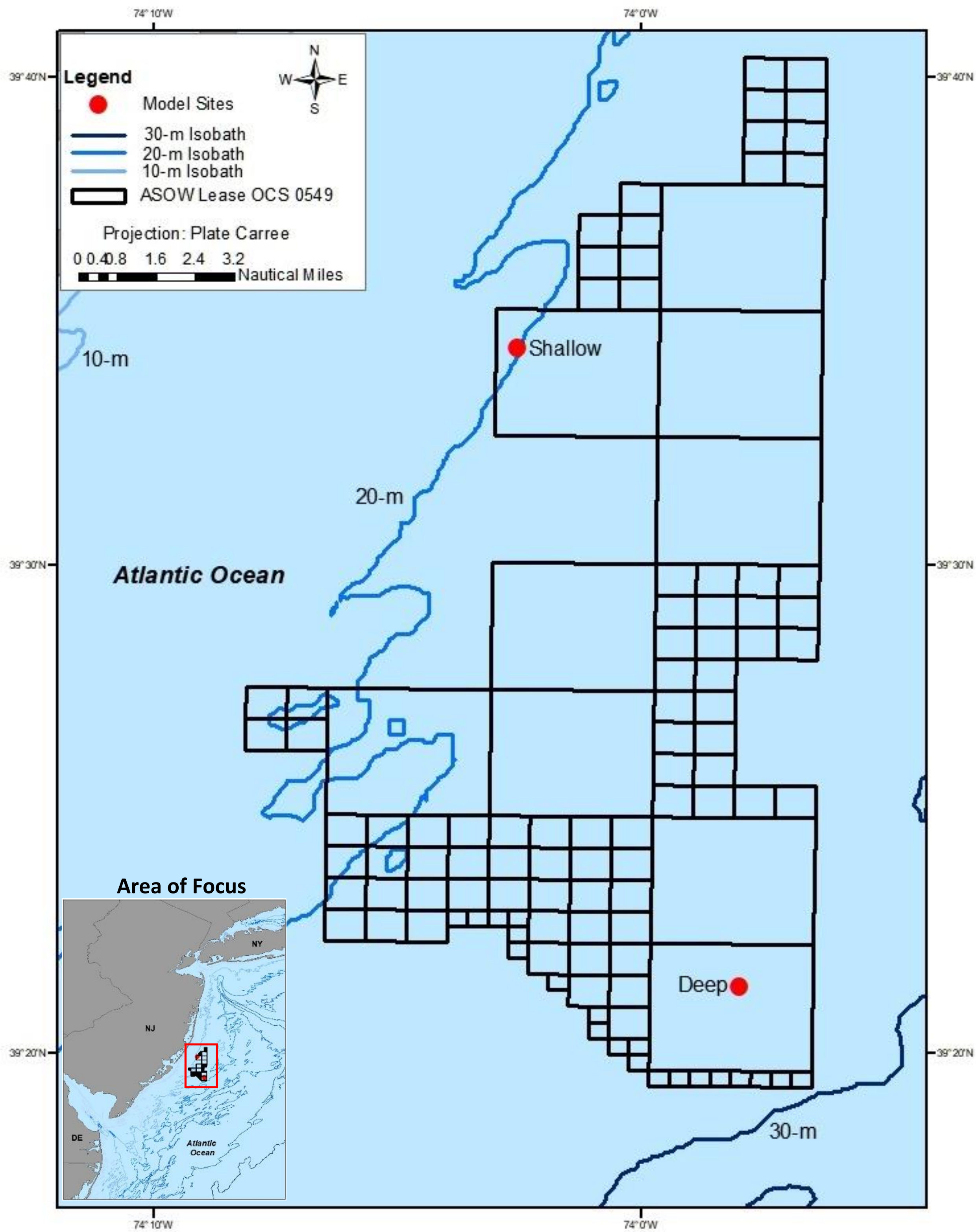

Figure 1. BOEM Lease Area OCS-A-0549 for the Atlantic Shores North Project.

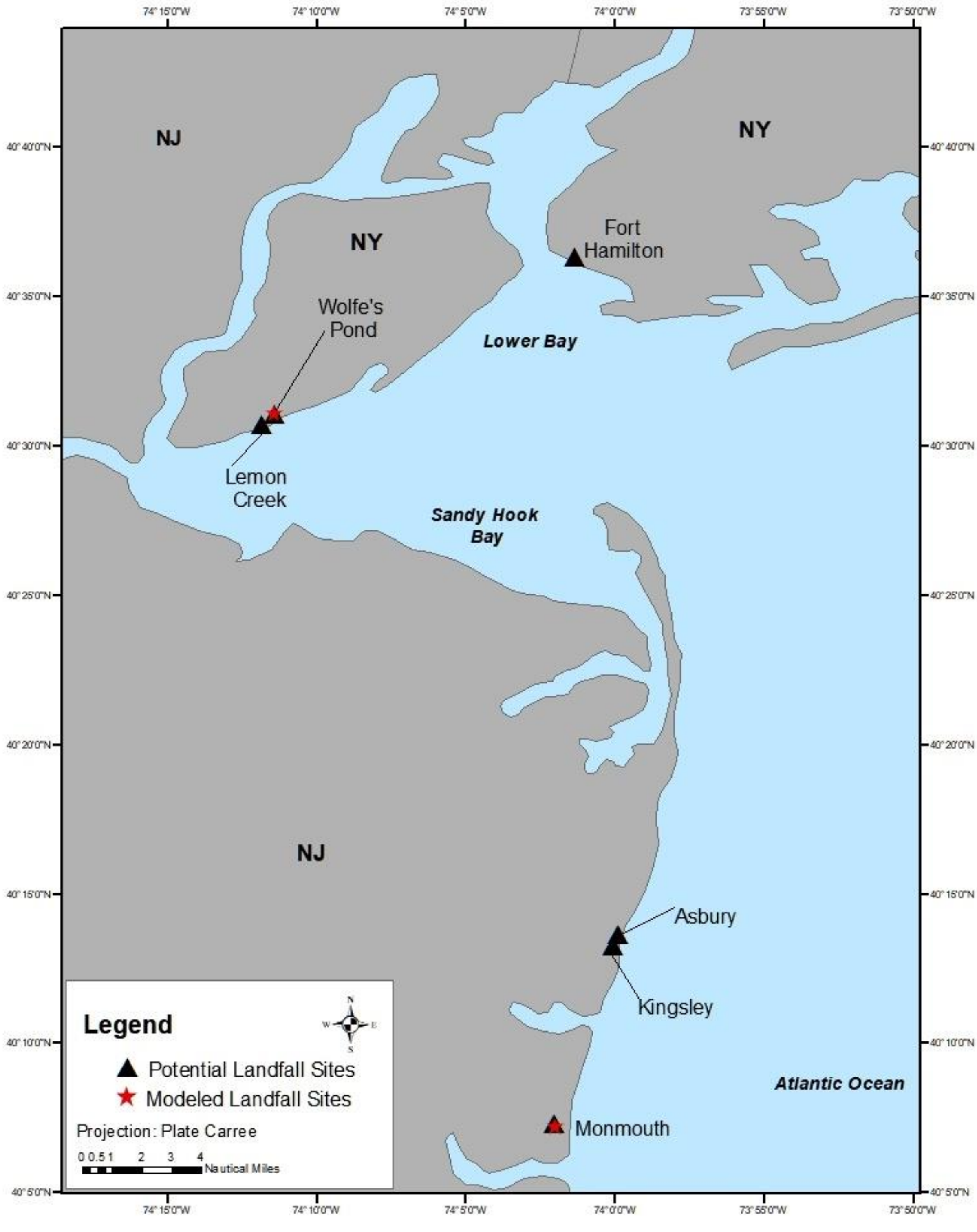

Figure 2. Potential Nearshore Landfall and Model along the New Jersey and New York Shoreline for Cofferdam, Conductor Barrel, and Goal Post Installations and Removals for the Atlantic Shores North Project

Jersey and/or New York where export cable lines come ashore. Three of the landfall sites identified for the cofferdam installation are in New Jersey while three additional landfall sites for the cofferdam installation are in New York (Figure 2).

As an alternative to cofferdam installation, ASOW is considering installing up to 11 conductor barrels and associated goal post structures at nearshore landing sites in New Jersey and/or New York where export cable lines come ashore. The conductor barrels and goal posts would be installed at the same New York and New Jersey landfall locations considered for the cofferdam installation (Figure 2).

The WTGs, OSSs, and Met Tower foundations will be installed by impact pile driving of either monopile and/or jacket pin piles. The maximum number of piles for the OSSs will be associated with the three-large OSS option, as each may require up to 24 piles, with three piles for each of the eight platform legs. Up to eight cofferdams are to be installed via vibratory pile driving, or up to 11 conductor barrels via impact pile driving and 11 goal posts via vibratory pile driving

Other potential noise-producing activities during the construction period of the Atlantic Shores North Project include high-resolution geophysical (HRG) surveys, and construction vessel support and transport. All these noise-producing activities also have the potential to affect marine species if the sound levels exceed the regulatory threshold criteria at which effects are recognized. Mitigation measures to lessen or abrogate potential effects on marine species are planned during the construction phase of the Project.

1.2 Modeling and Analysis Scope

The primary activities that are expected to generate underwater sound during the construction and installation of the proposed Project are impact and vibratory pile driving. The modeling and associated analysis included in this report focuses on impact and vibratory pile driving noise producing activities, including impact pile driving of 10-m and 15-m monopile foundations, 5-m pre- and post-piled piles for jacket foundations, or 1.54-m steel pipes for conductor barrels, as well as vibratory piling of sheet piles for cofferdams or 0.3-m steel pipes for goal posts.

Specific scenarios of impact and vibratory pile driving activities were modeled to assess the resulting unweighted and frequency-weighted broadband underwater acoustic fields. The acoustic ranges to physiological and behavioral auditory thresholds for marine mammals, fishes, and sea turtles were determined from these broadband sound fields. Animat modeling was performed to assess the resultant acoustic exposures of marine mammal and sea turtle species from impact pile driving sources in the Project area. Animat-based exposure ranges to the regulatory thresholds and acoustic exposures were estimated from the output of the animat modeling for impact pile driving. Acoustic exposures associated with vibratory pile driving for cofferdam or goal post installation and removal were determined using the acoustic ranges to physiological and behavioral auditory thresholds and calculating the ensonified areas to each threshold and factoring in the marine mammal densities. The appropriate regulatory thresholds described in Section 4 have been used as the basis from which to estimate acoustic exposures of marine mammals and sea turtles.

1.2.1 Monopile Foundations

For the Project, ASOW proposes to potentially install 10-m and 15-m monopiles by impact pile driving with a Menck 4400 hammer. The hammer ram mass of the Menck 4400 hammer is 220 tons. One monopile of either pile diameter is planned to be driven per day. Monopiles would potentially be used in the WTG and Met Tower foundations.

1.2.2 Piled Jacket Foundations

ASOW is proposing to install 5-m post-piled jacket piles for the foundations of the OSSs using a IHC S2500 hammer. The hammer ram mass of the IHC S2500 is 100 tons. Four post-piled jacket piles are planned to be driven per day. Instead of installing monopiles, ASOW may alternatively install 5-m pre-piled jacket piles as the foundations for the WTGs and Met Tower, using the same IHC S2500 hammer, and installing four pre-piled piles per day.

Although ASOW may install up to eight OSSs (three large, four medium, or eight small OSSs), modeling considered only the three large OSSs since installation of the large OSSs would include the largest number of pin piles and the greatest number of pile driving installation days, which together represent the maximum OSS installation scenario.

1.2.3 Cofferdams

ASOW is planning on installing ZZ46-700 sheet piles (width of 700 millimeters (mm) and varying lengths (14.3 m or 24.2 m)) at five potential cofferdam locations between New Jersey and New York (Figure 2) with vibratory pile driving using an APE 200T hammer. Two representative modeling locations have been selected for modeling of cofferdam installation, one per state, to capture the range of water depths and habitats at the potential installation locations, with one model site selected per state. The Monmouth location was modeled as the representative New Jersey location and the Wolfe's Pond location was modeled at the representative New York location (the Lemon Creek landfall location is adjacent to the Wolfe's Pond location).

1.2.4 Conductor Barrel and Goal Posts

ASOW is planning on installing 1.54-m diameter steel pipes as part of the conductor barrel at potential landfall locations in New Jersey and/or New York (Figure 2). The conductor barrel will be comprised of five 6.1-m sections of pipe to result in a total length of 30.5 m. The 1.54-m pipes will be installed on an angle of approximately 12° to the seafloor using a Grundoram Taurus pneumatic hammer. The conductor barrel is supported by a goal post structure comprised of two 0.3-m steel pipes installed vertically into the seafloor and an I-beam welded horizontally between the two vertical piles. The goal post 0.3-m steel pipes will be installed via vibratory pile driving using an APE 200T hammer.

Two representative modeling locations were selected for modeling of the conductor barrel and goal post installation, one per state, to capture the range of water depths and habitats at the potential installation locations, with one model site selected per state. The Monmouth location was modeled as the representative New Jersey location and the Wolfe's Pond location was modeled at the representative New York location (the Lemon Creek landfall location is adjacent to Wolfe's Pond location).

1.2.5 Planned Construction Schedule

ASOW is proposing two possible construction installation schedules for the wind turbine foundations, one schedule in which both monopiles and post- piled pin piles (for OSS jacket) are installed and a second schedule in which only pre- and post-piled pin piles are installed, both over a two-year construction installation period (Table 1). Regardless of the construction schedule selected, proposed pile driving construction activities are only being planned from May through December annually, although in Year 2, construction activities are planned to be completed by August. The same number of foundations (161 foundations) are proposed to be installed in either schedule (Table 1).

Under Schedule 1, in Year 1, ASOW estimates that a total of 107 (either 10-m and 15-m) monopiles and 48 (5-m) post-piled OSS jacket piles would be installed, for a total of 109 foundations; in Year 2, 51 monopiles and 24 post-piled OSS jacket piles would be installed with an associated total of 52 foundations installed (Table 1). The large OSSs may require up to 24 post-piled jacket piles per foundation, which is why the installation of 48 post-piles in Year 1 during June and August results in the installation of two foundations. In the Year 1 schedule, monopiles would be installed for the WTGs and Met Tower.

Year 1 of Schedule 2 includes the installation of 107 jacket foundations with 4 pre-piled 5-m pin piles per foundation and 48 5-m post-piled jacket piles, 24 per foundation, for a total of 109 foundations. In Year 2, 51 pre-piled jacket foundations and 24 post-piled piles would be installed for a total of 52 foundations (Table 1). The pre-piled piles would be the foundations for the WTGs and Met Tower while the post-piled piles would also be used for the OSS foundations.

Two potential installation schedules for cofferdams were also assessed. One schedule called for eight cofferdams to be installed at the New Jersey locations while the second schedule called for four cofferdams to be installed at the New Jersey locations and two to be installed at the New York locations. Two representative cofferdam modeling locations were used to represent a New York and a New Jersey location.

Cofferdam installation and extraction are conservatively expected to take two days per cofferdam, with approximately 55 sheet piles being installed per day at any of the locations. Up to six cofferdams will be installed and extracted, with up to four at a New Jersey nearshore location and two at a New York nearshore location. The installation of the cofferdams was modeled in the winter and extraction of the cofferdams was modeled in the spring, which resulted in 12 days of vibratory piling in both winter and spring. At the New Jersey cofferdam locations, each pile is estimated to take 119.1 seconds to install for a total of 109.2 minutes of installation per day. At the New York cofferdam locations, each pile is estimated to take 47.3 seconds to install for a total of 43.4 minutes of installation per day.

The installation schedule for the conductor barrel and goal posts called for eight conductor barrels/goal posts to be installed at the New Jersey locations and three conductor barrels/goal posts to be installed at the New York locations. Two representative modeling locations were used to represent a New York and a New Jersey location.

Table 1. Proposed Construction Schedules for the Two Years of Foundation Installations by Impact Pile Driving with the Construction Period Spanning May to December of Year 1 and May to August of Year 2.

Year	Month	*Construction Schedule 1*		*Construction Schedule 2*		Total Number Foundations
		Days Monopile Installation (1 Pile per Day)	*Days Post-piled Pin Pile OSS Jacket Installation (4 Piles per Day)*	*Days Pre-pile Jacket Pin Pile Installation (4 Piles/day)*	*Days Post-piled Pin Pile OSS Jacket Installation (4 Piles per Day)*	
Year 1	May	18		18		18
	June	10	6	10	6	11
	July	24		24		24
	August	9	6	9	6	10
	September	12		12		12
	October	14		14		14
	November	13		13		13
	December	7		7		7
Year 2	May	18		18		18
	June	10	6	10	6	11
	July	10		10		10
	August	13		13		13
	September					
	October					
	November					
	December					
Total		158	18	158	18	161

Conductor barrel installation and extraction were estimated to take one day per conductor barrel for a total of 10 hours per barrel. Goal post installation and extraction were estimated to take one day per goal post, with each goal post consisting of two 12-inch piles. Each pile would take 2 hours to install/extract, for a total of 4 hours per goal post. The installation of the conductor barrels and goal posts was modeled in the winter and extraction was modeled in the spring.

1.3 SECONDARY SOUND SOURCES DURING CONSTRUCTION

In addition to impact and vibratory pile driving, other construction related noise-producing activities include vessel traffic or presence and HRG survey activities. Noise effects associated with HRG surveys are covered in Section 7.2 of the COP, so no assessment nor information on HRG surveys is included herein. A qualitative assessment of vessel noise has been included.

During a typical construction workday for the Project, support, transport, and supply vessels related to Project construction will be operating in and about the lease area. Vessels will travel to and from the Lease Area for bunkering and provisioning and may remain at construction sites within the lease area for days or weeks at a time. The actual number of vessels will depend on the Project components' final design and construction schedule as well as compliance with

The Jones Act (U.S. Public Law 66-261)[1]. Intra- and interstate vessel transportation is regulated by The Jones Act, a U.S. Federal law that regulates maritime commerce and requires that vessels transporting cargo must be American made and operated and manned by a majority crew of U.S. citizens. Compliance with this Act may affect Project logistics, including the number of vessels available to operate on the Project at a given time.

Marine species in the Project area are expected to be already habituated to the presence, movements, and noise associated with routine ship traffic in the Project area. Sound produced by Project vessels would be similar to that produced by existing and ongoing vessel noise. The vessels operating within the lease area are expected to be slow-moving or stationary vessels; stationary vessels may operate their engines to maintain their position as required by their purpose.

Most of the underwater sound generated by ships is low frequency (LF) (<1,000 Hertz [Hz]), with most ship noise resulting from propeller cavitation that dominates the <200 Hz frequency range (Ross, 1976). The noise that ships produce results not only from the type of engine and propeller systems used but also from the speeds at which the ships travel. Generally, larger (>100 m), faster moving vessels generate more intense LF underwater sound than smaller, slower moving vessels or boats (Frankel and Gabriele, 2017; Southall et al., 2018). During activities for which ships must remain stationary or move very slowly, thrusters are typically used for dynamic positioning (DP), usually for relatively short durations. The type of sound and associated levels resulting from DP are similar to those generated by transiting vessels.

2 ACOUSTIC AND ANIMAT MODELING AND ANALYSIS METHODS

Both acoustic and animat modeling and analysis of the planned impact and vibratory pile driving sources were conducted for pile driving activities associated with the Project. This section describes the methodology, model inputs, model assumptions, and operational scenarios that were utilized for both types of modeling and associated analyses. Unless otherwise noted, pile driving operational information was supplied by Atlantic Shores.

2.1 MODELING AREA LOCATIONS

Two representative model locations within the Lease Area were selected for the modeling of the Project's impact pile driving scenarios (Figure 1). Since the seafloor, substrate, and water column characteristics across the lease area are relatively consistent, lease area bathymetry was the basis for selecting representative model locations. The seafloor of the lease area is relatively flat and slopes seaward (east) over the Lease Area from 20.2 to 29.7 m in water depth. Water depths within the lease area boundary at a 3-arc-second resolution were extracted and plotted as a histogram that depicted the 5th and 95th percentile water depths. The 5th percentile water depth, or 20.7 m, and the 95th percentile water depth, or 27.5 m, were selected as the shallow- and deep-water depths of the model sites, respectively. Two

1 The Jones Act is Section 27 of the Merchant Marine Act that provides for the promotion and maintenance of the U.S. merchant marine and specifically requires that goods transported by water between U.S. ports be carried in ships constructed in the U.S., fly the U.S. flag, are owned by U.S. citizens, and are crewed by U.S. citizens.

geographic points coinciding with these water depths in the northern and southern parts of the lease area were chosen (Table 2; Figure 1).

Table 2. Model Site Locations for Impact Pile Driving Within the Atlantic Shores Lease Area OCS-A-0549.

Modeling Site	*Water Depth (m)*	*Latitude (°N)*	*Longitude (°W)*
1 (Shallow)	20.7	39.5742	74.0425
2 (Deep)	27.5	39.3558	73.9667

Of Atlantic Shore's five possible cofferdam sites along the coasts of New Jersey and New York (Figure 2), one site in each state was selected for modeling of vibratory sheet pile installation of the cofferdams (Table 3). The Lemon Creek/ Wolfe's Pond location off southwestern Staten Island, NY was selected because it is representative of a shallow location, and the Monmouth, NJ site was selected because of its location in deeper water. The two model sites are thus representative of the possible range in water depths and coastal environmental conditions of Atlantic Shore's possible cofferdam locations in New York and New Jersey. These same modeling locations were used for the conductor barrel and goal post modeling.

Table 3. Landfall Model Site Locations of Cofferdams, Conductor Barrels, and Goal Posts for the Atlantic Shores North Project.

Modeling Site	*Water Depth (m)*	*Latitude (°N)*	*Longitude (°W)*
Monmouth (NJ)	12.3	40.114	74.023
Wolfe's Pond (NY)	4.9	40.511	74.180

2.2 Modeling Scenarios

Seven modeling and analysis scenarios (Table 4) were selected to represent the scope of the impact and vibratory pile driving operations for the Project, representing the planned installation of three types of structures: WTGs, OSSs, and the Met Tower at two model locations within the Lease Area. Modeling all four possible impact pile driving operational scenarios allows ASOW maximum operational flexibility. The cofferdam scenario assessed the installation and removal of cofferdams by vibratory pile driving at two model sites, one each located off the shoreline of New Jersey and New York (Table 3). The conductor barrel scenario assessed the installation and removal of conductor barrels by impact pile driving and the goal post scenario assessed the installation and removal of the goal posts by vibratory pile driving.

Two monopile diameters (10-m and 15-m) were modeled and both would be impact driven using the Menck 4400 hammer. For monopile Scenarios 1 and 2, only one monopile is planned to be driven per day. The monopiles would be installed for the WTG and Met Tower foundations.

Table 4. Impact and Vibratory Pile Driving Model Scenarios for the Atlantic Shores North Project.

Scenario Description	*Foundation Type*	*Pile Diameter (m) or Length/ Width (m)*	*Maximum Hammer Energy (kJ or kN)*	*Hammer Make/ Model*	*Modeling Locations*
Scenario 1: Monopile—Impact Pile Driving: 1 Pile Per Day	Monopile	10	3066	Menck 4400	Shallow (20.7 m): 39.5742°N, 74.0425°W Deep (27.5 m): 39.3558°N, 73.9667°W
Scenario 2: Monopile—Impact Pile Driving: 1 Pile Per Day	Monopile	15	3015	Menck 4400	
Scenario 3: Piled Jacket Foundation—Impact Pile Driving: 4 Piles Per Day	Pre-Piled Pin Pile	5	1904	IHC S2500	
Scenario 4: OSS Jacket Foundation—Impact Pile Driving: 4 Piles Per Day	Post-Piled Pin Pile	5	1904	IHC S2500	
Scenario 5: Cofferdams—Vibratory Pile Driving: 55 Sheet Piles Per Day	Sheet Piles (ZZ46-700)	14.3, 24.2/ 0.7	2.13 kN	APE 200T	Monmouth, NJ: 41.114°N, 74.023°W Lemon Creek/ Wolfe's Pond NY: 40.511°N, 74.180°W
Scenario 6: Conductor Barrel Installation and Removal—Impact Pile Driving: 1 Conductor Barrel Structure Per Day	Steel Pile	1.5	18 kJ	Grundoram Taurus	
Scenario 7: Goal Post Installation and Removal—Vibratory Pile Driving: 1 Goal Post Structure Per Day	Steel Pile	0.3	2.13 kN	APE 200T	

Two pin pile scenarios were modeled, one for 5-m pre-piled and one for 5-m post-piled jacket foundations (Table 2). The 5-m pre- or post-piled pin piles would be impact driven using the IHCS 2500 hammer. For either pin pile scenario, four piles would be driven per day. The post-piled Scenario 4 would be used to install the OSS foundation while the pre-piled Scenario 3 could be used to install the WTG or Met Tower foundations.

Cofferdams are planned to be installed via vibratory pile driving at multiple locations along the New Jersey and New York coastline (Figure 2). Two representative modeling locations were selected for modeling of cofferdam sheet pile installation to capture the range of water depths and habitats at the potential installation locations, with one model site selected each in nearshore New Jersey (NJ) and New York (NY) states. The ZZ46-700 sheet piles, which are 700 mm wide, and 24.2 m (NY sites) and 14.3 m (NJ sites) long will be driven to a penetration depth of 10 m by vibratory piling using an APE 200T hammer (Table 4).

The conductor barrel and goal posts will be installed as an alternative to the cofferdams, so the modeling locations were the same as those used for the cofferdams (Table 3). The conductor barrel will be installed via impact pile driving. The goal post, which will be installed via vibratory pile driving, is a support structure for the conductor barrel.

2.3 Acoustic Modeling

For acoustic propagation modeling, information related to the spectral characteristics of the acoustic sources and various environmental parameters are necessary. Where available, direct measurements were used in the modeling. When direct measurements were not available, proxies or databases were utilized to provide the best representative input into the modeling. The acoustic model inputs are described in this section, along with the modeling and analysis approach used for the ASOW North Project.

2.3.1 2.3.1 Impact Pile Driving Source Characteristics

2.3.1.1 Monopile and Pin Pile Spectra for Foundations

Representative source spectra for use in the acoustic propagation modeling of the planned monopiles and pin piles for the Atlantic Shores North Project were based on spectra derived and modeled by JASCO Applied Sciences for the Atlantic Shores North Project (Weirathmueller et al., 2022). The JASCO modeled source spectra were the most comparable spectral inputs available for the Project and were generated by JASCO using a combination of the GRLWEAP 2010 wave equation model and their Pile Driving Source Model (Weirathmueller et al., 2022). The parameters used in JASCO's modeling were evaluated against the current planned Atlantic Shores North Project parameters to evaluate the use of the JASCO modeled spectra as a proxy for the Project's impact pile driving source spectra (Table 5).

The JASCO modeling effort used similar pile diameters and the same hammer makes and models at similar strike energies as the MAI modeling effort for the Project. JASCO modeled spectra at two modeling locations near the Project area with water depths of 19 m and 28.1 m. MAI's modeling was performed at different modeling sites to ensure the sites are within the lease area; however, the water depth differences between the MAI and JASCO modeling sites are considered negligible.

To derive representative spectra for the monopile and pin piles in the Project, MAI scaled the JASCO-generated model results using the relationships presented in von Pein et al. (2022). This method of scaling is a practical approach to estimate spectra of impact driven piles based on differences in strike energy, pile diameter, water depth, and hammer ram weight. The scaling

Table 5. Modeling Parameters From JASCO's Modeling and MAI's Proposed Modeling of Impact Pile Driving Sources for the Atlantic Shores North Project.

Modeler	*Pile Type*	*Pile Size / Diameter (m)*	*Modeled Hammer*	*Maximum Strike Energy Modeled (kJ)*	*Water Depth at Modeling Locations (m)*
JASCO	Monopile	12	MENCK 4400	4,400	19 and 28.1 (one site outside Lease Area boundary and one within Lease Area OCS-A 0499))
	Monopile	15	MENCK 4400	4,400	
	Pre-and Post-Piled Pin Pile	5	IHC S2500	2,500	
MAI	Monopile	10	MENCK 4400	3,066	20.7 and 27.5
	Monopile	15	MENCK 4400	3,015	
	Pre-and Post-Piled Pin Pile	5	IHC S2500	1,904	

does not account for differences in sediment properties or hammer configurations apart from the ram weight. However, discrepancies due to these parameters can be minimized by scaling from spectra with similar soil parameters and hammer configurations. MAI chose to use JASCO's modeled spectra in the scaling due to the similarities with the Project in terms of sediment properties, water depths, pile diameters, hammer types, and proximity of the modeling locations.

- **Monopile Spectra**

The 10-m and 15-m monopiles planned for installation during the Project will be impact driven using the Menck 4400 hammer. Although the maximum hammer energy of the Menck 4400 hammer is 4,400 kiloJoules (kJ), the pile installation is expected to be achieved using the lower energy levels of 1,291, 1,937, 2,581, and 3,066 kJ for the 10-m monopile, and 1,260, 1,897, 2,536, and 3,015 kJ for the 15-m monopile. Thus, these are the hammer energy levels used in acoustic modeling.

Modeled spectra for the 12- and 15-m monopiles at a maximum strike energy of 4,400 kJ using the same Menck 4400 hammer were extracted from JASCO's modeling report for Atlantic Shores North (Weirathmueller et al., 2022) (Table 5). To represent the 15-m diameter monopile for the Project, the JASCO modeled spectrum of the 15-m monopile was scaled down using the energy scaling presented in von Pein et al. (2022) to represent the strike energies of 1,260, 1,897, 2,536, and 3,015 kJ being used in the Project. To represent the 10-m diameter monopile at 1,291, 1,937, 2,581, and 3,066 kJ planned for use on the Project, the JASCO modeled spectrum of the 12-m monopile was scaled down to represent the smaller diameter monopile to be used in the Project and the lower hammer energy levels (von Pein et al., 2022). The resulting spectra used in this modeling effort are shown in Figure 3.

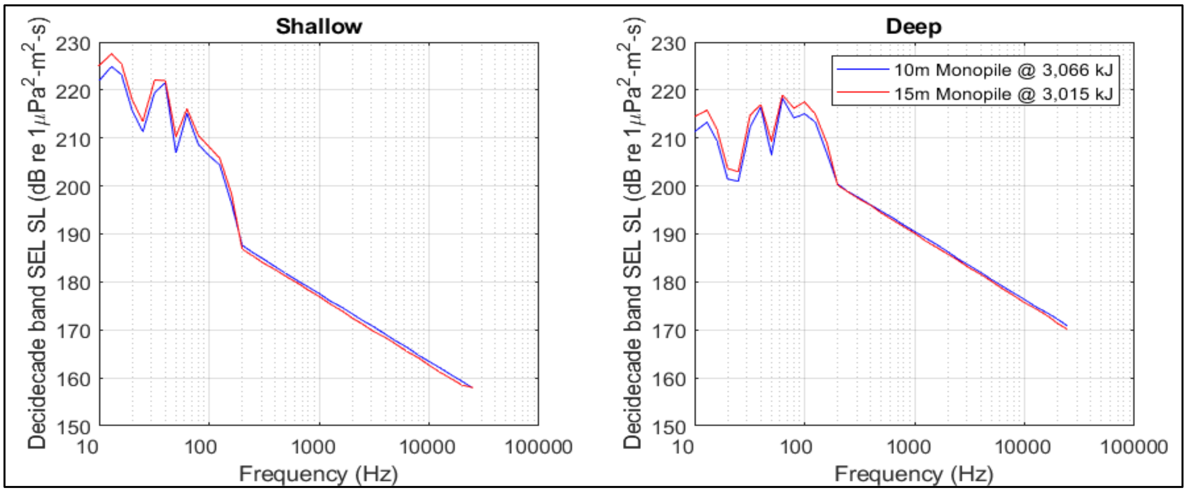

Figure 3. Decidecade band Sound Energy Level (SEL) Source Levels for 10-m (blue) and 15-m (Red) Diameter Monopiles at a Strike Energies of 3,066 and 3,015 kJ, respectively, at the modeling locations for the Atlantic Shores North Project.

- **Pin Pile Spectra**

The 5-m pre- and post-piled pin piles planned for the Project will be impact driven at a maximum strike energy of 1,904 kJ using the IHC S2500 hammer. The modeled spectra for the 5-m pre-piled pin piles at a maximum strike energy of 2,500 kJ using the same IHC S2500 hammer were extracted from JASCO's modeling report (Weirathmueller et al., 2022).

To represent the 5-m diameter pre-piled pin pile at 1,904 kJ for the Project (Figure 4), the JASCO modeled spectrum of the 5-m pin pile was scaled down to represent the lower strike energy using the von Pein et al. (2022) scaling for hammer energy. For the spectrum of the post-piled 5-m piles, the received levels will be increased by 2 dB from JASCO's pre-piled pin pile spectrum (Bellmann et al., 2020).

2.3.1.1 2.3.1.2 Conductor Barrel Spectrum

Four measured spectra from CalTrans (2020) were considered as proxies for modeling of the impact pile driving installation of conductor barrels at the Wolfe's Pond and Monmouth locations. These measurements were chosen as proxies due to similarities between the pile sizes and water depths between the measurements and the conductor barrel planned for the ASOW project. One of the measured spectra was for impact-driven installation of a 1.01 m diameter steel pipe in 13 m water depth with a Delmag D80 hammer. The other three measured spectra were from three 2.4 m (inner) diameter piles in 10 m water depth using a Menck MHU1700T impact hammer. The four spectra included frequencies up to ~5 kiloHertz (kHz) and were averaged to create a single proxy spectrum in decidecade bands. For frequencies greater than those available in the measurements described here, a 6 dB/octave falloff was assumed (ITAP (2020)). The average spectrum described above was scaled to a broadband source level of SEL SL 209 dB re 1 μPa^2 m^2 s, which was determined via the relationship with diameter from ITAP (2020), after scaling the relationship from a range of 750

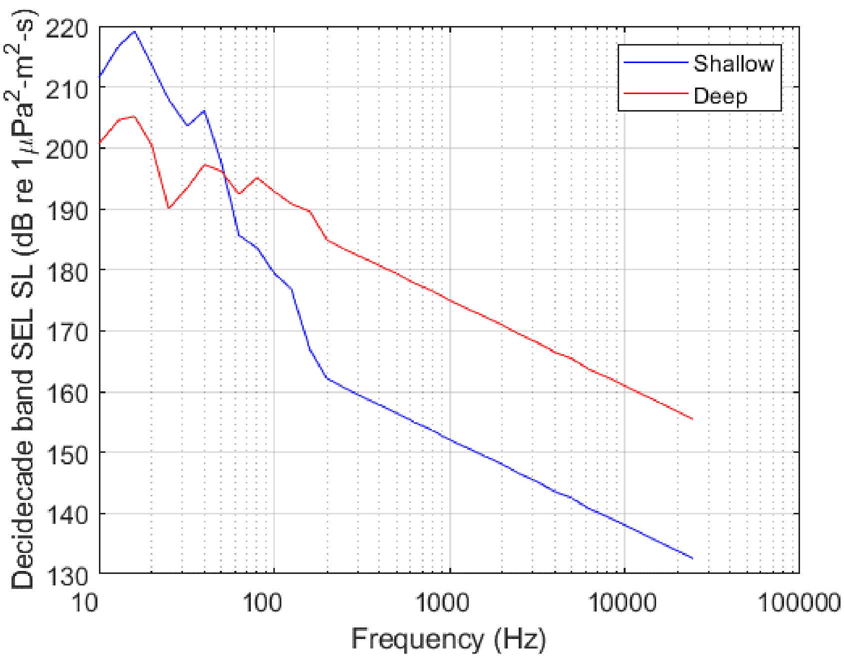

Figure 4. Decidecade Band Sound Energy Level (SEL) Source Levels for the 5-m Diameter Pre-Piled Pin Pile at a Hammer Strike Energy of 1,904 kJ for the Atlantic Shores North Project at the two modeling locations.

m to a range of 1 m with a 15 x $\log_{10}$ (range) assumption. This scaled spectrum was used as a representative spectrum for the modeling of the conductor barrel for the Atlantic Shores North Project (Figure 5).

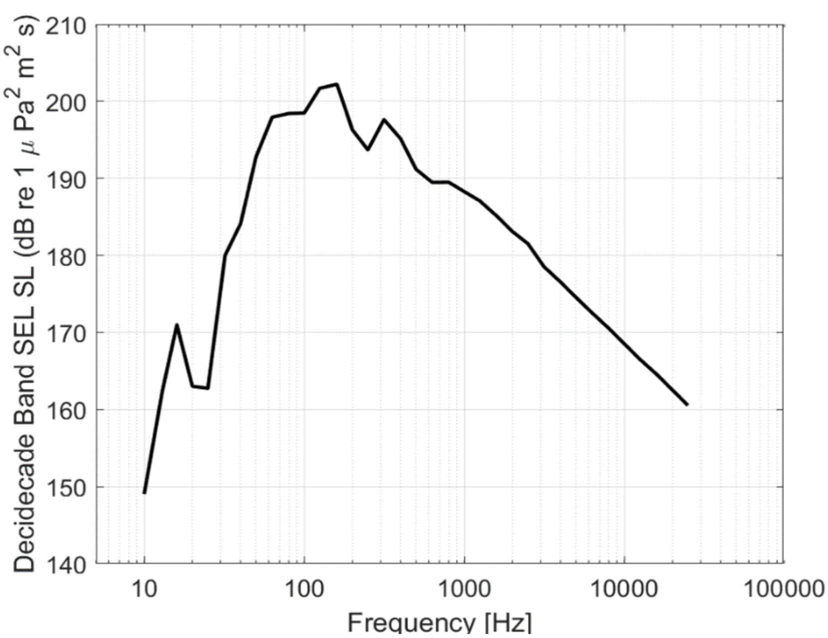

Figure 5. Decidecade Band Sound Energy Level (SEL) Source Levels for the 1.5-m Diameter Pile as Part of the Conductor Barrel for the Atlantic Shores North Project.

2.3.2 2.3.2 Vibratory Pile Driving Source Characteristics

2.3.2.1 Cofferdam SpectrumA representative spectrum was derived for use in the acoustic modeling of sheet piles installed via vibratory pile driving as part of cofferdam installation based on measurements presented in Illingworth and Rodkin (2017). The sheet piles proposed for the Project are ZZ46-700 piles with an expected width of 700 mm, which will be driven to a final penetration depth of 10 m using an APE 200T hammer.

Illingworth and Rodkin (2017) presented underwater acoustic measurements of 1.22 m sheet piles (comprised of four individual 30.5-centimeter pieces) installed via vibratory pile driving using an APE 300 hammer with an eccentric moment of 66.25 kilogram meter (kg-m) near Naval Station Mayport in Jacksonville, FL. One-second broadband RMS SPL sound levels were averaged at distances varying between 8 to 12 m, with an overall average RMS SPL level of 153 dB re 1 µPa for 1-second normalized to a range of 10 m based on average attenuation rates. Given the 10-m normalization, Illingworth and Rodkin (2017) concluded that the average transmission loss (TL) could be described by the relationship 13* $\log_{10}$(r2/r1), which was used to scale the spectrum to 1 m. This scaling resulted in the broadband level of 170 dB re 1 µPa m.

A representative spectrum for the Atlantic Shores vibratory pile driving of the cofferdams was derived using the Illingworth and Rodkin (2017) measured spectrum and transmission loss relationship. The measured spectrum at a 10 m range was corrected to a range of 1 m using the estimated transmission loss (13*$\log_{10}$(range)) to determine a representative source spectrum to use for the Project (Figure 6). The resulting broadband source level ($L_{p,rms}$) is 170 dB re 1 µPa m.

2.3.2.1 2.3.2.2 Goal Post Spectrum

A representative spectrum was derived for use in the acoustic modeling of 12-inch piles installed via vibratory pile driving as part of goal post installation based on measurements presented in Illingworth & Rodkin, Inc (2020). Measurements that were made during vibratory installation of two 20-inch diameter steel piles were presented in Illingworth & Rodkin, Inc. (2020). The approximate water depth for the installation location for the 20-inch piles was 6 m, which is similar to the water depths at the modeled locations of Wolfe's Pond and Monmouth. The hammer make and model were not provided in the Illingworth and Rodkin (2020) report. Median third-octave band spectral levels for each of the two pile installations (Figures B-2 and B-3 of Illingworth and Rodkin [2020]) were scaled to a matching broadband level and then averaged to create a proxy source spectrum for vibratory installation of the goal posts.

The broadband source level was determined by using the proxy spectrum and scaling it by the relationship between diameter and broadband level from Remmers andBellmann (2021), after scaling the relationship from a range of 750 m to a range of 1 m with a 15 x $\log_{10}$ (range) assumption. The average spectrum for the 20-inch piles was scaled to a broadband level of SPL

SL 184 dB re 1 µPa m. This scaled spectrum was used as a representative spectrum for the modeling of the goal posts barrel for the Atlantic Shores North Project (Figure 7).

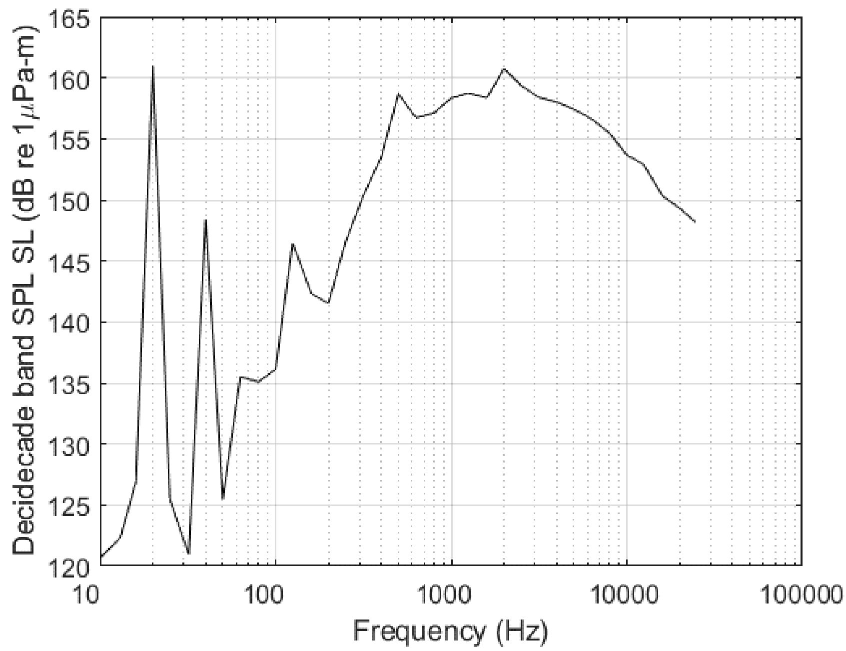

Figure 6. Decidecade Band Sound Pressure Level (SPL) Source Levels for the Cofferdam Sheet Piles Being Installed/Removed by Vibratory Pile Driving on the Atlantic Shores North Project.

2.3.3 Acoustic Propagation Modeling Inputs

Environmental parameters relevant to the model sites and lease area are a necessary input for the modeling of the acoustic source propagation. Described in this section are the environmental parameter inputs for the acoustic modeling of the impact pile driving sources.

2.3.3.1 Bathymetry

Bathymetric data for the Project area were obtained from the Coastal Relief Model (NOAA-NGDC, 1999) at a spatial resolution of 3 arc-seconds (approximately 90 m). The bathymetry data were extracted along radials in 10° increments emanating from each model location to the maximum modeled range, which for the Atlantic Shores Project is 150 km; the maximum modeled range can vary with season (month) and geographic location. The bathymetric data were extracted in range intervals of 25 m.

2.3.3.2 Sediment Characteristics and Geoacoustic Model

The geoacoustic parameters used in the acoustic modeling of the impact pile driving sources were derived from the geotechnical parameters of boring logs from within the Project lease area (Fugro USA Marine, 2022). Seafloor sediments of the Project lease area are characterized by alternating layers of sand and clay, with sand on the top of the seabed. The measured bulk

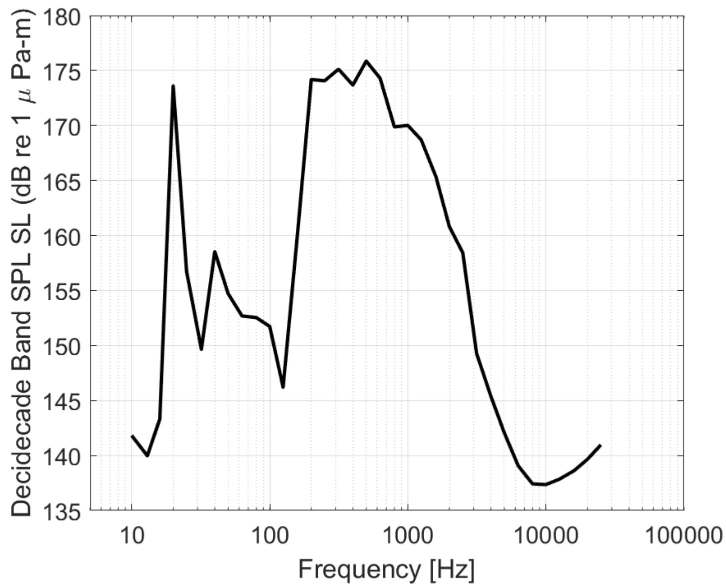

Figure 7. Decidecade Band Sound Pressure Level (SPL) Source Levels for the 0.3 m Diameter Piles Being Installed by Vibratory Pile Driving as Part of the Goal Post Installation/Removal on the Atlantic Shores North Project.

density and grain sizes at varying depths were extracted from Fugro USA Marine (2022) and a regression line was fit to these data.

The regression lines for grain size and density were used as inputs to the Buckingham (2005) geoacoustic model that was used to estimate the compressional wave velocity, attenuation, and the shear wave attenuation (Table 6) for the Project area. The shear wave velocity was calculated using the power law formula from Jensen et al. (2011) (Table 6).

The geoacoustic parameters used in the acoustic modeling of the cofferdams were representative of a sandy bottom. The sediment information was provided to MAI by Atlantic Shores, and MAI used the values and power law formula from Jensen et al. (2011) for sand to derive the geoacoustic model.

2.3.3.3 Sound Velocity Profile

For the impact pile driving modeling, sound velocity profiles (SVPs) for each month from May to December for each of the shallow and deep modeling sites were extracted from the GDEM-V 3.0 database (Carnes, 2009) (Figure 8). Based on a sensitivity study of the SVPs, three representative months were selected for modeling of the two model sites. The SVPs were grouped to roughly approximate seasons (summer: May to August; fall: September to November; and winter: December) according to similarity in the propagation loss versus range and water depth. For each of the approximate season groups, the most conservative month (i.e., the month in which the propagation loss increased most slowly in range) was selected. The

Table 6. Geoacoustic Model Output Used in the Acoustic Modeling for the Atlantic Shores North Project.

Water Depth (m)	*Compressional Velocity (m/s)*	*Compressional Attenuation (dB/wavelength)*	*Shear Velocity (m/s)*	*Shear Attenuation (dB/wavelength)*	*Density (g/cm³)*
0.1	1612	0.14	40	3.65	1.93
5	1704	0.51	130	3.65	1.94
10	1741	0.64	160	3.65	1.95
20	1789	0.80	197	3.65	1.97
30	1824	0.91	222	3.65	1.99
40	1854	1.00	242	3.65	2.01
50	1879	1.07	259	3.65	2.03
60	1902	1.13	273	3.65	2.05
70	1923	1.19	286	3.65	2.07
80	1942	1.24	298	3.65	2.09
90	1960	1.28	309	3.65	2.11
100	1977	1.32	318	3.65	2.13
110	1994	1.36	328	3.65	2.15
120	2009	1.39	336	3.65	2.17
130	2024	1.43	345	3.65	2.19
140	2039	1.46	352	3.65	2.21
150	2053	1.49	360	3.65	2.23

SVPs of these most conservative and representative months of May, October, and December were used in the acoustic propagation modeling for both the shallow and deep model sites.

For the cofferdam modeling, SVPs were extracted from the GDEM-V 3.0 database (Carnes, 2009) and representative months of April, July, October, and December were used in the acoustic propagation modeling for both the NJ and NY model sites. Modeling for the cofferdams encompassed all seasons.

2.4 Acoustic Propagation Modeling Approach for Impact Pile Driving

The primary source of underwater sound due to impact pile driving is a result of the compression of the pile during each hammer strike. The hammer strike produces an elastic wave in the pile that deforms the pile wall. The pile is compressed in the vertical (axial) dimension and expands in the horizontal (radial) dimension. This deformation or “bulge” travels down the pile at a speed close to the compressional wave speed in steel--which is faster than the speed of sound in seawater—resulting in a radiated acoustic Mach wave. The angle of the initial Mach cone relative to the pile axis (Equation 1) is dependent on the ratio of the sound speed in water (c_w) to the propagation speed of the radial deformation down the pile, which is approximated by the compressional wave speed in steel (c_p) (Reinhall and Dahl, 2011):

$$\theta = \sin^{-1}(c_w/c_p) \tag{1}$$

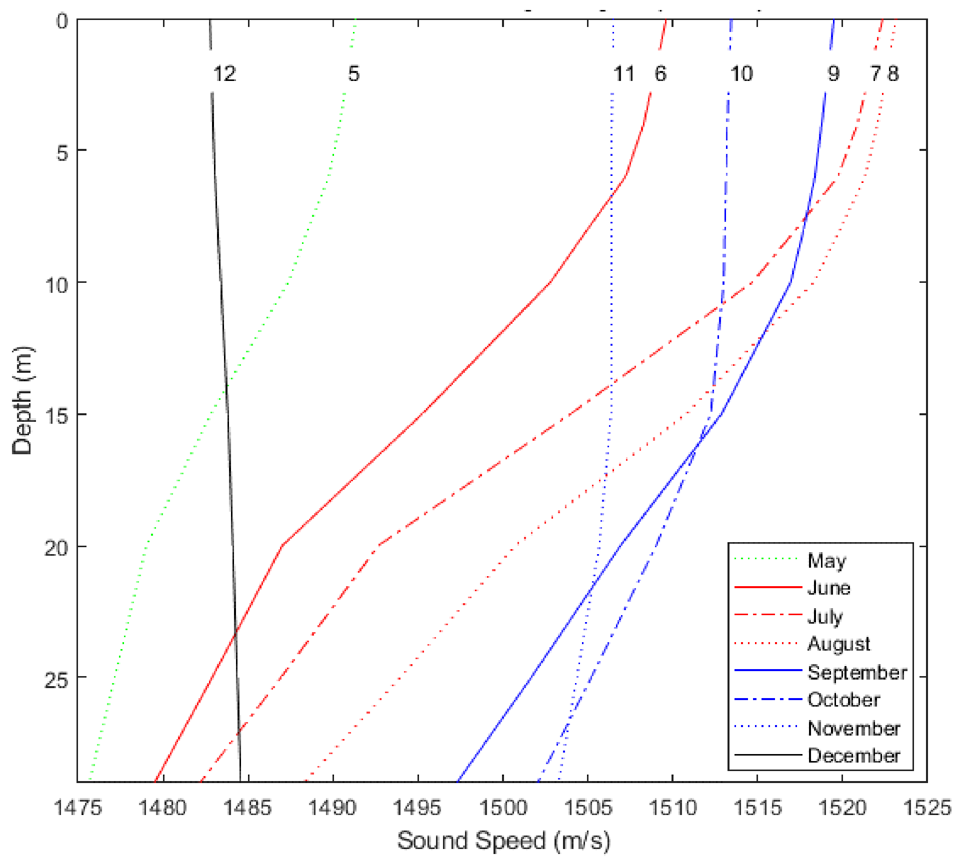

Figure 8. Sound Velocity Profiles for each Month of the May to December Pile Driving Construction Period at the Shallow Model Site in the OCS-A-0549 Lease Area for the Atlantic Shores North Project.

As the deformation travels down the pile, the resultant Mach wave propagates away at a downward angle; after reflection from the pile toe, the deformation travels back up the pile, producing an upward-going Mach wave. The amplitude of the deformation (and radiated acoustic wave in the water) is reduced with each successive reflection from the ends of the pile.

The sound pressure level associated with an up-going Mach wave is approximately 7 dB lower than that of the first down-going Mach wave. The second down-going Mach wave is further reduced, to a level 9 dB lower than the first (Dahl and Reinhall, 2013; Reinhall and Dahl, 2011).

MAI's acoustic modeling procedure accounts for the first down- and up-going Mach waves and neglects waves due to further reflections from the pile ends; elastic waves that are produced in the sediment by the deformation traveling along the pile are also neglected but the propagation of the water-borne acoustic waves in the sediment are included in the modeling, with modeling of shear attenuation as an effective additional compressional attenuation. The level of the up-going Mach wave is reduced by 7 dB in the modeling, further described below.

In the acoustic modeling of the impact pile driving sources for the Project, the pile is represented as a vertical line array. Vertical directionality of the propagating Mach wave is included in the model by specifying a beam-pattern from which the starting field for the parabolic equation is calculated; this starting field consists of a summation over the product of modes that solves an associated homogeneous waveguide problem (i.e., sine functions) and amplitudes given by the angular dependence of the beam-pattern. The pile beam-pattern was calculated for a vertical line array of elements with 1-m spacing from the sea surface to the seafloor. This representative array was used to compute a frequency-specific beam-pattern, steered at an angle equal to the Mach cone angle, which was then input into the Navy Standard Parabolic Equation (NSPE). The NSPE is an implementation of the RAM PE model (Collins, 1993), and includes the option to compute a starting field from an input beam-pattern, as described above.

The Mach cone angle has been measured at 17° (Reinhall and Dahl, 2011). However, the angle can vary between approximately 15° and 19° depending on the precise values of c_w and c_p (Equation 1) (Dahl et al., 2015). With the Mach angle being dependent on the material properties of the pile and the sound speed in water, MAI approximated an angle of 16° for use in the acoustic modeling of the impact pile driving scenarios. This 16° angle was applied to steer the beam pattern relative to the pile axis.

This process was followed for each third-octave center frequency in the bands from 10 Hz to 25 kHz. Radials were run at 10° bearing intervals to a maximum range of 150 km. The third-octave band source levels were added to each transmission loss (TL) value to produce a received level value at each range, depth, and bearing point. TL values were computed similarly for the upward going Mach wave, with the beam-pattern steered upward at an angle equal to the Mach cone angle. The third-octave band source levels were reduced by 7 dB, then added to the TL values to again produce a received level value at each range, depth, and bearing point.

Finally, the combined up- and down-going sound fields for each frequency were summed as intensities to generate a representative broadband sound field. This process was followed for each radial around the pile driving source to produce an N x two-dimensional grid of received sound levels in range, depth, and bearing. The resulting predicted acoustic sound exposure level (SEL) field was weighted using the low frequency (LF), mid-frequency (MF), high frequency (HF), pinnipeds in water (PW), and sea turtle (TU) weighting functions (NMFS, 2018). The peak level is derived using the relationship from Lippert et al. (2015). The sound pressure level (root mean square (SPL_{rms}) sound fields were derived using the relationship:

$$SEL = SPL_{rms} + 10 \times \log_{10}(T), \text{ where } T = 0.1 \text{ s.} \quad (2)$$

2.4.1 Acoustic Propagation Modeling Assumptions

The following assumptions were made for the acoustic modeling of the impact modeling scenarios:

- Two representative modeling locations were used in the acoustic modeling within the lease area as well as the landfall locations. The shallow and deep lease area model sites were representative of conditions throughout the wind energy area (WEA), while the Monmouth, NJ and Wolfe's Pond, NY landfall sites are representative of the nearshore conditions;

- Sound velocity profiles from May, October, and December were used in the acoustic modeling;
- Monthly mean sound velocity profiles were used to represent average conditions. On any given day, the SVP may differ from the modeled SVP, altering the acoustic propagation;
- The monopile diameters of 10-m and 15-m were modeled with a maximum strike energy of 3,066 and 3,015 kJ, respectively. Installation of only one monopile per day of any diameter was used in the modeling;
- The 5-m pre- and -post-piled skirt piles were modeled with a maximum strike energy of 1,904 kJ. Installation of four pin piles per day was considered;

a. Impact driven piles were modeled as a vertical line array; and

b. Source characteristics for the monopile and pin pile hammer sources were based on source spectra derived by JASCO (Weirathmueller et al., 2022) for the Project area. The actual source spectra produced during installation by impact pile driving may differ from the modeled source spectrum herein.

c. Conductor barrels:

    a. 1 day of installation/extraction per barrel;

    b. Each barrel will require 10 hours to install/extract;

    c. The installation was modeled in winter and extraction modeled in spring; and

    d. Source characteristics were based on four measured spectrum from CalTrans (2020) and then scaled for the 1.5-m diameter pile as part of the conductor barrel. The actual source spectra produced during installation by vibratory pile driving may differ from the modeled source spectrum herein.

2.5 ACOUSTIC PROPAGATION MODELING APPROACH FOR VIBRATORY PILE DRIVING

The NSPE was used for the acoustic propagation modeling. The sheet pile was represented as an omnidirectional point source located at the mid water column depth. The model was run for each third-octave center frequency in the bands from 10 Hz to 25 kHz. Radials were run at 10° bearing intervals to a maximum range of 100 km. The third-octave band source levels were added to each TL value to produce a received level value at each range, depth, and bearing point.

The received level fields for each frequency were summed as intensities to generate a representative broadband sound field. This process was followed for each of N radials around the source location to produce an N x two-dimensional grid of received sound levels in range, depth, and bearing. The SEL field was derived using the relationship:

$$SPL_{rms} = SEL - 10 \times \log_{10}(T), \text{ where } T = 1\text{ s} \tag{3}$$

In this case, the SEL = SPL_{rms}. The resulting predicted acoustic SEL field was weighted using the LF, MF, HF, PW, and TU weighting functions (NMFS, 2018).

2.5.1 Acoustic Propagation Modeling Assumptions for Vibratory Pile Driving

The following assumptions were made for the acoustic modeling of the vibratory modeling scenarios:

- Two representative modeling landfall locations were used in the acoustic modeling. These model sites were representative of the range of conditions at the potential landfall installation locations;
- Sound velocity profiles from April, July, October, and December were used in the acoustic modeling;
- Monthly mean sound velocity profiles were used to represent average conditions. On any given day, the SVP may differ from the modeled SVP, altering the acoustic propagation;
- Cofferdams
  a. Conservative estimate assumed 2 days of installation/extraction per cofferdam;
  b. Assumed 43.4 minutes of daily hammer time at the NY modeling site (Wolfe's Pond) and 109.2 minutes of daily hammer time at the NJ modeling site (Monmouth);
  c. Sheet piles were modeled as an omnidirectional point source located at mid water column depth; and
  d. Source characteristics for the sheet pile source were based on measurements from Illingworth and Rodkin (2017). The actual source spectra produced during installation by vibratory pile driving may differ from the modeled source spectrum herein.
- Goal Posts
  a. Assumed 1 day of installation/extraction per goal post;
  b. Each goal post consisted of two 0.3 m piles;
  c. Each pile required 2 hours to install/extract for a total of 4 hours per goal post; and
  d. Source characteristics for the source were based on measurements from Illingworth and Rodkin (2020). The actual source spectra produced during installation by vibratory pile driving may differ from the modeled source spectrum herein.

2.6 Sound Level Reduction Due to Mitigation

Various sound reduction levels were assessed to determine the potential effects of sound attenuation methods as a means of mitigation. Broadband sound reduction levels of 6, 10, and 15 dB were modeled to determine the effects on ranges to regulatory thresholds of marine mammals, sea turtles, and fish and acoustic exposures of marine mammals and sea turtles. No mitigation was modeled for the cofferdam installation.

2.7 Implementation of Pile Installation Schedule

The pile progression schedule (Table 7) was accounted for when calculating the acoustic ranges to the regulatory thresholds for marine mammals, sea turtles, and fishes. For the 10-m and 15-m monopile scenarios (Table 2), one monopile (of either diameter) per day will be installed with a total of 5,448 and 10,110 hammer blows per day, respectively. For both the 5-m pre- and

Table 7. The Planned Hammer Strike Energy Progression and Installation Duration Used in the Modeling of Impact and Vibratory Pile Driving for the Atlantic Shores North Project. Values for Blows per Minute are Rounded to the Nearest Integer.

Model Scenario/ Pile Type/ Number Piles Installed per Day/Method	*Hammer Type*	*Hammer Energy (kJ)*	*Duration at Energy Level (minutes)*	*Blows per minute*	*Number of Hammer Blows per Pile*	*Total Duration for Pile Install per Pile (minutes/ hours)*	*Total Number of Blows per Pile*
Scenario 1: 10-m Monopile (1 pile per day; impact pile driving)	Menck 4400	1291	50.5	15	758	206.8/3.4	5,448
		1937	19.6	30	588		
		2581	30.7	30	921		
		3066	106.0	30	3181		
Scenario 2: 15-m Monopile (1 pile per day; impact pile driving)	Menck 4400	1260	50.3	15	755	362.1/6.0	10,110
		1897	30.2	30	905		
		2536	34.5	30	1,036		
		3015	247.1	30	7,414		
Scenario 3: 5-m Pre-piled Pin Pile (4 piles per day; impact pile driving); this progression represents a single pin pile	IHC S2500	955	17.6	30	527	112.1/1.9	6,195
		1430	7.3	60	435		
		1904	87.2	60	5233		
Scenario 4: 5-m Post-Piled Pin Pile (4 piles per day; impact pile driving) (OSS Jacket); this progression represents a single pin pile	IHC S2500	955	17.6	30	527	112.1/1.9	6,195
		1430	7.3	60	435		
		1904	87.2	60	5,233		

Table 7. The Planned Hammer Strike Energy Progression and Installation Duration Used in the Modeling of Impact and Vibratory Pile Driving for the Atlantic Shores North Project. Values for Blows per Minute are Rounded to the Nearest Integer.

Model Scenario/ Pile Type/ Number Piles Installed per Day/Method	*Hammer Type*	*Hammer Energy (kJ)*	*Duration at Energy Level (minutes)*	*Blows per minute*	*Number of Hammer Blows per Pile*	*Total Duration for Pile Install per Pile (minutes/ hours)*	*Total Number of Blows per Pile*
Scenario 5: Sheet Pile (55 sheet piles per day; vibratory pile driving) (Cofferdam)	APE 200T	2.13 kN	X	X	X	X	X
Scenario 6: Conductor Barrel Installation and Removal (1 conductor barrel per day)	Grundoram Taurus	18 kJ	600	180	108,000	600/10	108,000
Scenario 7: Goal Post Installation and Removal (1 goal post per day); this progression represents a single goal post comprised of 2 piles	APE 200T	2.13 kN	X	X	X	240/4	X

post-piled skirt pile scenarios, four pin piles will be installed each day with a total of 6,195 hammer blows per pile and 24,780 hammer blows per day, respectively. Note that the number of blows per minute are rounded to the nearest integer as a fractional blow is not physically possible.

At the landfall site, conductor barrel installation and removal, one conductor barrel per day will be installed with a total of 108,000 blows per day. For cofferdam and goal post installation and removal, hammer energy will be 2.13 kN and 55 sheets per day will be installed via vibratory pile driving for cofferdams and a single goal post comprised of 2 piles will be installed daily via vibratory pile driving.

2.8 Animat Modeling Approach

Animat modeling was conducted to determine acoustic exposures of marine mammals and sea turtles from impact pile driving. The potential acoustic exposures of protected marine mammals and sea turtles were estimated using the Acoustic Integration Model© (AIM). AIM is a Monte Carlo-based statistical model (Frankel et al., 2002) in which many repeated simulations provide the probability of an outcome. AIM simulations create realistic animal movement tracks that, collectively, provide a reasonable representation of the movements of the animals in a population. Animats, or simulated animals, are programmed with a range of movement parameters, such as minimum and maximum swim speeds or dive depths (Table B-1; Appendix B). The underlying statistical distribution for these parameters is uniform, except for speed. Speed can be specified with a truncated normal (eight standard deviations between the minimum and maximum speed) or a gamma distribution as best fits the data for that animat. Multiple behavioral states can be included for each species or species group to best represent real animal movement.

The AIM model simulated the four-dimensional (range, depth, bearing, and time) movements of marine mammals and sea turtles during impact and vibratory pile driving. Animats were randomly distributed in a model box. Animats were further limited within this modeling box by the coastline and the minimum water depth at which each species is known to occur based on the available scientific literature (Appendix B, Table B-1). The simulated animat movements were integrated with the acoustic propagation modeling outputs of the sound fields for the Project’s planned impact and vibratory pile driving to predict exposure histories for each simulated animal over a 24-hour period.

The modeled marine mammal and sea turtle animats were set to populate the simulation area with representative, nominal densities (e.g.,0.25 animats/km^2) that are typically higher than those estimated for the species in the real-world marine environment from the Marine Geospatial Ecology Laboratory (MGEL) (2022) database and DiMatteo et al. (2023) for marine mammal and sea turtle densities, respectively. This “over population” of the modeling environment increases the sample size and ensures that the result of the animat model simulation is not unduly influenced by the chance placement of a small number of simulated marine mammals. To obtain final exposure estimates, the modeled results are normalized by the ratio of the modeled animat density to the real-world marine mammal or sea turtle density estimates, allowing for greater statistical power without overestimating exposures.

An AIM simulation consists of a user-specified number of steps forward in time at which the received sound level and three-dimensional position of the animat were recorded to calculate acoustic exposure estimates. The predicted sound received level is sampled by AIM every 30 seconds. Animats sample the entire water column, even in shallow waters, when a 30-second timestep is used in the AIM simulations. Histogram counts of animat depth in 1-m depth bins illustrate that an example harbor porpoise during a 24-hr simulation using a 30-second time step appropriately sample all depths (Figure 9). For an AIM time step, an animat is moved according to the rules describing its behavior. At the end of each time step, each animat "evaluates" its environment, potentially including its three-dimensional location and water depth.

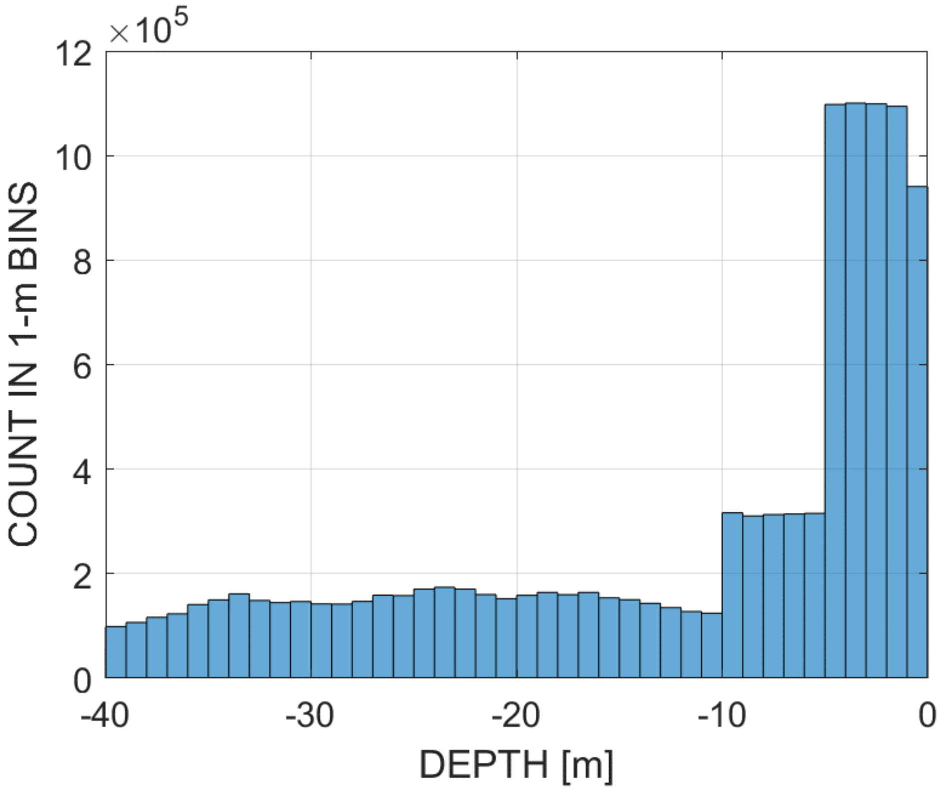

Figure 9. Histogram Plot in 1-meter Intervals Showing the Distribution of a Harbor Porpoise Animat as it Moves Through the Water Column (from 0 to 40 meters Water Depth) during an AIM Simulation using a 30-second Time Step.

To maximize sample size, AIM simulations are run with the source operating continuously for the entire modeling period. These results are then sampled to reflect the actual operating characteristics of the source. For example, to predict the exposures created by driving a monopile (nominally 2 hours), a 24-hour exposure history would be produced. Then multiple 2-hour time periods would be sequentially extracted from that simulation output (e.g., 0 to 2 hours, 2 to 4 hours). Thus, multiple sequential estimates were produced for each model scenario, and the mean value of exposure levels were reported.

AIM simulations were run for each marine mammal or sea turtle species or group for each impact or vibratory piling source scenario at all model site locations and months. Histories of each species/group's acoustic exposure for each of the acoustic sources are the result when all AIM simulations are completed.

2.8.1 Animal Aversion

In animat modeling, the simulated animals respond to the user specified boundaries set for various environmental parameters. If an environmental variable has exceeded the user-specified boundary value (e.g., water too shallow), then the animat will alter its course to react to the environment. These animat responses to the environmental limits are entitled "aversions." Several potential aversion variables that can be used to build an animats' behavioral pattern. The aversions programmed for the Project's AIM modeling was for water depth, which was based on available scientific literature for each species (Table B-1, Appendix B).

2.8.2 Animat Modeling Assumptions

Modeling with AIM for the Project was based on a number of conservative assumptions:

- Depth limitations (aversions) were set for each simulated species based on the movement parameters available in scientific literature (Table B-1, Appendix B); no other aversions were applied;
- Although the migratory state of species is considered in terms of their potentially differing swim or dive parameters during migration, the animats for migrating species are not programmed differently since the duration of the model event is 24 hours and the duration of any single exposure estimate is no longer than 7.5 hours; and
- Marine mammal densities were extracted from MGEL (2022) while sea turtle densities were extracted from DiMatteo et al. (2023) for the Project area.

3 Calculation of Acoustic Exposure and Range to Regulatory Thresholds

3.1 Acoustic and Exposure Range to Regulatory Threshold Estimates

3.1.1 Estimation of Acoustic Ranges to Regulatory Thresholds

To compute the ranges to regulatory thresholds, the modeled SEL sound fields were converted to cumulative 24-hour (hr) SEL sound fields. For the impact pile driving scenarios, the different strike energy levels and the number of expected hammer blows at each energy (Table 7) were used to convert between the single strike SEL (SEL_{ss}) and the cumulative SEL (SEL_{cum}) using the following, where N is the number of pile strikes at each strike energy level:

$$SEL_{cum} = SEL_{ss} + 10\log_{10} N \quad (4)$$

For the vibratory pile driving scenarios, the 1 sec SEL (SEL_{1s}) was converted to the SEL_{cum} using the following, where T_{event} is the duration of the event in seconds.

$$SEL_{cum} = SEL_{1s} + 10\log_{10} T_{event} \quad (5)$$

The maximum received level-over-depth at each range step and along each radial was taken and the maximum range to each acoustic threshold was determined along each radial. The 95th percentile of these ranges was calculated and is the acoustic range reported for the Project. The 95th percentile range is a representation of the range to each threshold that eliminates major outliers and better represents all the modeled radials. All acoustic ranges presented to regulatory threshold are the 95th percentile range. Since these values are taken from static sound fields, the SEL ranges reflect the acoustic ranges to stationary virtual receivers.

3.1.2 Estimation of Exposure Ranges to Regulatory Thresholds

An alternative method for estimating the range to regulatory threshold is based on the results of animat movement modeling rather than acoustic propagation modeling. The basic approach of the exposure range method includes convolving the four-dimensional representation of animal movements (space and time) with the appropriate frequency-weighted sound field predicted for the pile type and model location(s). As each animat moves through the sound field, the predicted received sound level is recorded, along with the distance of the animat from the sound source.

The SEL_{cum} and maximum SPL_{rms} for each animat is calculated over a day (24 hours). The modeled animats that have a predicted SEL_{cum} or SPL_{rms} that exceeds the regulatory thresholds for the modeled taxa are identified, and the range to the closest point of approach (CPA) (i.e., minimum distance between each animat and the acoustic pile driving source) that exceeds an acoustic threshold is determined, producing a distribution of ranges. The 95th percentile of these distances is defined as the animat-based exposure range. These ranges to thresholds supplement the purely acoustically derived range to thresholds, which are based upon the assumption that the animals (receivers) are stationary for the duration of the simulation.

3.2 ACOUSTIC EXPOSURE ESTIMATION

3.2.1 Impact Pile Driving Scenarios

The acoustic exposure history for each animat modeled for impact pile driving of the monopiles and pin piles was analyzed to produce the metrics of maximum root- mean square sound pressure level, cumulative sound exposure level, and peak sound pressure level. These modeled acoustic exposure estimates were then scaled by the ratio of real-world density estimates to the modeled animat density. The regional real-world marine mammal densities were the average monthly (or annual in some cases) densities (MGEL, 2022) while the regional sea turtle densities were seasonal estimates (DiMatteo et al., 2023).

The application of the real-world density and density scaling results in the predicted number of acoustic exposures for each species or species group for each pile driven. Summing the number of exposures above the relevant threshold provides an estimate of the number of regulatory exposures. The density-scaled acoustic exposures provided the per-foundation daily exposure estimates and were determined by month using the corresponding monthly animal density. The daily exposures were multiplied by the planned number of piles to be driven each month to determine the total number of acoustic exposures per month of the entire construction period. The monthly takes for each foundation type were combined to derive monthly acoustic exposures, which were then combined for annual acoustic exposures based on the annual installation schedules. The annual takes were then combined for an overall acoustic exposure per species.

3.2.2 Vibratory Pile Driving Scenarios

Acoustic exposures due to the vibratory pile driving for cofferdam and goal post installation were estimated using the zone of influence (ZOI). The ZOI is the ensonified area around a sound source, which was determined through acoustic propagation modeling. The ZOI was calculated according to the following, where r is the largest 95th percentile range to the acoustic threshold at each model site:

$$ZOI = \pi r^2 \tag{6}$$

With these modeling locations being close to shore, the ZOI extends over land. The area over land was excluded from the exposure calculation.

The ZOI was incorporated with the marine animal densities (ρ_{animal}) to estimate the number of potential acoustic exposures for each species at each model site according to the following, where the # days is the number of expected days of vibratory pile driving:

$$Acoustic\ Exposures = ZOI * \ \rho_{animal} * \#\ days \tag{7}$$

Per season, per cofferdam and goal post as well as overall acoustic exposures (PTS and behavioral) were calculated.

4 Regulatory Criteria and Guidance: Acoustic Thresholds Used to Evaluate Potential Impacts to Marine Mammals, Sea Turtles, and Fish

4.1 Marine Mammals

Under the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) is allowed, upon request, to authorize the incidental, but not intentional, “taking” of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region. The term “take,” as defined in Section 3 (16 U.S. Code [U.S.C.] section 1362 (13)) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, with two levels of harassment: Level A and Level B. By definition, Level A harassment is any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock, while Level B harassment is any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

NMFS has provided guidance for assessing the physiological impacts (Level A) of anthropogenic sound on marine mammals under their regulatory jurisdiction, which includes whales, dolphins, seals, and sea lions (NMFS, 2018). The guidance specifically defines hearing groups, develops auditory weighting functions, and identifies the received levels or acoustic threshold levels, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (permanent threshold shift [PTS] or temporary threshold shift [TTS]) for acute, incidental exposure to underwater sound. Southall et al. (2019) published consistent weighting functions and threshold levels for marine mammal species included in the NMFS (2018) guidance but included all marine mammal species (not just those under NMFS jurisdiction) for all noise exposures (both under water and in air), as well as updating the hearing groups. Unless otherwise noted, the following information on marine mammal hearing groups follows the NMFS (2018) definitions and nomenclature.

4.1.1 Marine Mammal Hearing Groups

Marine mammal hearing groups are defined as (NMFS, 2018; Southall et al., 2019):

- Low-frequency (LF) Cetaceans—this group consists of the mysticetes (baleen whales) with a collective generalized hearing range of 7 Hz to 35 kilohertz (kHz);
- Mid-frequency (MF) Cetaceans—includes most of the dolphins, all toothed whales except for *Kogia* spp., and all the beaked and bottlenose whales with a generalized hearing range of approximately 150 Hz to 160 kHz (renamed high-frequency cetaceans by Southall et al. (2019) because their best hearing sensitivity occurs at frequencies of several tens of kHz or higher);
- High-frequency (HF) Cetaceans—incorporates all the true porpoises, the river dolphins, plus *Kogia* spp., *Cephalorhynchus* spp. (genus in the dolphin family Delphinidae), and two species of *Lagenorhynchus* (Peale's and hourglass dolphins) with a generalized hearing range estimated from 275 Hz to 160 kHz (renamed very high-frequency cetaceans by Southall et al. (2019) since some of these species have best hearing sensitivity at frequencies exceeding 100 kHz);
- Phocids Underwater (PW)—consists of true seals with a generalized underwater hearing range from 50 Hz to 86 kHz (renamed phocid carnivores in water by Southall et al. 2019); and
- Otariids Underwater (OW)—includes sea lions and fur seals with a generalized underwater hearing range from 60 Hz to 39 kHz (termed other marine carnivores in water by Southall et al. (2019) and includes otariids, as well as walrus [Family Odobenidae], polar bear, and sea and marine otters [Family Mustelidae]). No otariid pinnipeds occur in the waters of the Atlantic Shores North Project, therefore this suite of species was not included within the analysis.

Within their generalized hearing ranges, the ability to hear sounds varies with frequency, as demonstrated by examining audiograms of hearing sensitivity (NMFS, 2018; Southall et al., 2019).

4.1.2 Auditory Weighting Functions

To reflect higher noise sensitivities at specific sound frequencies, auditory weighting functions were developed for each functional hearing group that reflected the best available data on hearing ability (composite audiograms), susceptibility to noise-induced hearing loss, impacts of noise on hearing, and data on equal latency (Figure 10) (DoN, 2017). These weighting functions are applied to individual sound received levels to reflect the susceptibility of each hearing group to noise-induced threshold shifts, which is not the same as the range of best hearing.

4.1.3 Auditory Injury Exposure Criteria

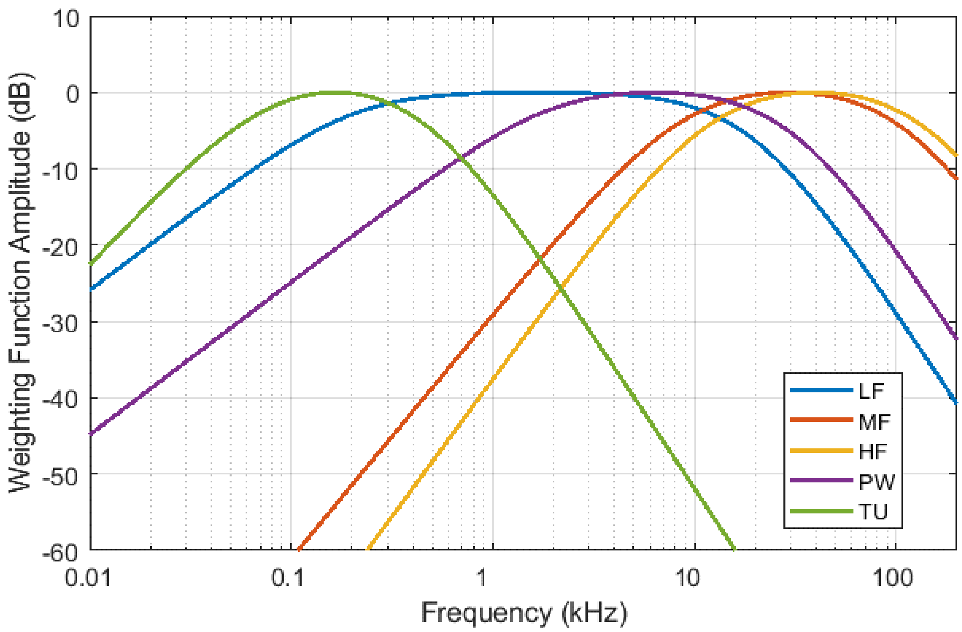

Figure 10. Auditory Weighting Functions for Cetaceans (Low Frequency [LF], Mid-Frequency [MF], and High Frequency [HF] Species) and Pinnipeds in Water (PW) from NMFS (2018) and for Sea Turtles (TU) from DoN (2017).

Although NMFS (2018) defined acoustic threshold levels at which PTS and TTS are predicted to occur for each marine mammal hearing group for impulsive and continuous signals, only information about the PTS injury exposure criteria for marine mammals are presented herein. Continuous sound signals do not have the high peak pressure with rapid rise time and decay characteristic of impulsive sounds; instead, the pressure (i.e., intensity) of continuous signals is more consistent throughout the signal. The PTS acoustic threshold levels are defined using metrics of the cumulative sound exposure level (SEL) over a 24-hr period and the peak sound pressure level. For the cumulative SEL, the appropriate frequency weighting for each hearing group is applied, which is reflected in the subscript of each threshold (e.g., the LF cetacean threshold is identified as $L_{E,LC}$). The cumulative SEL metric considers both received level and duration of exposure over the duration of the activity within a 24-hr period. Impulsive sounds are assessed against the SEL and peak thresholds, whereas non-impulsive sounds are assessed only against an SEL threshold (Table 8).

Table 8. Acoustic Threshold Levels for Marine Mammal Injurious (PTS Onset) Harassment (MMPA Level A; NMFS, 2018) and Behavioral Harassment (NOAA, 2005) Associated with Impulsive and Non-Impulsive (Continuous) Sound.

Hearing Group	*Impulsive Sounds**			*Non-Impulsive Sounds*	*Continuous Sounds*
	PTS Onset		*Behavior (dB re 1μPa)*	*PTS Onset*	*Behavior (dB re 1 μPa)*
	SEL (dB re 1 μPa²-s)	*Peak (dB re 1μPa)*		*SEL (dB re 1 μPa²-s)*	
Low-frequency cetaceans (LF)	183 dB ($L_{E,LF,24h}$)	219 dB ($L_{pk,0\text{-}pk,flat}$)	160 dB (L_p)	199 dB ($L_{E,LF,24h}$)	120 dB (L_p)
Mid-frequency cetaceans (MF)	185 dB ($L_{E,MF,24h}$)	230 dB ($L_{pk,0\text{-}pk,flat}$)		198 dB ($L_{E,MF,24h}$)	
High-frequency cetaceans (HF)	155 dB ($L_{E,HF,24h}$)	202 dB ($L_{pk,0\text{-}pk,flat}$)		173 dB ($L_{E,HF,24h}$)	
Phocid pinnipeds underwater (PW)	185 dB ($L_{E,PW,24h}$)	218 dB ($L_{pk,0\text{-}pk,flat}$)		201 dB ($L_{E,PW,24h}$)	

*Dual metric thresholds for impulsive sounds: The metric to be used is whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds are recommended for consideration.

The peak PTS sound pressure levels (L_{pk}) have a reference value of 1 µPa while the cumulative sound exposure level (L_E) has a reference value of 1 µPa^{2}s. The subscript "flat" indicates sound pressures are unweighted. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal (LF, MF, and HF cetaceans and PW pinnipeds) auditory weighting function. The accumulation period for SEL thresholds is indicated in hours in the subscript (e.g., $L_{E,\ 24h}$).

4.1.4 Behavioral Response Exposure Criteria

The behavioral threshold for marine mammals, which is part of MMPA Level B harassment along with TTS[2], is defined by NMFS as 120 dB re 1 µPa (L_P) for continuous sources, such as vibratory pile driving, and 160 dB re 1 µPa (L_P) for impulsive sources, such as impact pile driving (NOAA, 2005) (Table 8).

4.2 Sea Turtles

4.2.1 Auditory Weighting Functions

To reflect higher noise sensitivities at specific sound frequencies, auditory weighting functions for sea turtles were developed that reflected the best available data on hearing ability (composite audiograms), susceptibility to noise-induced hearing loss, impacts of noise on

2 NMFS considers behavioral effects to be the onset of MMPA Level B harassment while TTS is upper Level B harassment.

hearing, and data on equal latency (Figure 10) for sea turtles (DoN, 2017). These weighting functions are applied to individual sound received levels to reflect the susceptibility to noise-induced threshold shifts, which is not the same as the range of best hearing.

4.2.2 Auditory Injury and Behavior Exposure Criteria

For sea turtles, the U.S. Navy's *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (DoN, 2017) outlines both peak and cumulative SEL thresholds to assess PTS injury as well as behavior in sea turtles (Table 9).

Table 9. Acoustic Threshold Levels for Physiologic and Behavioral Acoustic Effects to Sea Turtles (DoN, 2017).

Species Group	***Impulsive Signals***		***Non-Impulsive Signals***	***Behavior (L_{prms} dB re 1μPa (Unweighted)***
	Injury		***Injury***	
	SEL (dB re 1μPa²-s) (Weighted)	***Peak (dB re 1μPa) (Unweighted)***	***SEL (dB re 1μPa²-s) (Weighted)***	
Sea turtles (TU)	204 ($L_{E,TU, 24h}$)	232 ($L_{pk,0\text{-}pk,flat}$)	220 ($L_{E, TU,24h}$)	175

The cumulative SEL metric is assessed with the appropriate frequency weighting for sea turtles (Figure 8). The sea turtle injury criteria are incorporated into the effects guidance on sea turtles published by the National Fisheries Marine Fisheries Service's (NMFS's) Greater Atlantic Regional Fisheries Office (GARFO).

4.3 FISHES

In a cooperative effort between federal and state agencies, interim criteria were developed to assess the potential for injury to fishes exposed to impact pile driving sounds. These noise injury thresholds have been established by the Fisheries Hydroacoustic Working Group, which was assembled by NMFS with thresholds subsequently adopted by NMFS (FHWG, 2008). GARFO has applied these standards for assessing the potential effects to fish species and sea turtles listed under the Endangered Species Act (ESA) that have been exposed to elevated levels of underwater sound produced during pile driving (GARFO, 2019). These noise thresholds are based on sound levels that have the potential to produce injury or illicit behavioral responses from fishes (Table 10). Separate criteria are provided in GARFO (2019) for fishes weighing less than and more than two grams.

A Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, also developed sound exposure guidelines for fish and sea turtles (Table 10; Popper et al., 2014). This working group identified three types of fish, depending on how they might be affected by underwater sound. The categories include fishes with no swim bladder or other gas chamber (e.g., dab and other flatfish); fishes with swim bladders in which hearing does not involve the swim bladder or other

Table 10. Acoustic Threshold Levels for Physiologic Impacts to Fishes (FHWG 2008, GARFO 2019, Popper et al. 2014).

Fsh Group	*Impulsive Signals*		*Non-Impulsive Signals*	*Behavior SPL$_{rms}$ (dB re 1 µPa) (Unweighted) ($L_{rms,flat}$)*
	Injury		*Injury*	
	SEL (dB re 1 µPa^2-s) (Unweighted) ($L_{E,\ flat,\ 24h}$)	*Peak (dB re 1 µPa) (Unweighted) $L_{pk,0\text{-}pk,flat}$)*	*SPL (dB re 1 µPa) (Unweighted) ($L_{rms,\ flat}$)*	
Fishes without swim bladders**	> 216	> 213		
Fishes with swim bladder not involved in hearing**	203	> 207		
Fishes with swim bladder involved in hearing**	203	> 207	170	
All Fish (mass ≥2 g)* and +	187	206		150
All Fish (mass <2 g)* and +	183	206		150

*FHWG 2008; **Popper et al. 2014; + GARFO 2019 (for salmon and sturgeon)

gas volume (e.g., salmonids); and fishes with a swim bladder that is involved in hearing (e.g., channel catfish). GARFO (2019) defined the behavioral impact threshold for fish as 150 dB re 1 µPa (Table 11).

Table 11. Acoustic Threshold Levels for Behavioral Impacts to Fishes (GARFO, 2019).

Group	*Behavioral threshold (dB re 1 µPa, unweighted)*
Small fish (mass <2g)	150
Large Fish (mass ≥2 g)	150

5 MODELED MARINE MAMMALS AND SEA TURTLES

Sixteen species of marine mammals and four species of sea turtles that may potentially occur in the waters of the Project area and nearshore waters, at least seasonally were modeled, although many more marine mammals may occur in the region, particularly in deeper, offshore waters (Tables 12 to 16). These 20 marine species were assessed for potential impacts associated with exposure to underwater acoustic impacts associated with Project pile driving

Table 12. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory [MGEL], 2022) in the 7.1-km Buffered Lease Area 0549 During the Annual Impact Pile Driving Construction Period (May Through December) for the Atlantic Shores North Project; Some Species Were Modeled as a Group.

Marine Mammal Species		***Model Group***	***Monthly Density (animals/km^2)***							
			May	***June***	***July***	***August***	***September***	***October***	***November***	***December***
Mysticetes										
Common minke whale (*Balaenoptera acutorostrata*)			0.00774	0.00157	0.00034	0.00015	0.00012	0.00066	0.00015	0.00035
Fin whale (*Balaenoptera physalus physalus*)			0.00075	0.00069	0.00036	0.00022	0.00022	0.00037	0.00041	0.00146
Humpback whale (*Megaptera novaeangliae*)			0.00083	0.00060	0.00013	0.00008	0.00023	0.00076	0.00117	0.00141
North Atlantic right whale (*Eubalaena glacialis*)			0.00009	0.00003	0.00001	0.00001	0.00002	0.00003	0.00012	0.00042
Sei whale (*Balaenoptera borealis*)			0.00022	0.00006	0.00001	0.00001	0.00002	0.00007	0.00030	0.00048
Odontocetes										
Atlantic spotted dolphin (*Stenella frontalis*)			0.00002	0.00008	0.00019	0.00062	0.00042	0.00044	0.00029	0.00002
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)			0.00482	0.00375	0.00012	0.00004	0.00041	0.00386	0.00506	0.00489
Common bottlenose dolphin (*Tursiops truncatus*)	Western North Atlantic Northern Migratory Coastal stock		0.23816	0.32765	0.32684	0.34785	0.36630	0.34530	0.33514	0.19006
	Western North Atlantic Offshore stock)		0.06055	0.08442	0.08747	0.08734	0.08235	0.08193	0.08977	0.05813
Harbor porpoise (*Phocoena phocoena*)			0.00943	0.00039	0.00030	0.00012	0.00002	0.00010	0.00045	0.03064

Table 12. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory [MGEL], 2022) in the 7.1-km Buffered Lease Area 0549 During the Annual Impact Pile Driving Construction Period (May Through December) for the Atlantic Shores North Project; Some Species Were Modeled as a Group.

Marine Mammal Species	***Model Group***	***Monthly Density (animals/km²)***							
		May	***June***	***July***	***August***	***September***	***October***	***November***	***December***
Long-finned pilot whale[1](*Globicephala melas*)	Pilot Whale	0.00006							
Risso's dolphin (*Grampus griseus*)		0.00012	0.00004	0.00002	0.00002	0.00002	0.00007	0.00045	0.00068
Short-beaked common dolphin (*Delphinus delphis*)		0.02101	0.00712	0.00302	0.00151	0.00019	0.00747	0.04034	0.03821
Short-finned pilot whale[1] (*Globicephala macrorhynchus)*	Pilot Whale	0.00005							
Sperm whale (*Physeter macrocephalus*)		0.00012	0.00001	0.00000	0.00000	0.00000	0.00000	0.00005	0.00005
Pinnipeds									
Gray seal[1] (*Halichoerus grypus*)	Seal	0.04869	0.00958	0.00109	0.00079	0.00162	0.00901	0.02426	0.04794
Harbor seal[1] (*Phoca vitulina*)	Seal	0.10939	0.02153	0.00245	0.00176	0.00365	0.02023	0.05449	0.10770

1 Densities in the MGEL 2022 database are only available for the Pilot Whale and Seal guilds and not for the individual species so these densities were scaled by the ratio of their abundances; additionally, densities for the Pilot Whale guild are only available annually and not monthly.

Table 13. Potentially Occurring Sea Turtle Species and their Respective Seasonal Mean Densities (DiMatteo et al. 2023) in the Buffered Lease Area 0549 During the Annual Construction Period of the Atlantic Shores North Project; All Sea Turtle Species Modeled as a Representative Group.

Sea Turtle Species	*Monthly Density (animals/km²)*							
	May	*June*	*July*	*August*	*September*	*October*	*November*	*December*
Green turtle (*Chelonia mydas)*	0.0000	0.3746	0.4554	0.3268	0.4814	0.2676	0.0253	0.0000
Kemp's ridley turtle (*Lepidochelys kempii)*	0.0000	0.02814	0.0309	0.03077	0.01781	0.01907	0.003945	0.0000
Leatherback turtle (*Dermochelys coriacea)*	0.04848	0.22700	0.55460	0.87080	0.96160	0.69350	0.10140	0.00385
Loggerhead turtle (*Caretta caretta*)	0.1771	0.4163	0.3130	0.2767	0.2889	0.5197	0.2788	0.0622

Table 14. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Cofferdam Model Areas Used in the Vibratory Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km²)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Mysticetes													
Common minke whale	WP	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00021
	Mon	0.00013	0.00013	0.00021	0.00319	0.00248	0.00046	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021
Fin whale	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Mon	0.00035	0.00011	0.00024	0.00030	0.00009	0.00011	0.00005	0.00004	0.00007	0.00009	0.00010	0.00034
Humpback whale	WP	0.00042	0.00027	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
	Mon	0.00076	0.00049	0.00037	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00001	0.00002	0.00079
North Atlantic right whale	WP	0.00016	0.00018	0.00008	0.00005	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00010
	Mon	0.00017	0.00019	0.00021	0.00011	0.00003	0.00001	0.00000	0.00000	0.00001	0.00001	0.00002	0.00010
Sei whale	WP	0.00000	0.00000	0.00000	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001
	Mon	0.00020	0.00013	0.00016	0.00020	0.00013	0.00007	0.00002	0.00001	0.00002	0.00005	0.00018	0.00042
Odontocetes													
Atlantic spotted dolphin	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Mon	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00017	0.00033	0.00020	0.00007	0.00000	0.00000
Atlantic white-sided dolphin	WP	0.00002	0.00001	0.00002	0.00003	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00006	0.00005
	Mon	0.00047	0.00030	0.00046	0.00124	0.00052	0.00024	0.00001	0.00001	0.00004	0.00043	0.00105	0.00103
Common bottlenose dolphin—Northern Coastal Migratory stock	WP	0.00172	0.00057	0.00118	0.00797	0.01676	0.01943	0.01716	0.01550	0.01744	0.01908	0.01464	0.00905
	Mon	0.03661	0.01246	0.01631	0.06915	0.17419	0.28310	0.22517	0.16424	0.22768	0.29993	0.25955	0.18494
Harbor porpoise	WP	0.00170	0.00186	0.00228	0.00304	0.00045	0.00003	0.00001	0.00000	0.00000	0.00002	0.00004	0.00168
	Mon	0.01469	0.01254	0.01607	0.01941	0.00368	0.00024	0.00007	0.00002	0.00001	0.00008	0.00031	0.01563
Long-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Risso's dolphin	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 14. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Cofferdam Model Areas Used in the Vibratory Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km^2)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Risso's dolphin	Mon	0.00000	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00008
Short-beaked common dolphin	WP	0.00046	0.00026	0.00059	0.00222	0.00210	0.00032	0.00001	0.00000	0.00001	0.00034	0.00223	0.00143
	Mon	0.00316	0.00133	0.00201	0.00488	0.00316	0.00059	0.00003	0.00001	0.00002	0.00244	0.01359	0.00974
Short-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Sperm whale	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Mon	0.00001	0.00001	0.00001	0.00003	0.00004	0.00000	0.00000	0.00000	0.00000	0.00000	0.00007	0.00005
Pinnipeds													
Gray seal*	WP	0.03959	0.03496	0.06499	0.06373	0.01688	0.07216	0.00961	0.00424	0.01069	0.13527	0.05165	0.03429
	Mon	0.02334	0.02334	0.03255	0.03440	0.02573	0.07851	0.00560	0.00315	0.00727	0.05789	0.03122	0.03866
Harbor seal*	WP	0.08895	0.07855	0.14601	0.14320	0.03792	0.16212	0.02159	0.00952	0.02402	0.30392	0.11604	0.07705
	Mon	0.07808	0.05243	0.07313	0.07729	0.05780	0.17638	0.01258	0.00707	0.01633	0.13005	0.07015	0.08687

*Densities in the MGEL 2022 database are only available for Pilot Whale and Seal guilds/groups and not for the individual species, so these densities were scaled by the ratio of their abundances to derive individual densities for both species of pilot whales and the seals; additionally, densities for the Pilot Whale guild are only available annually and not monthly

Table 15. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Conductor Barrel Model Areas Used in the Impact Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km^2)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Mysticetes													
Common minke whale	WP	0.00001	0.00001	0.00001	0.00011	0.00008	0.00001	0.00000	0.00000	0.00000	0.00001	0.00000	0.00000
	Mon	0.00013	0.00013	0.00021	0.00319	0.00248	0.00046	0.00004	0.00002	0.00004	0.00030	0.00006	0.00011
Fin whale	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Mon	0.00035	0.00011	0.00024	0.00030	0.00009	0.00011	0.00005	0.00004	0.00007	0.00009	0.00010	0.00034
Humpback whale	WP	0.00043	0.00028	0.00037	0.00002	0.00001	0.00001	0.00000	0.00000	0.00000	0.00001	0.00003	0.00079
	Mon	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001
North Atlantic right whale	WP	0.00017	0.00019	0.00009	0.00006	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00011
	Mon	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Sei whale	WP	0.00001	0.00000	0.00000	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001
	Mon	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Odontocetes													
Atlantic spotted dolphin	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	Mon	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00017	0.00033	0.00020	0.00007	0.00000	0.00000
Atlantic white-sided dolphin	WP	0.00002	0.00002	0.00003	0.00003	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00006	0.00005
	Mon	0.00047	0.00030	0.00046	0.00124	0.00052	0.00024	0.00001	0.00001	0.00004	0.00043	0.00105	0.00103
Common bottlenose dolphin—Northern Coastal Migratory stock	WP	0.00197	0.00065	0.00130	0.00836	0.01717	0.01982	0.01813	0.01733	0.01947	0.01985	0.01519	0.01002
	Mon	0.03661	0.01246	0.01631	0.06915	0.17419	0.28310	0.22517	0.16424	0.22768	0.29993	0.25955	0.18494
Harbor porpoise	WP	0.00190	0.00208	0.00257	0.00347	0.00053	0.00004	0.00001	0.00000	0.00000	0.00002	0.00004	0.00188
	Mon	0.00015	0.00013	0.00016	0.00019	0.00004	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00016
Long-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Risso's dolphin	WP	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 15. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Conductor Barrel Model Areas Used in the Impact Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km²)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Risso's dolphin	Mon	0.00000	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00008
Short-beaked common dolphin	WP	0.00062	0.00033	0.00063	0.00180	0.00149	0.00026	0.00001	0.00000	0.00001	0.00048	0.00301	0.00199
	Mon	0.00316	0.00133	0.00201	0.00488	0.00316	0.00059	0.00003	0.00001	0.00002	0.00244	0.01359	0.00974
Short-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Sperm whale	WP	0.00062	0.00033	0.00063	0.00180	0.00149	0.00026	0.00001	0.00000	0.00001	0.00048	0.00301	0.00199
	Mon	0.00001	0.00001	0.00001	0.00003	0.00004	0.00000	0.00000	0.00000	0.00000	0.00000	0.00007	0.00005
Pinnipeds													
Gray seal*	WP	0.02918	0.02583	0.04860	0.04724	0.01348	0.04679	0.00828	0.00398	0.01000	0.12665	0.03821	0.02549
	Mon	0.00035	0.00023	0.00033	0.00034	0.00026	0.00079	0.00006	0.00003	0.00007	0.00058	0.00031	0.00039
Harbor seal*	WP	0.06557	0.0582	0.10920	0.10613	0.03028	0.10514	0.01860	0.00895	0.02246	0.28455	0.08585	0.05726
	Mon	0.07808	0.05243	0.07313	0.07729	0.05780	0.17638	0.01258	0.00707	0.01633	0.13005	0.07015	0.08687

*Densities in the MGEL 2022 database are only available for Pilot Whale and Seal guilds/groups and not for the individual species, so these densities were scaled by the ratio of their abundances to derive individual densities for both species of pilot whales and the seals; additionally, densities for the Pilot Whale guild are only available annually and not monthly

Table 16. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Goal Post Model Areas Used in the Vibratory Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km²)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Mysticetes													
Common minke whale	WP	0.00001	0.00001	0.00001	0.00011	0.00008	0.00001	0	0	0	0.00001	0	0
	Mon	0.0002	0.0002	0.00032	0.00496	0.00428	0.00086	0.00009	0.00004	0.00006	0.00042	0.0001	0.00017
Fin whale	WP	0	0	0	0	0	0	0	0	0	0	0	0
	Mon	0.00102	0.00036	0.00063	0.00078	0.0003	0.0003	0.00018	0.00014	0.0002	0.00023	0.0002	0.00104
Humpback whale	WP	0.00043	0.00028	0.00037	0.00002	0.00001	0.00001	0	0	0	0.00001	0.00003	0.00079
	Mon	0.00082	0.00053	0.00083	0.00061	0.00034	0.00032	0.0001	0.00008	0.00015	0.00036	0.00096	0.00131
North Atlantic right whale	WP	0.00025	0.00027	0.00011	0.00009	0.00001	0	0	0	0	0.00001	0.00005	0.00017
	Mon	0.00031	0.00034	0.00033	0.00022	0.00005	0.00002	0.00001	0.00001	0.00001	0.00002	0.00005	0.0002
Sei whale	WP	0.00001	0	0	0.00001	0.00001	0	0	0	0	0	0	0.00001
	Mon	0.00023	0.00015	0.0002	0.00025	0.00016	0.00007	0.00002	0.00001	0.00002	0.00006	0.00022	0.00046
Odontocetes													
Atlantic spotted dolphin	WP	0	0	0	0	0	0	0	0	0	0	0	0
	Mon	0	0	0	0	0	0.00006	0.00034	0.00064	0.00031	0.00013	0.00001	0
Atlantic white-sided dolphin	WP	0.00002	0.00002	0.00003	0.00003	0	0	0	0	0	0.00001	0.00006	0.00005
	Mon	0.00086	0.00052	0.0008	0.00196	0.00104	0.00045	0.00003	0.00002	0.00011	0.00085	0.00181	0.00184
Common bottlenose dolphin—Northern Coastal	WP	0.00197	0.00065	0.0013	0.00836	0.01717	0.01982	0.01813	0.01733	0.01947	0.01985	0.01519	0.01002
	Mon	0.03629	0.01222	0.01518	0.06307	0.161	0.26198	0.21233	0.15753	0.20011	0.27269	0.24134	0.17548

Table 16. Potentially Occurring Marine Mammals and Their Respective Monthly (or Annual) Mean Densities (Marine Geospatial Ecology Laboratory, 2022) in the Wolfe's Pond (WP), NY and Monmouth (Mon), NJ Buffered Goal Post Model Areas Used in the Vibratory Pile Driving Modeling for the Atlantic Shores North Project.

Marine Mammal Species	*Wolfe's Pond (WP)/ Monmouth (Mon)*	*Monthly Density (animals/km²)*											
		Jan	*Feb*	*Marc*	*Apr*	*May*	*Jun*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Migratory stock													
Harbor porpoise	WP	0.0019	0.00208	0.00257	0.00347	0.00053	0.00004	0.00001	0	0	0.00002	0.00004	0.00188
	Mon	0.01877	0.0163	0.02142	0.02674	0.00519	0.00036	0.00015	0.00004	0.00001	0.0001	0.00038	0.0187
Long-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Risso's dolphin	WP	0	0	0	0	0	0	0	0	0	0	0	0
	Mon	0.00001	0	0	0.00001	0.00001	0.00001	0	0	0	0	0.00004	0.00018
Short-beaked common dolphin	WP	0.00062	0.00033	0.00063	0.0018	0.00149	0.00026	0.00001	0	0.00001	0.00048	0.00301	0.00199
	Mon	0.00597	0.00234	0.00311	0.00727	0.00529	0.00132	0.00013	0.00005	0.00005	0.00354	0.02004	0.01643
Short-finned pilot whale*	WP	0.00000											
	Mon	0.00000											
Sperm whale	WP	0	0	0	0	0	0	0	0	0	0	0	0
	Mon	0.00001	0.00001	0.00001	0.00004	0.00006	0	0	0	0	0	0.00008	0.00004
Pinnipeds													
Gray seal*	WP	0.02918	0.02583	0.04861	0.04724	0.01348	0.04679	0.00828	0.00398	0.01000	0.12665	0.03821	0.02549
	Mon	0.04051	0.02678	0.03408	0.03949	0.03070	0.06438	0.00449	0.00259	0.00574	0.04529	0.03158	0.04051
Harbor seal*	WP	0.06557	0.05802	0.10920	0.10613	0.03028	0.10514	0.01861	0.00895	0.02246	0.28456	0.08585	0.05726
	Mon	0.09103	0.06017	0.07656	0.08873	0.06896	0.14465	0.01008	0.00582	0.01291	0.10176	0.07094	0.09103

*Densities in the MGEL 2022 database are only available for Pilot Whale and Seal guilds/groups and not for the individual species, so these densities were scaled by the ratio of their abundances to derive individual densities for both species of pilot whales and the seals; additionally, densities for the Pilot Whale guild are only available annually and not monthly

activities. Some of these species were modeled as species' groups rather than individual species: pilot whales (inclusive of long-finned and short-finned pilot whales), seals (inclusive of harbor and gray seals), and sea turtles (including green, Kemp's ridley, leatherback, and loggerhead turtles). Although sea turtles were modeled as a group, the dive and swim parameters of the leatherback turtle were used as the basis for the movement parameters in the animat modeling of the turtle group due to the extensive movement information available for this species compared to the other turtle species. However, individual sea turtle species' seasonal densities were applied to the turtle modeling results to calculate individual's acoustic exposures by turtle species. Additionally, although seals and pilot whales were modeled as species' groups, individual densities were applied to each species based scaling of their individual abundances.

Following are descriptions of each of the modeled marine mammal and sea turtle species, highlighting those aspects of their occurrence, population estimates, behavior, movements, or hearing that are relevant to animat modeling and acoustic exposure estimation.

5.1 Modeled Marine Mammals

5.1.1 Mysticetes

Mysticetes, or baleen whales, are members of the low frequency hearing group of marine mammals. Five mysticete species potentially occur in the waters of the Project area, four of which are listed under the MMPA and some of which are additionally listed under the ESA.

5.1.1.1 Common Minke Whale (*Balaenoptera acutorostrata*)

Common minke whales are smaller baleen whales, reaching only about 8 to 9 m in length (Jefferson et al., 2015). Minke whales are widely distributed in tropical to polar waters of the Atlantic, Pacific, and Indian oceans, most often observed in coastal/neritic and inshore waters but infrequently also occurring in pelagic waters. In U.S. Atlantic waters, a strong seasonal component to minke whale's distribution exists in both the continental shelf and in deeper, off shelf waters, with minke whales occurring more commonly in shelf waters in spring and fall while from September through April, these whales are found in deeper, offshore waters (Hayes et al., 2022). Common minke whales are thought to be migratory, at least in some areas, moving from high latitude feeding grounds to lower latitude breeding grounds, although these migratory pathways are poorly understood (Cooke, 2018). Common minke whales potentially occurring in the waters of the Project area are most likely be part of the Canadian East Coast stock, which is estimated to include 21,968 whales (Hayes et al., 2023).

Tagged minke whales have been recorded diving to a maximum depth of 150 m but typically dive no deeper than 120 m (Kvadsheim et al., 2017). Common minke whale dives typically are between 1 and 6 minutes (min) in duration (Stern, 1992; Joyce et al., 1989; Stockin et al., 2001). The mean swim speed for minke whales in Monterey Bay was 8.3 kilometers per hour (kph) (Stern, 1992), but Blix and Folkow (1995) reported a "cruising" speed of minke whales at 11.7 kph.

Although the hearing sensitivity of minke whales has not been directly measured (Ketten, 2000) models of their middle ears predicts their best hearing overlaps with their vocalization frequency range (Tubelli et al., 2012). Minke whales produce a variety of sounds, primarily moans, clicks, downsweeps, ratchets, thump trains, grunts, and "boings" in the 80 Hz to 20 kHz range, and the signal features of their vocalizations consistently include LF, short-duration downsweeps from 250 to 50 Hz (Edds-Walton, 2000, Mellinger et al., 2000, Risch et al., 2014).

5.1.1.2 Fin Whale (*Balaenoptera physalus*)

Fin whales are listed as endangered under the ESA throughout their range. Fin whales are the second largest whale species, with males reaching 25 m and females reaching 26 m in length. Fin whales are a cosmopolitan species, only avoiding ice covered and tropical waters. Migratory patterns of the fin whale in the northern hemisphere are not well understood, but in the North Atlantic, some individual fin whales are known to remain at high latitudes year-round, while others remain at low latitudes throughout the year. Fin whales in the Project area are members of the Western North Atlantic stock, which has been estimated to include 6,802 individuals (Hayes et al., 2023).

Fin whales dive for a mean duration of 4.2 min at depths averaging 60 m (Croll et al., 2001; Panigada et al., 2004). The deepest dive recorded for a fin whale was to a depth of 1,470 m but dives to <100 m are more routine (Panigada et al., 1999). Swimming speeds average between 9.2 and 14.8 kph (Aguilar and García-Vernet, 2018). Watkins (1981) reported bursts of speed in fin whales up to 20 kph.

No direct measurement of fin whale hearing sensitivity has been made. Cranford and Krysl (2015) generated synthetic audiograms of a small fin whale and suggested that the fin whale hears sound through bone conduction via its skull; they suggested that sound waves interact in the skull to produce deformations that induce motion in the ear complex, which results in best hearing in the low frequency range. Fin whales produce a variety of LF sounds that range in frequency from 10 to 200 Hz (Cranford and Krysl, 2015; Edds, 1988; Watkins, 1981; Watkins et al., 1987). Fin whales produce well-known "20 Hz pulses" and most of their vocalizations are below 100 Hz (Watkins et al. 1987). Males can produce these pulses in a repeated pattern that functions as song, a presumed reproductive display (Morano et al., 2012). Fin whales are known to respond to anthropogenic noise such as shipping vessel noise, airguns, and small vessel noise (Jahoda et al., 2003, Castellote et al., 2012).

5.1.1.3 Humpback Whale (*Megaptera novaeangliae*)

The worldwide ESA status of the humpback whale was revised, with 14 worldwide distinct population segments (DPSs) identified. Humpback whales occurring in the Project area are part of the West Indies DPS, which is not listed under the ESA.

Humpback whales are a medium sized baleen whale, with typical adult sizes of 15 to 16 m. They are a cosmopolitan species found in all ocean basins. All populations, except that of the Arabian Sea, migrate seasonally between high latitude feeding grounds and low latitude reproductive areas, where calving is known to occur. Northwest Atlantic humpbacks migrate from their summer feeding grounds off the northeastern U.S. and Canada to their winter mating and calving groups in the West Indies of the Caribbean. Humpback whales occurring in the Project area are part of the Gulf of Maine stock, which is estimated at a population size of 1,396 whales (Hayes et al., 2023).

Dive times of humpback whales have been recorded from 3 to 4 min in duration (Dolphin, 1987; Strong, 1990), but Burrows et al. (2016) reported dive times that ranged from 7.5 to 9.6 min, with a mean of 6.0 min. Dive times on the wintering grounds can be much longer, with singing humpbacks typically diving between 10 and 25 min in duration (Chu, 1988). The deepest recorded humpback dive is 240 m, with most dives ranging between 60 and 120 m (Hamilton et al., 1997). During their long-distance migrations, humpback whales swim at speeds ranging from 1.3 to 14.2 kph (Cerchio et al., 2016; Guzman and Félix, 2017; Kennedy et al., 2014).

Hearing has not been measured in humpback whales, but they were the first whale known to produce songs. Vocalizations span from 10 Hz to more than 24 kHz (Frankel et al., 1995, Au et al., 2006, Zoidis et al., 2008) but most of the energy is concentrated below 2 kHz. Humpback whales are known to react to anthropogenic sound (Frankel and Clark, 2000, Fristrup et al., 2003, Dunlop et al., 2018). Like some other whale species, they have shown the ability to at least partially compensate for increases in masking noise by increasing their source level (Dunlop et al. 2014).

5.1.1.4 North Atlantic Right Whale (*Eubalaena glacialis*)

The North Atlantic right whale (NARW) is listed as endangered under the ESA. NARW are a large slow-moving whale that typically grows to a length of 13 to 16 m. NARWs are found in temperate to subpolar waters of the North Atlantic Ocean (Jefferson et al., 2015), where they most commonly occur in coastal and continental shelf waters from Florida to Newfoundland. The NARW population migrates between its winter southeast U.S. calving grounds (primarily coastal waters off eastern Florida and Georgia) and its summer feeding grounds from New England north to the Canadian Maritimes and the Gulf of St. Lawrence (Kenney, 2018). Passive acoustic monitoring has shown the year-round occurrence of NARW in the waters of the Gulf of Maine, New Jersey, and Virginia (Hayes et al., 2022). Shifting patterns in the habitat use by NARW over the last two decades is likely due to the changing distributions of their prey (Meyer-Gutbrod and Greene, 2014). The current estimated population of the Western North Atlantic stock of NARW is 338 whales (Hayes et al., 2023).

Baumgartner and Mate (2003) found that the average foraging dive time of a NARW was 12.2 min, with a maximum dive of 16.3 min, while the average dive depth was 121 m, with a maximum depth of 174 m. The maximum dive depth recorded by NARWs was 306 m (Mate et al., 1992). In the waters of Florida winter ground, right whales averaged speeds of 1.3 kph (Hain et al., 2013).

NARW are low-frequency hearing specialists. Their predicted hearing ranges from 10 to 22,000 Hz (Parks et al. 2007b). Their vocalizations have most of their energy below 2,000 Hz (Parks et al., 2011). The characteristics of NARW vocalizations have been shown to change in response to increased noise (Parks et al. 2011, Parks et al. 2007a).

5.1.1.5 Sei Whale (*Balaenoptera borealis*)

The sei whale is listed as endangered under the ESA. Sei whales occur in temperate, oceanic waters of all world oceans, occurring very uncommonly in neritic waters (Horwood, 2018). Adult sei whales can obtain lengths of 18 m (Jefferson et al., 2015). The sei whale is migratory, seasonally traveling between low latitude calving grounds to high latitude foraging grounds, although these migrations may not be as extensive as that of other mysticetes (Jefferson et al., 2015). In the northwestern Atlantic Ocean, sei whales range from the cool, continental shelf edge waters of the northeastern U.S. to Newfoundland, Canada; the greatest numbers of sei whales in U.S. eastern waters occur in spring (Hayes et al., 2022). Acoustic recordings indicate that sei whales occur year-round in the waters of the New York Bight and southern New England (Davis et al., 2020). Sei whales occurring in the Project area are members of the Nova Scotia stock, with an estimated population of 6,292 whales (Hayes et al., 2023).

Ishii et al. (2017) documented foraging sei whales diving to 57 m during the day and to no more than 12.2 m at night, with maximum durations of 12 min. Dive times of sei whales range from 0.75 to 15 min, with a mean duration of 1.5 min (Schilling et al., 1992). When foraging, sei whales make shallow dives of 20 to 30 m, followed by a deep dive up to 15 min in duration (Gambell, 1985). Mean swim speeds during migration range from 6.2 to 7.4 kph while off-migration swim speeds are about 3.6 to 6 kph (Prieto et al., 2014; Ishii et al., 2017). The maximum speed of sei whales of 27.4 kph has been reported (Olsen et al., 2009).

No direct measurements of sei whale hearing sensitivity exist (Ketten, 2000; Thewissen, 2002). Sei whale vocalizations are the least studied of all the rorquals. Rankin and Barlow (2007) recorded sei whale vocalizations in Hawaii and reported that all vocalizations were downsweeps, ranging from on average from 100.3 to 446 Hz for “high frequency” calls and from 39.4 to 21.0 Hz for “low frequency” calls. In another study, McDonald et al. (2005) recorded sei whales with an average call frequency of 433 Hz. A series of sei whales frequency-modulated calls have been recorded south of New Zealand with a frequency range of 34 to 87 Hz (Calderan et al., 2014).

5.1.2 Odontocetes

Odontocetes, or toothed whales, include all dolphins and porpoises as well as the sperm whale and smaller whale species. Nine odontocete species potentially occur in the waters of the Project area. Most odontocetes are in the mid-frequency cetacean (MFC) hearing group but species like the harbor porpoise, with higher frequency hearing ranges, are part of the high frequency cetacean (HFC) hearing group.

5.1.2.1 Atlantic Spotted Dolphin (*Stenella frontalis*)

Atlantic spotted dolphins are about 1.5 to 2.3 m in length and are found only in the tropical and warm-temperate waters of the Atlantic Ocean and associated seas and occur commonly in the waters off the southeastern U.S. and the Gulf coasts, in the Caribbean, and off West Africa (Jefferson et al., 2015). They inhabit waters usually about 200 m in depth but may occasionally swim closer to shore to feed. Atlantic spotted dolphins occurring in the Project area are part of the Western North Atlantic stock, which is estimated to include 39,921 individuals (Hayes et al., 2023).

Atlantic spotted dolphins have been recorded diving to 40 to 60 m of water depth, with an average dive time of around 6 min, and most, if not all dives with a duration of less than10 min in duration (Perrin, 2009a). Davis et al. (1996) reported that 94% of a tracked Atlantic spotted dolphin were to less than 40 m and all recorded dives were of short duration (2 min).

No current hearing data on Atlantic spotted dolphins exist. Atlantic spotted dolphins produce a variety of sounds, including whistles, whistle-squawks, buzzes, burst-pulses, synch pulses, barks, screams, squawks, tail slaps, and echolocation clicks. Like other odontocetes, they produce broadband, short duration echolocation signals. Their broadband clicks have peak frequencies between 60 and 120 kHz and their whistles range in frequency from 1 to 23 kHz and with a duration less than one second (Azevedo et al., 2010; Lammers et al., 2003).

5.1.2.2 Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

Atlantic white-sided dolphins are about 2.4 to 2.7 m in length and occur only in the cold-temperate to subpolar waters of the North Atlantic Ocean, typically in continental shelf waters up to 100 m (Jefferson et al., 2015). In the western North Atlantic, this species' range extends from the waters off western Greenland to the New York Bight, with occasional winter sightings as far south as North Carolina (Hayes et al., 2020). Atlantic white-sided dolphins potentially occurring in the waters of the Project area are part of the Western North Atlantic stock, which has an estimated population of 93,233 dolphins (Hayes et al., 2023).

Atlantic white-sided dolphins are probably not deep divers. A tagged dolphin dove for an average of 38.8 sec, with 76% of its dives lasting less than 1 minute; this dolphin also swam at an average speed of 5.7 kph (Mate et al., 1994). The maximum dive time recorded from a tagged white-sided dolphin is 4 min (Cipriano, 2009).

No hearing data are available on the Atlantic white-sided dolphin. Whistle vocalizations of Atlantic white-sided dolphins have been recorded with a dominant frequency of 6 to 15 kHz (Richardson et al., 1995). The average estimated SL for an Atlantic white-sided dolphin is approximately 154 dB re 1 µPa @ 1 m (Croll et al., 1999).

5.1.2.3 Common Bottlenose Dolphin (*Tursiops truncatus*)

The common bottlenose dolphin is typically 2 to 3.9 m in length. Common bottlenose dolphins are distributed worldwide in temperate to tropical waters and occur in diverse habitats ranging from inshore to open ocean waters (Scott and Chivers 1990, Sudara and Mahakunayanakul 1998, Wells and Scott 2009). Common bottlenose dolphins in the U.S. Atlantic waters are divided into multiple offshore, estuarine, and coastal migratory stocks. Hayes et al. (2021) defines the boundary between the Western North Atlantic, Northern Migratory Coastal stock and the Western North Atlantic, Offshore stock of common bottlenose dolphins as the 20-m isobath north of Cape Hatteras, NC. Thus, in the waters of the Project area, two stocks of common bottlenose dolphins may occur, the Western North Atlantic Offshore and Northern Migratory Coastal stocks. The estimated abundance of common bottlenose dolphins in the Offshore stock is 62,851 individuals while the Northern Coastal Migratory stock consists of 6,639 individuals (Hayes et al., 2023).

Dive times for bottlenose dolphins range from 38 sec to 1.2 min, with dives having been recorded to last as long as 10 min (Croll et al., 1999; Mate et al., 1995). Wild offshore bottlenose dolphins were reported to dive to depths greater than 450 m (Klatsky et al., 2007). The deepest dive recorded for a bottlenose dolphin is 535 m by a trained individual (Ridgway, 1986). Sustained swim speeds for bottlenose dolphins' range between 4 and 20 kph although they may reach speeds as high as 54 kph (Lockyer and Morris, 1987).

Bottlenose dolphins hear underwater sounds in the range of 150 Hz to 135 kHz (Johnson, 1967; Ljungblad et al., 1982). Their best underwater hearing occurs between 15 and 110 kHz, with the threshold level range is 42 to 52 dB RL (Au, 1993). Nachtigall et al. (2000) more recently measured the range of highest sensitivity as between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz. Bottlenose dolphins produce a variety of whistles, echolocation clicks, low-frequency narrow, "bray" and burst-pulse sounds with frequencies as low as 50 Hz and as high as 150 kHz with dominant frequencies at 0.3 to 14.5 kHz, 25 to 30 kHz, and 95 to 130 kHz (Janik 2000).

5.1.2.4 Harbor Porpoise (*Phocoena phocoena*)

Harbor porpoises are small, coastal odontocetes that are common in the waters of the northern hemisphere. They reach a maximum size of about 1.5 m and are typically difficult to spot at the sea surface due to their small size and very short surface durations. Harbor porpoises occur in cool temperate to subpolar waters of the North Atlantic and Pacific oceans, typically in shallow, nearshore waters that are less than 100 m in depth (Jefferson et al., 2015). Harbor porpoises in the Project area are part of the Gulf of Maine/Bay of Fundy stock, which has an estimated abundance of 95,543 individuals (Hayes et al., 2023).

Maximum swim speeds for harbor porpoises range from 16.6 and 22.2 kph (Gaskin et al., 1974). Dive times range between 0.7 and 1.7 min with a maximum dive duration of 9 min (Westgate et al., 1995). The majority of dives range from 20 to 130 m, although maximum dive depths have reached 226 m (Westgate et al., 1995).

Harbor porpoises are classified as high frequency hearing specialists and produce narrowband high-frequency echolocation clicks (Madsen et al., 2005). Harbor porpoises can hear frequencies in the range of 100 Hz to 140 kHz (Kastelein et al., 2002; Kastelein et al., 2015; Villadsgaard et al., 2007). Kastelein et al. (2002) determined the best range of hearing for a two-year-old male was 16 to 140 kHz; this harbor porpoise also demonstrated the highest upper frequency hearing of all odontocetes presently known (Kastelein et al., 2002). Harbor porpoises produce click and whistle vocalizations that cover a wide frequency range, from 40 Hz to at least 150 kHz (Verboom and Kastelein, 1995). Variations in click trains apparently represent different functions based on the frequency ranges associated with each activity.

5.1.2.5 Pilot Whales (Long-finned Pilot Whale [*Globicephala melas*] and Short-finned Pilot Whale [*Globicephala macrorhynchus*])

Both the short- and long-finned pilot whales occur in the North Atlantic Ocean. Adult pilot whales reach lengths of about 6.5 m. Sightings of pilot whales in the western North Atlantic occur primarily near the continental shelf break from Florida to the Nova Scotian Shelf (Mullin & Fulling, 2003). Pilot whales tend to concentrate in areas of high bathymetric relief or strong thermal fronts and are typically found almost exclusively along the continental shelf edge and slope regions (Hamazaki, 2002). In the North Atlantic Ocean, long-finned pilot whales occur from Iceland, Greenland, and the Barents Sea south to North Carolina and North Africa, while short-finned pilot whales have a more tropical and subtropical distribution, ranging from North Carolina through the wider Caribbean Sea and Gulf of Mexico(Hayes et al. 2022); the species' ranges overlap in mid-Atlantic waters. Pilot whales in the Project area could be either the

Western North Atlantic stocks of short- or long-finned species of pilot whales, which have abundances of 28,924 whales and 39,215 whales, respectively (Hayes et al., 2023).

Pilot whales generally have swim speeds ranging between 12 to 12 kph (Shane, 1995). Long-finned pilot whales swim at an average speed of 3.3 kph (Nelson and Lien, 1996), while short-finned pilot whales swim at speeds ranging between 7 and 9 kph (Norris and Prescott, 1961); short-finned pilot whale can perform underwater 'sprints' with velocities ranging up to 32.4 kph that are associated with foraging attempts (Aguilar Soto et al., 2008). Both short-finned and long-finned pilot whales are considered deep divers. Dive depths of long-finned pilot whales range from 16 m during the day to 648 m during the night, with dive durations varying between 2 and 13 min (Baird et al., 2002). Short-finned pilot whales off Tenerife, Canary Islands dove repeatedly to 300 m, with very few dives between 300 and 500 m, and many dives with a maximum depth between 500 and 1,019 m (Aguilar de Soto, 2008). Generally, dive times increase with dive depth, to a maximum duration of 21 min (Ridgway, 1986).

The best hearing sensitivity for a captive pilot whale was measured between 40 and 56 kHz with the upper limit of functional hearing between 80 and 100 kHz. Pilot whales echolocate with a precision like bottlenose dolphins. Short-finned pilot whales produce sounds as low as 280 Hz and as high as 100 kHz, with dominant frequencies between 2 to 14 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1969; Fish and Turl, 1976; Scheer et al., 1998). The mean frequency of calls produced by short-finned pilot whales is 7,870 Hz, much higher than the mean frequency of calls produced by long-finned pilot whales (Rendell et al., 1999). Echolocation abilities have been demonstrated during click production (Evans, 1973). SLs of clicks have been measured as high as 180 dB (Fish and Turl, 1976).

5.1.2.6 Risso's Dolphin (*Grampus griseus*)

Risso's dolphin's range in length from 2.6 to 3.9 m. These dolphins inhabit deep oceanic and continental slope waters worldwide, from tropical to temperate waters of both hemispheres (Leatherwood et al., 1980; Baird, 2009). They appear, however, to have a strong preference for temperate waters between 30° and 45° in latitude (Jefferson et al., 2015). Little to nothing is known about the movement or migration patterns of Risso's dolphins. Risso's dolphins in the Project area are part of the Western North Atlantic stock, which is comprised of 35,215 individuals (Hayes et al., 2023).

Dive times up to 30 min have been reported for Risso's dolphins (Jefferson et al., 2015). Out of 37 foraging dives observed from tagged Risso's dolphins, 57% were in shallow water depths (<90 m) while only 12% were to deep water depths (350 to 450 m) (Arranz et al., 2018). Typical Risso's dolphin swimming speeds range from 2 to 12 kph (Shane, 1995), but a tagged Risso's dolphin in the Gulf of Mexico swam average speeds of 7.19 kph and dove to 400 to 500 m (Wells et al., 2009).

Audiograms for Risso's dolphins indicate that their hearing ranges in frequency from 1.6 to 110 kHz, with optimal hearing occurring between 4 and 80 kHz (Nachtigall et al., 1995). Risso's dolphins produce sounds as low as 0.1 kHz and as high as 65 kHz. Their dominant vocalizing frequencies are between 2 to 5 kHz and 65 kHz (Corkeron & Van Parijs, 2001; Watkins, 1967;

Au, 1993). Risso's dolphins produce tonal whistles, burst-pulse sounds, echolocation clicks, and a hybrid burst-pulse tonal signal (Corkeron and Van Parijs, 2001).

5.1.2.7 Short-beaked Common Dolphin (*Delphinus delphis)*

The common dolphin is one of the most abundant dolphins in the world. It reaches lengths of about 1.8 m. Common dolphins are distributed worldwide in temperate, tropical, and subtropical oceans, primarily along continental shelf and steep bank regions where upwelling occurs (Jefferson et al., 2015). Short-beaked common dolphins seem to be most common north of 50°N in the Atlantic Ocean (Croll et al., 1999). In the Project area, short-beaked common dolphins are designated as members of the Western North Atlantic stock, which consists of 172,974 dolphins (Hayes et al., 2023).

Swim speeds for common dolphins have been measured at 5.8 kph with maximum speeds ranging from 16.2 kph to 37.1 kph (Croll et al., 1999; Hui, 1987). Dive depths range between 9 and 200 m, with a majority of dives from 9 to 50 m (Evans, 1994). The deepest dive recorded for common dolphins was 260 m (Evans, 1971) with a maximum dive duration documented at 5 min (Heyning and Perrin, 1994).

Little is known about hearing in the common dolphin. The hearing threshold of a common dolphin was measured with an auditory range from 10 to 150 kHz, with greatest sensitivity between 60 and 70 kHz (Popov and Klishin, 1998). Common dolphins produce sounds as low as 0.2 kHz and as high as 150 kHz, with dominant frequencies at 0.5 to 18 kHz and 30 to 60 kHz (Au 1993; Moore & Ridgway, 1995). Signal types consist of clicks, squeals, whistles, and creaks (Evans, 1994). The whistles of common dolphins range between 3.5 and 23.5 kHz (Ansmann et al., 2007). Most of the energy of echolocation clicks is concentrated between 15 and 100 kHz (Croll et al., 1999). In the North Atlantic, the mean SL of common dolphin whistles was estimated at about 143 dB with a maximum of 154 dB (Croll et al., 1999).

5.1.2.8 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the largest toothed whale, with males averaging 16 m while females are smaller at only about 12 m in length (Jefferson et al., 2015). Sperm whales are primarily found in deeper (1,000 m) ocean waters and distributed in polar, temperate, and tropical waters of the world's oceans. In the waters of the U.S. Atlantic, sperm whales are distributed from the continental shelf edge and slope to open ocean waters and are often associated with the Gulf Stream and its features. Sperm whales potentially occurring in the Project area are part of the North Atlantic stock, which includes 4,349 whales (Hayes et al., 2023).

Sperm whales may make the longest and deepest dives of any mammal, with the maximum-recorded dive reaching 1,500 m (Davis et al., 2007), although examination of stomach contents of sperm whales suggests that sperm whales may dive as deep as 3,200 m (Clarke, 1976). Foraging dives to depths of 294 to 1,433 m and non-foraging dives to a water depth of 500 m were recently measured (Guerra et al., 2017; Joyce et al., 2017). In general, dive durations range between 18.2 to 65.3 min (Watkins et al., 2002). Sperm whale's surface speeds generally average 1.3 to 4 kph, with maximum speeds of about 9.4 kph (Jochens et al., 2008; Lockyer, 1997; Watkins et al., 2002; Whitehead, 2018), although Lockyer (1997) reported dive swim rates ranging up to 10.1 kph.

The measured hearing of a stranded sperm whale calf suggested an auditory range of 2.5 to 60 kHz, with best hearing sensitivity between 5 and 20 kHz (Ridgway & Carder, 2001). Measurements of evoked response data from one stranded sperm whale have shown a lower limit of hearing near 100 Hz (Gordon et al., 1996). Sperm whales produce broadband clicks with energy from less than 100 Hz to 30 kHz (Goold and Jones, 1995; Møhl et al., 2000; Thode et al., 2002; Weilgart and Whitehead, 1997). Regular click trains and creaks have been recorded from foraging sperm whales and may be produced as a function of echolocation. A series of short clicks, termed "codas," have been associated with social interactions and are thought to play a role in communication.

5.1.3 Pinnipeds

5.1.3.1 Gray Seal (*Halichoerus grypus*)

Gray seals are between 2 to 3 m in length and occur in coastal temperate to sub-polar waters of the North Atlantic Ocean and Baltic Sea (Jefferson et al., 2015). In the northwestern Atlantic, gray seals occur principally in coastal waters of eastern Canada (Labrador) to the northeastern U.S. (New Jersey) but may occasionally occur extralimitally further south (Hayes et al., 2020). Gray whales that may potentially occur in the Project area are part of the Western North Atlantic stock that consists of 27,300 seals (Hayes et al., 2023).

Swim speeds of gray seals average 4.5 kph. Gray seals dives are short, between 4 and 10 min, with a maximum dive duration recorded at 30 min (Hall and Thompson, 2009). A maximum dive depth of over 300 m has been recorded for this species, but most dives are relatively shallow, from 60 to 100 m to the seabed (Hall and Thompson, 2009).

Gray seals' underwater hearing range has been measured from 2 kHz to 90 kHz, with best hearing between 20 kHz and 50 to 60 kHz (Ridgway and Joyce, 1975). Gray seals produce in-air sounds at 100 Hz to 16 kHz, with predominant frequencies between 100 Hz and 4 kHz for seven characterized call types, and up to 10 kHz for "knock" calls (Asselin et al., 1993). Oliver (1978) has reported sound frequencies as high as 30 and 40 kHz for these seals.

5.1.3.2 Harbor Seal (*Phoca vitulina*)

Harbor seals are also known as common seals and are one of the most widely distributed pinnipeds in the world and the most common seal in U.S. Atlantic waters. They are typically less than 2 m in length and occur principally in temperate to polar coastal waters of North America, Europe, and eastern Asia (Jefferson et al., 2015). In the northwestern Atlantic Ocean, harbor seals occur from eastern Canada through Maine waters year-round and seasonally southward to southern New England and mid-Atlantic waters (Schroeder, 2000; Rees et al., 2016; Toth et al., 2018). The Western North Atlantic stock of harbor seals consists of 61,336 seals (Hayes et al., 2023).

Harbor seals were recorded swimming from 4.1 to 4.5 kph during dives in the St. Lawrence Estuary (Lesage et al. 1999). Maximum swim speeds for harbor seals have been recorded over 13 kph (Bigg, 1981). In general, harbor seals dive for less than 10 min and above 150 m of water depth (Jefferson et al., 2015). Lesage et al. (1999) found that more than half of harbor seals dives in the St. Lawrence Estuary were to water depths less than 4 m and dives to waters greater than 4 m were predominantly foraging dives. Hastings et al. (2004) found that most harbor seal dives in the Gulf of Alaska were less than 4 min in duration and to water depths less than 20 m. The deepest diving harbor seal was reported to have dove to a water depth of 481 m, with the longest dive lasting 35 min (Eguchi and Harvey, 2005).

The harbor seal can hear sounds in the range of 75 Hz to a maximum of 180 kHz (Kastak and Schusterman, 1998; Terhune, 1991). Underwater hearing thresholds are ~ 53 dB @ 4 kHz (Kastelein et al., 2010). Harbor seals produce a variety of sounds including clicks, groans, grunts, and creaks that range in frequency from 0.1 to 7 kHz, although clicks can range from 8 to more than 150 kHz, with dominant frequencies between 12 and 40 kHz (Hanggi and Schusterman, 1994), Richardson et al., 1995).

5.2 Modeled Sea Turtles

Four species of sea turtles potentially occur in the waters of the Project area, at least seasonally. These sea turtles are all classified as either threatened or endangered under the ESA.

5.2.1 Green Turtle (*Chelonia mydas*)

Eleven distinct population segments (DPSs) for the green turtle have been designated worldwide as either threatened or endangered under the ESA (NOAA, 2016). Green turtles potentially occurring in the project area are part of the North Atlantic DPS, which is listed as threatened. The ESA critical habitat in the coastal waters around Culebra Island, Puerto Rico and its outlying keys established in 1998 remains in effect for the North Atlantic DPS. The global population of the green turtle is estimated at 570,926 turtles, while the North Atlantic DPS has an estimated population of 167,424 individuals (NOAA, 2016).

Green turtles are widespread throughout tropical, subtropical, and warm-temperate waters of the Atlantic, Pacific, and Indian oceans and Mediterranean Sea between 30° N and 30°S (Lazell, 1980). Except during the juvenile lifestage and adult migrations when green turtles are found in the oceanic environment, green turtles principally inhabit the neritic zone, typically occurring in nearshore and inshore waters where they forage primarily on sea grasses and algae (Mortimer, 1982). The nesting of green turtles occurs on nearly 1,800 nesting beaches worldwide in over 80 countries (Hirth, 1997; Pike, 2013).

Green turtles typically make shallow and short-duration dives to no more than 30 m for <23 min but dives more than 138 m and for durations of 307 min have been recorded, with these deeper dives usually occurring during winter (Blanco et al., 2013, Hays et al., 2000, Hochscheid et al., 1999, Rice and Balazs, 2008). Godley et al. (2002) reported travel speeds for green turtles ranging from 0.6 to 2.8 kph, with faster swim speeds associated with traverse across deeper, open waters. Song et al. (2002) reported average swimming speeds ranging from 1.4 to 3 kph for migrating green turtles.

Juvenile green sea turtles have a narrow range of low frequency underwater hearing, from 50 to 1,600 Hz, with the best sensitivity between 200 and 400 Hz and an averaged threshold of 95 to 96 dB re 1 µPa (RMS) (Piniak et al., 2016). Ketten and Bartol (2006) found that juvenile green turtles exhibited a somewhat broader hearing range than sub-adult green turtles, whose hearing was measured at 100 to 500 Hz. Charrier et al. (2022) observed that juvenile green turtles produce 10 different types of sound that can be classified as pulses, calls, squeaks, and frequency modulated sounds, with the frequency characteristics of the generated sounds in the range of their measured hearing.

5.2.2 Kemp's Ridley Turtle (*Lepidochelys kempii*)

The Kemp's ridley turtle is the rarest sea turtle worldwide and has the most restricted distribution. The Kemp's ridley turtle is listed as endangered throughout their range under the ESA with no designated critical habitat. Although abundance information for the Kemp's ridley turtle is sparse, the 2012 estimated population of female Kemp's ridley turtles 2 years and older was 248,307 turtles with 10,987 nests reported in 2014 (NMFS and USFWS, 2015).

Kemp's ridley turtles are found primarily in the neritic waters along the U.S. and Mexico coasts of the Gulf of Mexico and western North Atlantic Ocean (Byles and Plotkin 1994, Marquez-M. 1994, Plotkin 2003). Adult females make relatively short annual migrations from their feeding grounds in the western Atlantic and Gulf of Mexico to their principal nesting beach at Rancho Nuevo, Mexico. Unique among sea turtles, adult males are non-migratory, remaining resident in coastal waters near Rancho Nuevo year-round. In contrast, juvenile Kemp's ridleys make longer migrations between their winter-feeding grounds in the Gulf of Mexico and Florida to their summer feeding grounds in coastal waters and embayments of the U.S. East Coast. Kemp's ridley turtles participate in arribada nesting, with the major arribada nesting site at Rancho Nuevo; however, solitary nesting has been recorded at 10 beaches along 193 km of Mexican shoreline in Tamaulipas and another 20 mi (32 km) in Veracruz, Mexico.

Kemp's ridleys make shallow dives (<164 ft [<50 m]) of short duration (12 to 18 min) (Lutcavage and Lutz 1997). Renaud (1995) reported the mean dive duration as 33.7 min, with 84 percent of the submergences <60 min. Mean swimming speeds were reported to range from 0.4 to 0.7 kt (0.7 to 1.3 kph), with over 95% of the actual velocity values <2.7 kt (<5 kph) (Renaud, 1995).

Kemp ridley turtles appear to have the most restricted hearing range (100 to 500 Hz) with their best hearing sensitivity between 100 and 200 Hz(Ketten & Bartol. 2006). Ferrara et al. (2019) found that Kemp's ridley hatchlings produced underwater sounds, most of which showed peak frequencies between 560 and 750 Hz, which is above the hearing range measured by Ketten and Bartol (2006).

5.2.3 Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the largest turtle in the world and one of the largest living reptiles. As a species, the leatherback is listed endangered throughout its range under the ESA. Critical habitat for the leatherback turtle has been designated in the Caribbean Sea waters adjacent to Sandy Point Beach, St. Croix, U.S. Virgin Islands, as well as in the northeast Pacific Ocean waters from California to Washington (NOAA 1979, 2012). Nel (2012) reported the worldwide leatherback abundance as 57,147 to 61,256 nests annually. The subpopulation of leatherback turtles in the northwest Atlantic Ocean is the largest in the world, with an estimated 34,000 to

94,000 individuals (The Turtle Expert Working Group, 2007) and 50,842 nests per year (Wallace et al., 2013).

Leatherbacks are the most pelagic and most widely distributed of any sea turtle and can be found circumglobally in temperate and tropical oceans (Spotila, 2004). The largest Atlantic nesting sites are located in Gabon, Africa and Trinidad, Caribbean Sea (Wallace et al., 2013). Highly migratory, leatherbacks in the western Atlantic travel north in the spring, following the Gulf Stream and feeding opportunistically, arriving in continental shelf and coastal waters off New England and Atlantic Canada where they remain through October. In the fall, some leatherbacks head south essentially retracing their offshore migratory route while others cross the Atlantic to Great Britain and migrate south along the eastern Atlantic (James et al., 2005).

Leatherback turtles make the deepest dives of any sea turtle, with the deepest dive recorded at 4,198 ft (1,280 m) (Doyle et al., 2008). Their longest duration dive was 86.5 min, but most dives are no more than 40 min (Byrne et al., 2009; López-Mendilaharsua et al., 2009; Sale et al., 2006). Hougthon et al. (2008) found that 99.6 percent of leatherback dives were to water depths less than 300 m while only a 0.4 percent were to deeper water depths, with the dives to waters >300 m occurring principally during the day and during migrational transit. In the Atlantic, Hays et al. (2004) determined that migrating and foraging adult leatherbacks spent 71 to 94 percent of their diving time at depths from 70 to 110 m. The modal speeds of swimming leatherback turtles ranged between 2 to 3 kph with absolute maximum speeds in the range of 6.5 to 10 kph (Eckert, 2002). Inter-nesting leatherback turtles swam at speeds ranging from 1.25 to 2.5 kph (Byrne et al., 2009).

Leatherback hatchlings can hear both underwater and in air, and were found to detect sound from 50 to 1,200 Hz underwater, with best hearing sensitivty was between 100 and 400 Hz with a threshold of 84 dB re 1µPa^2 at 300 Hz (Dow Piniak et al., 2012). Cook and Forest (2005) noted that female leatherbacks make broadband sounds when ashore during nesting, including breath noises, grunts, and gular pumps that ranged in frequency from 300 to 500 Hz. Hatchlings also produce sounds when in their nests but no underwater sound production by any lifestage of leatherbacks has been documented Ferrara et al. (2014).

5.2.4 Loggerhead Turtle (*Caretta caretta*)

Five loggerhead DPS are listed as endangered under the ESA while four DPS are listed as threatened (NOAA and USFWS 2011). Only members of the threatened Northwest Atlantic Ocean DPS occur in the project area. In 2014, critical habitat was designated for the Northwest Atlantic Ocean DPS in the northwestern Atlantic Ocean and the Gulf of Mexico that includes nearshore reproductive habitat, winter habitat, breeding areas, constricted migratory corridors, and *Sargassum* habitat (NOAA, 2014). Critical habitat for the Northwest Atlantic Ocean DPS additionally includes 38 marine areas along the coastlines and offshore of North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, and Texas (DoI, 2014). Casale and Tucker (2017) estimated the minimum global population of loggerhead turtles as 200,246 individuals. One of the two major global populations occurs in southeastern U.S. and northern Gulf of Mexico waters, with the number of U.S. nests estimated at approximately 68,000 to 90,000 nests per year. The largest concentration of loggerhead female turtles in the Northwest Atlantic DPS nest along the coast of Florida. The most recent Florida count of 53,000 loggerhead nests was reported in 2019, down from the 2016 count of 65,807 nests (FFWCC, 2019). The nesting population in Florida had declined sharply, but since 2007, the nesting population of female loggerheads in Florida has increased by 65 percent (FFWCC, 2019).

Loggerhead turtles are found in coastal to oceanic temperate, tropical, and subtropical waters of the Atlantic, Pacific, and Indian oceans and the Mediterranean Sea (Dodd, 1988). Although loggerhead turtles are highly migratory, no movements across the equator are known, and loggerheads migrate hundreds to thousands of miles between feeding and nesting grounds.

Howell et al. (2010) found that more than 80 percent the time, loggerheads in the North Pacific Ocean dove to water depths <5 m, but 90 percent of their time was spent diving to depths <15 m). Even as larger juveniles and adults, loggerheads' routine dives are only to 9 to 22 m (Lutcavage and Lutz, 1997). Migrating male loggerheads along the U.S. East Coast dove to water depths of 20 to 40 m (Arendt et al., 2012). An adult loggerhead made the deepest recorded dive to 764 ft (233 m), staying submerged for 8 min (Sakamoto et al., 1990). The longest duration dive by a loggerhead turtle was 614 min during deep-bottom resting dives (Broderick et al. 2007). Sakamoto et al. (1990) reported loggerhead diving speeds ranging from 0.75 to 3.5 kph, while migrating females swam at minimum speeds of 0.75 to 1.7 kph (Godley et al., 2003).

The underwater hearing of a single adult loggerhead was measured from 50 to 3200 Hz using auditory evoked potential methods and from 50 to 1131 Hz using behavioral methods (Martin et al. 2012). Bartol and Bartol (2011) found that the hearing range using both auditory evoked potential and behavioral methods was the same, 50 to 1,200 Hz, in both post-hatchling and juvenile loggerhead turtles.

5.3 Marine Mammal and Sea Turtle Density Derivation

Population estimates are a necessary part of the analysis process to estimate the effect that acoustic exposure has on the potentially occurring protected marine mammals and sea turtles in an area. Density estimates for each marine mammal species (or species group) were derived for each month (or annually for some species) while sea turtle density estimates were only available by season.

For use in impact pile driving modeling, marine mammal and sea turtle densities were estimated for the buffered Atlantic Shores North Lease Area 0549. The buffer distance applied to the perimeter of Lease Area 0549 was the largest acoustic range to a regulatory threshold for the pile driving hammer sources proposed for use in the project, which was 7.1 km (4.4 miles). This distance of 7.1 km was buffered (i.e., added) onto the outer lease area boundary (Figure 11), and marine mammal and sea turtle densities were derived for all impact pile driving construction activities by taking the mean of the monthly densities in all grid cells within this buffered area.

For use in the landfall modeling and analysis for the cofferdam/conductor barrel/goal post, marine mammal densities were estimated for the buffered model sites at Wolfe's Pond, NY and Monmouth, NJ. The buffer distances of 1,650 m

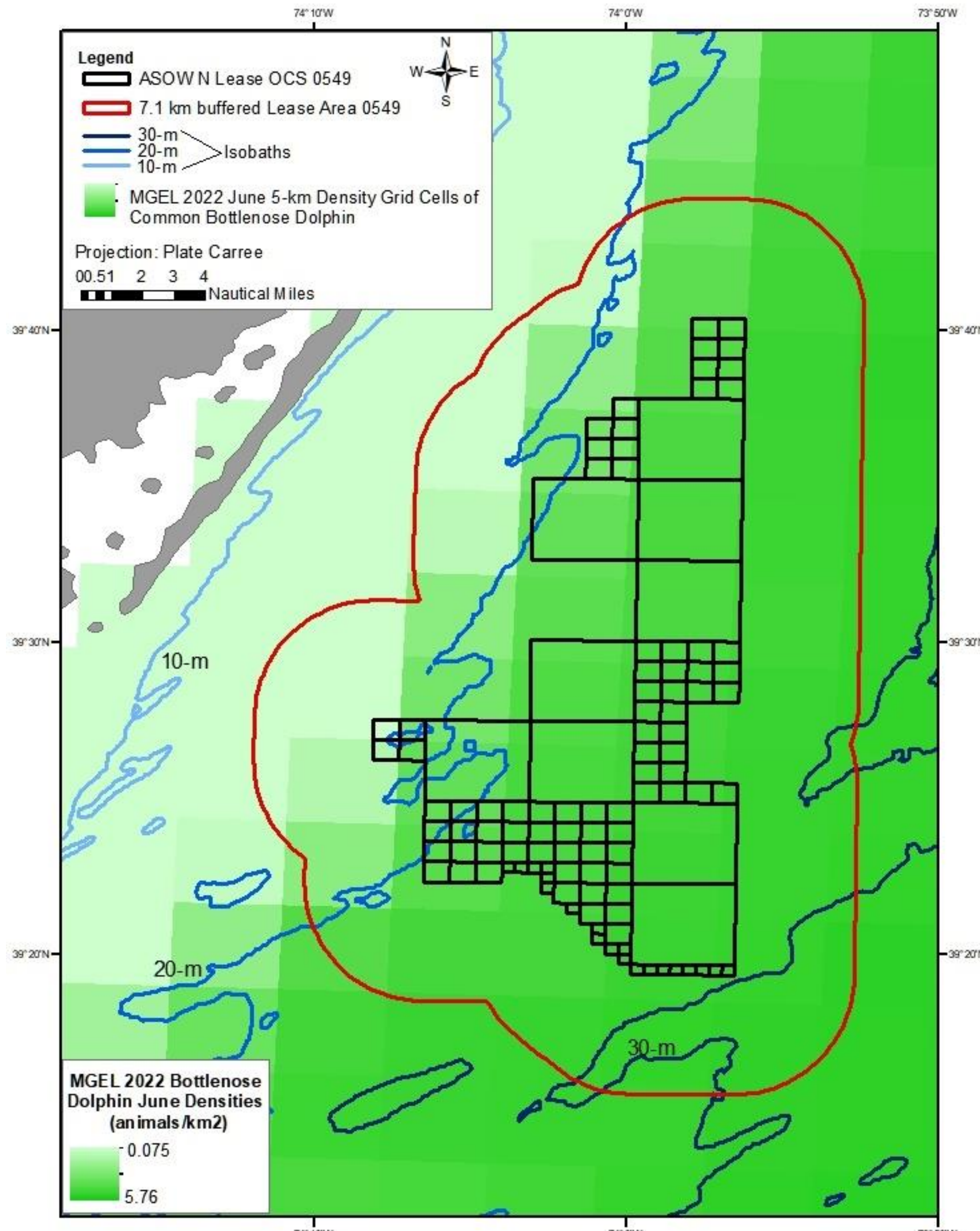

Figure 11. MGEL (2022) June Density Surface Showing the5-km Density Grid Cells for the Common Bottlenose Dolphin in the 7.1-km Buffered Lease Area for the Atlantic Shores North Project; Only the Grid Cells Within the Buffered Lease Area Are Included in the Monthly Density Estimate.

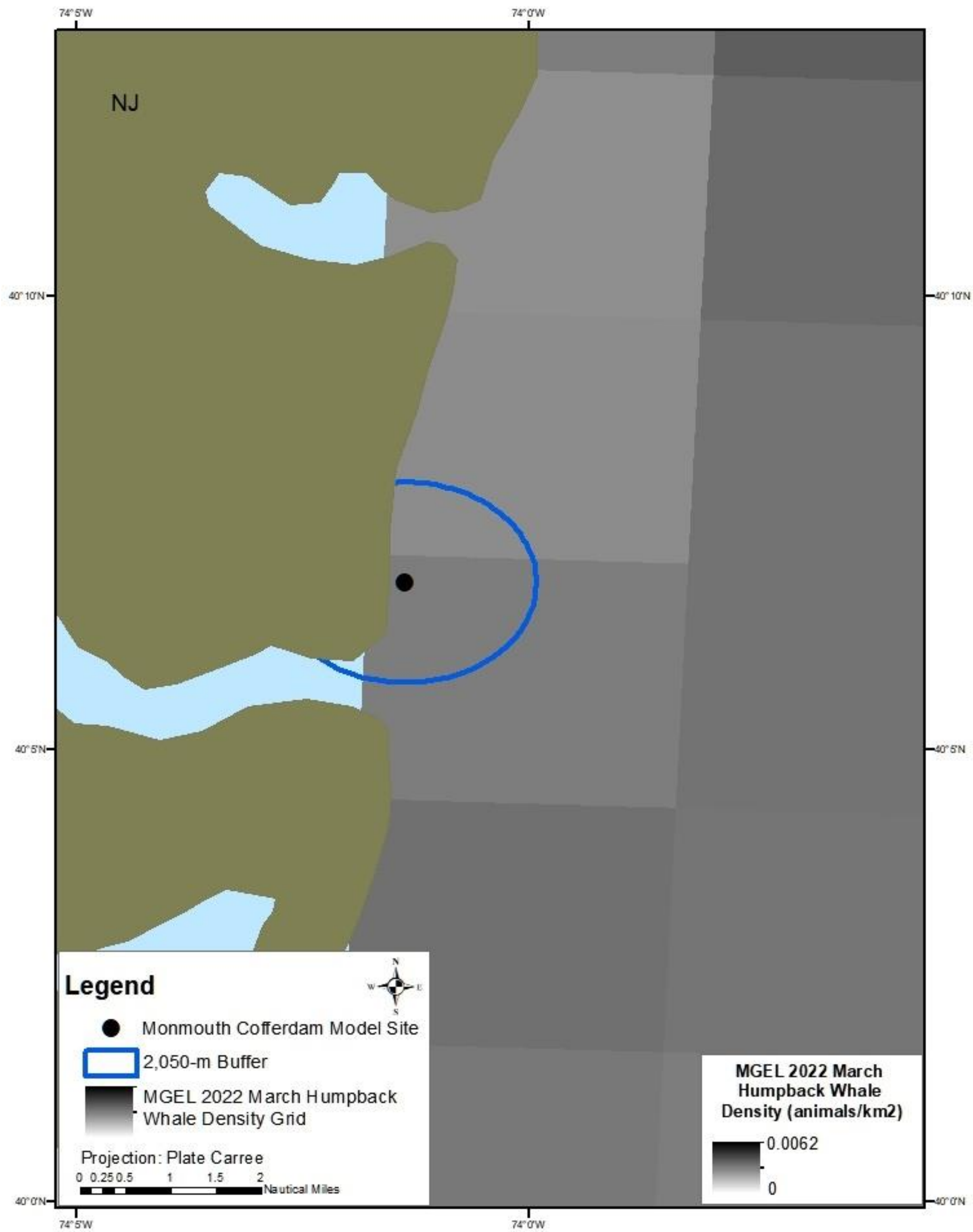

Figure 12. MGEL (2022) March Density Surface Showing the5-km Density Grid Cells for the Humpback Whale in the 2,050-m Buffered Monmouth, NJ Cofferdam Model Area for the Atlantic Shores North Project; Only the Grid Cells Within the Buffered Area Are Included in the Monthly Density Estimate.

and 2,050 m, respectively, were applied to the Wolfe's Pond and Monmouth model sites for the cofferdam modeling (Figure 12). The buffer distances of 2,985 m and 12,385 m, respectively, were applied to the Wolfe's Pond and Monmouth model sites for the goal post modeling. The buffer distances of 400 m and 820 m, respectively, were applied to the Wolfe's Pond and Monmouth model sites for the conductor barrel modeling. These buffer distances represent the largest acoustic range to a regulatory threshold for each model site. Marine mammal densities were derived at these representative model sites by taking the mean of the monthly densities in all grid cells that are within the buffered areas.

5.3.1 Marine Mammal Density Derivation

The Marine Geospatial Ecology Laboratory (MGEL) (2022) marine mammal density estimates represent the best available marine mammal data for the Project area; the methodology by which the MGEL densities were derived is described in Roberts et al. (2016). MGEL monthly (or annual for some species) density data are delineated in 5 km square grid cells in U.S. Atlantic waters and by species or species groups with discrete density designated for each monthly (or annual) grid cell within the MGEL datasets. To determine the marine mammal densities for the Project area or the cofferdam model areas, marine mammal densities were compiled for the buffered areas for all pile driving activities. The MGEL grid cell densities within the buffered lease area or model areas were averaged for each month to provide mean monthly densities for each marine mammal species/species group (or an annual density); only grid cells within the boundary of the buffered lease or model areas were included in the density estimate (Figures 9 and 10).

For the pilot whales, only annual density estimates are available in MGEL (2022), as insufficient information on their populations is available to derive monthly density estimates. For the pilot whales species, the annual mean density estimate was used as an input for each month of the modeling periods. Additionally, in the MGEL density dataset, densities are only available for the generalized groups of seals and pilot whales rather than for the individual species of harbor and gray seals as well as short-finned and long-finned pilot whales. To obtain density estimates for each of these individual species that were treated as a group in the MGEL 2022 database, the MGEL (2022) group density (i.e., seals or pilot whales densities) was scaled by the abundances of each of the individual species (Hayes et al. 2023), using the following equation, with the harbor seal as an example:

$$\rho_{\text{harbor seal}}=\rho_{\text{MGEL(both)}}*(a_{\text{harbor seal}}/(a_{\text{harbor seal}}+a_{\text{gray seal}})) \tag{8}$$

where ρ represents density and *a* represents abundance. These abundance-scaled density estimates provide realistic and species-specific density estimates annually or monthly for each of the grouped species.

Two stocks of common bottlenose dolphin (Northern Migratory Coastal and Offshore) are present within the Project area, but density estimates are only available in the MGEL density data for the bottlenose species in its entirety. Hayes et al. (2021) defines the boundary between the Western North Atlantic, Northern Migratory Coastal stock and the Western North Atlantic, Offshore stock of common bottlenose dolphins as the 20-m isobath north of Cape Hatteras, NC.

Thus, the 20-m isobath was used to define and differentiate the stock boundaries of the common bottlenose within the MGEL (2022) data and derive density estimates for each stock of the bottlenose dolphin. The 20-m isobath transects only the western portion of the lease area (Figure 9). All bottlenose dolphin density grids cells <20 m in the buffered lease area were used to calculate the monthly density estimates of the Northern Migratory Coastal stock of bottlenose dolphins while all density grid cells >20 m in the buffered lease area were used to calculate the density of the Offshore stock of bottlenose dolphins (Table 12). Since both landfall model sites are in shallow waters <20-m in depth, all bottlenose dolphins occurring in the landfall model areas (for cofferdam, conductor barrel, and goal post modeling) were attributed solely to the Northern Migratory Coastal stock of bottlenose dolphins (Tables 14, 15, and 16).

5.3.2 Sea Turtle Density Derivation

The best available sea turtle densities for the Project area are available from Duke University's MGEL, (DiMatteo et al. 2023) (Table 13), which were prepared for the U.S. Navy for the Atlantic U.S. waters. The densities were available in 10 x10 kilometer grid cells, the resolution of which aligned with the environmental covariates used in the density modeling. The sea turtle density estimates in each grid cell represent the monthly mean, averaged for the period from 2003 to 2019, except for the green turtle, which covered the period from 2010 to 2019. Densities were estimated using a density surface model that correlated local abundances observed during systematic line transect surveys with environmental conditions observed at that same location and time. For unsurveyed areas and times, densities were estimated by extrapolation.

5.4 PROTECTED MARINE HABITATS

5.4.1.1 Essential Fish Habitat

Essential fish habitat (EFH) for species of managed species of fish and invertebrates is found in the Project area. The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) ensure protection of marine habitat essential to the production of federally managed marine and anadromous species within the U.S. EEZ. Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. §1802[10]). Soft bottom, hard bottom, and pelagic types of EFH have been designated in the region in which the Project area is located. Various lifestages of species that utilize these types of occurring habitat have EFH designated by a fishery management council. A full description of the EFH designated for the Project area may be found in the COP for the Atlantic Shores North Project.

6 RESULTS

The following sections include the results of all acoustic and animat modeling conducted on impact and vibratory pile driving activities planned for the Project area.

6.1 OTHER SOUND SOURCES

Noise associated with construction vessels operating in the project area may affect the ambient noise environment episodically. The actual number of construction-related vessels operating in the Project area is unknown at this time and will depend on the Project's final construction schedule. As noted, vessels will make trips to and from the Project area for bunkering and provisioning and may otherwise remain in the Project area for days or weeks at a time. Marine animals in the Project area are expected to be already habituated to the types and levels of sounds produced by the Project's construction vessel traffic, given the relatively high level of existing vessel traffic in the area. Sound produced by transiting Project vessels would be like existing, ongoing vessel noise. Much of vessel activity and their associated sounds would be from slow-moving or stationary vessels when thrusters may be used for relatively short durations of station-keeping. The sound levels resulting from station-keeping are similar to those due to transiting vessels.

Like most ocean areas near any continental margins, the ambient noise environment of the Project area is dominated by noise from ships. Most of the underwater sound generated by ships is low frequency (<1,000 Hz), with most ship noise resulting from propeller cavitation that dominates the <200 Hz frequency range (Ross, 1976). The noise ships produce results not only from the type of engine and propeller systems used but also from the speeds at which the ships travel. Generally, larger (>328 ft [100 m]), faster moving vessels generate more intense LF underwater sound than smaller, slower moving vessels or boats (Frankel and Gabriele, 2017; Southall et al., 2018).

Most research on ship noise is from large vessels, fishing vessels, or small boats. Underwater sound from smaller fishing vessels (15 to 46 m), which would be of comparable size to the construction vessels likely to be operating in the Project area during the construction season can travel at speeds from 13 to 18.4 kph. Sounds from small fishing vessels with frequencies ranging from 1.1 to 1.9 kHz have been reported with peak received levels of 137.6 131.2 dB re 1 µPa (Amron et al., 2021). Parsons et al. (2021) reported that estimated source levels for fishing vessels ranged from 145 to 195 dB re 1 µPa-m. While the construction vessels will produce some underwater noise, the lower speed at which the vessels will typically operate in the Project area is likely result in the addition of only transient and low levels of noise that will be limited to small areas with the overall Project area. These levels will add less to the ambient noise environment than the majority of other ocean-going vessels.

6.1.1 Potential for Noise Effects on Protected Marine Essential Fish Habitat

Adverse impacts to EFH are defined as "any impact that reduces quality and/or quantity of EFH"; adverse impacts include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR §600). Vessel noise generated by the construction vessels operating in the Project area would be low frequency and only added to the ambient noise environment for very brief time periods. Thus, the effect of construction vessel noise is to ephemerally increase the ambient noise environment in very limited areas.

There is no potential for physical or chemical alterations of the water or substrate from sound transmissions, and there is no potential for loss of or injury to benthic organisms or prey species since they have little or no sensitivity to low frequency sound. Therefore, there is little to no potential for impacts to the quality or quantity of EFH from the ephemeral addition and limited areas of construction vessel noise. Thus, no adverse impacts on any type of EFH are reasonably expected from exposure to construction vessel noise.

6.2 Modeled Acoustic Source Levels

The source levels for the unmitigated impact pile driving of 10-m and 15-m monopiles, 5-m pre- and post-piled pin pile, and vibratory pile driving of sheet piles were derived, as detailed in Sections 2.3.1 and 2.3.2 (Table 17).

Table 17. Broadband Source Levels of the Maximum Modeled Hammer Strike Energies of each Impact and Vibratory Pile Driving Source and Scenario.

Source Scenario/Maximum Strike Energy	***Model Site***	***Broadband Source Levels***		
		SEL_{ss} or $SEL_{1\text{-}sec}$ (dB re 1 µPa^2-m^2-s)	***Peak SPL (dB re 1 µPa-m)***	***SPL_{rms} (dB re 1 µPa-m)***
10-m monopiles (impact pile driving)/3,066 kJ	Shallow	230	281	240
	Deep	224	273	234
15-m monopile (impact pile driving)/3,015 kJ	Shallow	232	284	242
	Deep	226	275	236
5-m Pre-Pin Piles (impact pile driving)/1,904 kJ	Shallow	223	271	233
	Deep	210	254	220
5-m Post Pin Piles (impact pile driving)/1,904 kJ	Shallow	225	273	235
	Deep	212	256	222
Sheet Piles (vibratory pile driving)	Monmouth, NJ and Wolfe's Pond, NY	170	NA	170

6.3 Modeled Ranges to Acoustic Thresholds for Impact Pile Driving of Foundations

Acoustic ranges to the regulatory thresholds for marine mammals, sea turtles, and fish have been calculated based on the results of the acoustic modeling for all impact pile driving scenarios for each of the two model sites. A description of how these ranges were calculated is provided in Section 3.1.1.

6.3.1 PTS Injury Acoustic Ranges for Marine Mammals and Sea Turtles

Acoustic ranges to marine mammal and sea turtle regulatory thresholds were calculated for the unmitigated and mitigated (three sound attenuation levels of 6, 10, and 15 dB) sound levels for each model site (shallow and deep). Acoustic ranges to the 95th percentile for marine mammals and sea turtles to PTS thresholds for the shallow and deep model sites (Tables 18 and 19, respectively) and have been derived.

6.3.2 PTS Injury and TTS Acoustic Ranges for Fish

Acoustic ranges to fish regulatory thresholds were calculated for the unmitigated and mitigated (three sound attenuation levels of 6, 10, and 15 dB) sound levels for each model site (shallow and deep). Acoustic ranges to the 95th percentile for marine mammals and sea turtles to PTS and TTS thresholds for the shallow (Tables 20 and 21) and deep model (Tables 22 and 23) sites, respectively have been derived.

6.3.3 Behavioral Acoustic Ranges for Marine Mammals, Sea Turtles, and Fish

Acoustic ranges to the behavior regulatory thresholds for marine mammals, sea turtles, and fishes were calculated for the unmitigated and mitigated (three sound attenuation levels of 6, 10, and 15 dB) sound levels for each model site (shallow and deep). Acoustic ranges to the 95th percentile for the behavior thresholds for the shallow and deep model sites (Tables 24 and 25, respectively) have been derived for marine mammals, sea turtles, and fish.

6.4 Modeled Ranges to Acoustic Thresholds for Impact Pile Driving of Conductor Barrel

Acoustic ranges to the regulatory thresholds for marine mammals, sea turtles, and fish have been calculated based on the results of the acoustic modeling for the impact pile driving of the conductor barrel at two model sites. A description of how these ranges were calculated is provided in Section 3.1.1.

Acoustic ranges to marine mammal and sea turtle regulatory thresholds were calculated for the unmitigated sound levels for each model site (Monmouth and Wolfe's Pond) (Table 26). Acoustic ranges to fish regulatory thresholds were calculated for the unmitigated sound levels for each model site (Monmouth and Wolfe's Pond) (Tables 27 and 28). Acoustic ranges to the behavioral regulatory thresholds for marine mammals, sea turtles, and fishes were calculated for the unmitigated sound levels for each model site (Table 29).

6.5 Modeled Ranges to Acoustic Thresholds for Vibratory Pile Driving

6.5.1 Cofferdam Installation/Extraction

Acoustic ranges to the regulatory thresholds for marine mammals, sea turtles, and fish have been calculated based on the results of the acoustic modeling for the vibratory pile driving of the cofferdam for each of the two model sites. A description of how these ranges were calculated is provided in Section 3.1.1.

Table 18. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Shallow Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS Thresholds for Marine Mammals (NMFS, 2018) and Sea Turtles (DoN, 2017) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) Thresholds are Unweighted While the SEL (L_E) Thresholds are Weighted According to the Hearing Group and are Accumulated over 24-hrs.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Acoustic ranges (m) to PTS thresholds for marine mammals and sea turtles**									
			LFC		*MFC*		*HFC*		*PW*		*TU*	
			183 dB L_E	*219 dB L_{pk}*	*185 dB L_E*	*230 dB L_{pk}*	*155 dB L_E*	*202 dB L_{pk}*	*185 dB L_E*	*218 dB L_{pk}*	*204 dB L_E*	*232 dB L_{pk}*
10-m monopile	May - Aug	0	5,085	350	<50	100	350	1,500	750	350	1,500	<50
		6	3,285	150	<50	<50	150	950	300	200	800	<50
		10	2,300	100	<50	<50	100	700	<50	150	450	<50
		15	1,435	<50	<50	<50	<50	400	<50	<50	200	<50
	Sep-Nov	0	4,585	300	<50	100	300	1,400	735	350	1,450	<50
		6	2,950	150	<50	<50	150	900	300	200	750	<50
		10	2,135	100	<50	<50	<50	650	150	100	450	<50
		15	1,350	<50	<50	<50	<50	400	<50	<50	200	<50
	Dec	0	5,435	300	<50	<50	300	1,500	750	350	1,600	<50
		6	3,535	<50	<50	<50	150	950	250	150	800	<50
		10	2,450	<50	<50	<50	100	735	<50	<50	400	<50
		15	1,500	<50	<50	<50	<50	350	<50	<50	150	<50
15-m monopile	May - Aug	0	6,735	350	<50	150	450	1,600	1,200	400	2,235	100
		6	4,485	200	<50	<50	200	1,050	585	200	1,250	<50
		10	3,285	150	<50	<50	150	750	300	150	800	<50
		15	2,100	<50	<50	<50	<50	450	150	<50	400	<50
	Sep-Nov	0	5,950	350	<50	100	400	1,500	1,150	400	2,100	100
		6	4,000	200	<50	50	200	1,000	550	200	1,150	<50
		10	2,985	150	<50	50	150	700	300	150	750	<50
		15	1,985	<50	<50	50	<50	450	150	<50	350	<50
	Dec	0	7,300	350	<50	50	435	1,700	1,250	400	2,400	<50
		6	4,870	150	<50	50	200	1,150	600	200	1,250	<50
		10	3,600	<50	<50	50	100	850	250	<50	800	<50
		15	2,250	<50	<50	50	100	550	<50	<50	350	<50

Table 18. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Shallow Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS Thresholds for Marine Mammals (NMFS, 2018) and Sea Turtles (DoN, 2017) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) Thresholds are Unweighted While the SEL (L_E) Thresholds are Weighted According to the Hearing Group and are Accumulated over 24-hrs.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Acoustic ranges (m) to PTS thresholds for marine mammals and sea turtles**									
			LFC		*MFC*		*HFC*		*PW*		*TU*	
			183 dB L_E	*219 dB L_{pk}*	*185 dB L_E*	*230 dB L_{pk}*	*155 dB L_E*	*202 dB L_{pk}*	*185 dB L_E*	*218 dB L_{pk}*	*204 dB L_E*	*232 dB L_{pk}*
Jacket (5-m pre-piled pin piles)	May - Aug	0	2,250	<50	<50	<50	<50	250	200	<50	500	<50
		6	1,350	<50	<50	<50	<50	150	<50	<50	200	<50
		10	850	<50	<50	<50	<50	<50	<50	<50	100	<50
		15	450	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Sept-Nov	0	2,100	<50	<50	<50	<50	250	150	<50	450	<50
		6	1,250	<50	<50	<50	<50	150	<50	<50	200	<50
		10	800	<50	<50	<50	<50	<50	<50	<50	100	<50
		15	400	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Dec	0	2,300	<50	<50	<50	<50	<50	<50	<50	400	<50
		6	1,350	<50	<50	<50	<50	<50	<50	<50	<50	<50
		10	950	<50	<50	<50	<50	<50	<50	<50	<50	<50
		15	350	<50	<50	<50	<50	<50	<50	<50	<50	<50
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	2,650	<50	<50	<50	<50	300	250	<50	650	<50
		6	1,600	<50	<50	<50	<50	200	100	<50	250	<50
		10	1,085	<50	<50	<50	<50	100	<50	<50	150	<50
		15	585	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Sep-Nov	0	2,450	<50	<50	<50	<50	300	250	<50	600	<50
		6	1,500	<50	<50	<50	<50	200	100	<50	250	<50
		10	1,000	<50	<50	<50	<50	<50	<50	<50	150	<50
		15	550	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Dec	0	2,735	<50	<50	<50	<50	250	200	<50	650	<50
		6	1,600	<50	<50	<50	<50	<50	<50	<50	200	<50
		10	1,150	<50	<50	<50	<50	<50	<50	<50	<50	<50
		15	550	<50	<50	<50	<50	<50	<50	<50	<50	<50

*LFC= low frequency cetaceans; MFC=mid-frequency cetaceans; HFC=high frequency cetaceans; PW=phocid pinnipeds in water; TU=sea turtles

Table 19. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS Thresholds for Marine Mammals (NMFS, 2018) and Sea Turtles (DoN, 2017) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) Thresholds are Unweighted While the SEL (L_E) Thresholds are Weighted According to the Hearing Group and are Accumulated over 24-hrs.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Acoustic ranges (m) to PTS thresholds for marine mammals and sea turtles**									
			LFC		*MFC*		*HFC*		*PW*		*TU*	
			183 dB L_E	*219 dB L_{pk}*	*185 dB L_E*	*230 dB L_{pk}*	*155 dB L_E*	*202 dB L_{pk}*	*185 dB L_E*	*218 dB L_{pk}*	*204 dB L_E*	*232 dB L_{pk}*
10-m monopile	May - Aug	8	8,100	250	<50	<50	1,550	1,550	1,200	250	2,150	<50
		6	5,235	150	<50	<50	650	900	400	150	1,000	<50
		10	3,700	<50	<50	<50	450	600	200	100	500	<50
		15	2,150	<50	<50	<50	250	300	100	<50	200	<50
	Sep -Nov	0	7,135	250	<50	<50	1,135	1,500	1,085	250	1,950	<50
		6	4,635	150	<50	<50	600	850	400	150	935	<50
		10	3,300	<50	<50	<50	400	550	200	100	500	<50
		15	1,900	<50	<50	<50	200	300	100	<50	200	<50
	Dec	0	9,620	150	<50	<50	1,300	1,785	1,200	200	2,450	<50
		6	6,150	<50	<50	<50	600	950	400	<50	1,035	<50
		10	4,350	<50	<50	<50	435	600	200	<50	500	<50
		15	2,450	<50	<50	<50	200	250	<50	<50	200	<50
15-m monopile	May - Aug	0	12,205	300	100	<50	2,000	1,885	2,135	350	3,585	<50
		6	7,725	150	<50	<50	1,050	1,085	900	150	1,750	<50
		10	5,635	100	<50	<50	600	700	450	100	1,085	<50
		15	3,600	<50	<50	<50	300	400	200	50	450	<50
	Sep -Nov	0	9,870	300	<50	<50	1,450	1,700	1,885	350	3,200	<50
		6	6,600	150	<50	<50	785	1,050	850	150	1,700	<50
		10	4,985	100	<50	<50	500	700	435	100	1,000	<50
		15	3,200	<50	<50	<50	300	400	200	<50	450	<50
	Dec	0	13,905	200	<50	<50	1,850	2,100	2,285	250	4,250	<50
		6	8,735	<50	<50	<50	885	1,200	950	<50	2,000	<50
		10	6,485	<50	<50	<50	500	750	450	<50	1,185	<50
		15	4,250	<50	<50	<50	200	400	200	<50	450	<50

Table 19. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS Thresholds for Marine Mammals (NMFS, 2018) and Sea Turtles (DoN, 2017) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) Thresholds are Unweighted While the SEL (L_E) Thresholds are Weighted According to the Hearing Group and are Accumulated over 24-hrs.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Acoustic ranges (m) to PTS thresholds for marine mammals and sea turtles**									
			LFC		*MFC*		*HFC*		*PW*		*TU*	
			183 dB L_E	*219 dB L_{pk}*	*185 dB L_E*	*230 dB L_{pk}*	*155 dB L_E*	*202 dB L_{pk}*	*185 dB L_E*	*218 dB L_{pk}*	*204 dB L_E*	*232 dB L_{pk}*
Jacket (5-m pre-piled pin piles)	May - Aug	0	2,635	<50	<50	<50	550	<50	150	<50	250	<50
		6	1,235	<50	<50	<50	250	<50	<50	<50	100	<50
		10	650	<50	<50	<50	200	<50	<50	<50	<50	<50
		15	250	<50	<50	<50	100	<50	<50	<50	<50	<50
	Sep -Nov	0	2,350	<50	<50	<50	500	<50	150	<50	250	<50
		6	1,200	<50	<50	<50	200	<50	<50	<50	100	<50
		10	650	<50	<50	<50	150	<50	<50	<50	<50	<50
		15	250	<50	<50	<50	100	<50	<50	<50	<50	<50
	Dec	0	2,950	<50	<50	<50	500	<50	100	<50	250	<50
		6	1,350	<50	<50	<50	200	<50	<50	<50	<50	<50
		10	650	<50	<50	<50	150	<50	<50	<50	<50	<50
		15	250	<50	<50	<50	<50	<50	<50	<50	<50	<50
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	3,235	<50	<50	<50	650	100	200	<50	400	<50
		6	1,650	<50	<50	<50	300	<50	<50	<50	150	<50
		10	935	<50	<50	<50	200	<50	<50	<50	<50	<50
		15	400	<50	<50	<50	100	<50	<50	<50	<50	<50
	Sep -Nov	0	2,970	<50	<50	<50	585	100	200	<50	400	<50
		6	1,500	<50	<50	<50	300	<50	<50	<50	150	<50
		10	850	<50	<50	<50	200	<50	<50	<50	<50	<50
		15	400	<50	<50	<50	100	<50	<50	<50	<50	<50
	Dec	0	3,635	<50	<50	<50	600	<50	200	<50	400	<50
		6	1,785	<50	<50	<50	235	<50	<50	<50	<50	<50
		10	985	<50	<50	<50	200	<50	<50	<50	<50	<50
		15	400	<50	<50	<50	100	<50	<50	<50	<50	<50

*LFC= low frequency cetaceans; MFC=mid-frequency cetaceans; HFC=high frequency cetaceans; PW=phocid pinnipeds in water; TU=sea turtles

Table 20. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Shallow Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Founda-tion Type	Month	Sound Reduction Level (dB)	*Ranges (m) to Injury and TTS thresholds for fish*														
			Fish: No Swim Bladder					*Fish: Swim bladder not involved in hearing*					*Fish: Swim bladder involved in hearing*				
			Mortality and potential mortal injury		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*
			219 dB L_E	***213 dB L_{pk}***	***216 dB L_E***	***213 dB L_{pk}***	***186 dB L_E***	***210 dB L_E***	***207 dB L_{pk}***	***203 dB L_E***	***207 dB L_{pk}***	***186 dB L_E***	***207 dB L_E***	***207 dB L_{pk}***	***203 dB L_E***	***207 dB L_{pk}***	***186 dB L_E***
10-m monopile	May - Aug	0	500	600	785	600	7600	1500	1050	2750	1050	7600	2000	1050	2750	1050	7600
		6	200	350	350	350	5600	785	600	1650	600	5600	1100	600	1650	600	5600
		10	100	200	150	200	4500	450	400	1100	400	4500	700	400	1100	400	4500
		15	<50	150	85	150	3235	200	250	600	250	3235	350	250	600	250	3235
	Sep-Nov	0	500	600	700	600	6785	1400	1000	2535	1000	6785	1850	1000	2535	1000	6785
		6	200	300	300	300	5050	700	600	1500	600	5050	1050	600	1500	600	5050
		10	100	200	150	200	4050	435	400	1050	400	4050	650	400	1050	400	4050
		15	<50	100	<50	100	2950	200	235	550	235	2950	300	235	550	235	2950
	Dec	0	550	685	800	685	7935	1500	1050	2885	1050	7935	2035	1050	2885	1050	7935
		6	150	300	300	300	5935	800	685	1650	685	5935	1100	685	1650	685	5935
		10	<50	150	<50	150	4720	400	350	1100	350	4720	735	350	1100	350	4720
		15	<50	<50	<50	<50	3385	150	200	650	200	3385	300	200	650	200	3385
15-m monopile	May - Aug	0	850	700	1185	700	9085	2100	1150	3635	1150	9085	2685	1150	3635	1150	9085
		6	350	350	550	350	6920	1185	700	2300	700	6920	1600	700	2300	700	6920
		10	200	250	300	250	5550	750	450	1600	450	5550	1050	450	1600	450	5550
		15	100	150	150	150	4135	350	250	950	250	4135	550	250	950	250	4135
	Sep-Nov	0	800	650	1100	650	8085	1950	1050	3300	1050	8085	2485	1050	3300	1050	8085
		6	350	350	550	350	6150	1100	650	2100	650	6150	1500	650	2100	650	6150
		10	200	250	300	250	5000	700	450	1500	450	5000	1000	450	1500	450	5000
		15	100	150	150	150	3750	350	250	900	250	3750	550	250	900	250	3750
	Dec	0	950	785	1250	785	9635	2185	1200	3835	1200	9635	2835	1200	3835	1200	9635
		6	350	350	685	350	7285	1250	785	2385	785	7285	1685	785	2385	785	7285
		10	150	200	300	200	5885	850	550	1685	550	5885	1150	550	1685	550	5885

Table 20. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Shallow Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Founda-tion Type	*Month*	*Sound Reduction Level (dB)*	*Ranges (m) to Injury and TTS thresholds for fish*														
			Fish: No Swim Bladder					*Fish: Swim bladder not involved in hearing*					*Fish: Swim bladder involved in hearing*				
			Mortality and potential mortal injury		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*
			219 dB L_E	*213 dB L_{pk}*	*216 dB L_E*	*213 dB L_{pk}*	*186 dB L_E*	*210 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*	*207 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*
15-m	Dec	15	<50	<	<	<	4385	350	250	1050	250	4385	685	250	1050	250	4385
Jacket (5-m pre-piled pin piles)	May - August	0	200	<50	300	<50	4700	650	200	1350	200	4700	900	200	1350	200	4700
		6	<	<	100	<50	3250	300	<	700	<	3250	400	<	700	<50	3250
		10	<	<	<	<	2450	200	<	400	<	2450	250	<	400	<	2450
		15	<	<	<	<	1635	<50	<	250	<	1635	100	<	250	<	1635
	Sep-Nov	0	200	<	300	<	4250	550	200	1300	200	4250	850	200	1300	200	4250
		6	<	<	100	<	3000	300	<	650	<	3000	400	<	650	<	3000
		10	<	<	<	<	2285	200	<	400	<	2285	250	<	400	<	2285
		15	<	<	<	<	1550	<50	<	200	<	1550	100	<	200	<	1550
	Dec	0	<	<	200	<	4950	1050	<	1850	<	4950	1350	<	1850	<	4950
		6	<	<	<	<	3735	200	<	1150	<	3735	350	<	1150	<	3735
		10	<	<	<	<	3050	<50	<	350	<	3050	<	<	350	<	3050
		15	<	<	<50	<	2185	<50	<	50	<	2185	<	<	50	<	2185
OSS Jacket (5-m post-piled pin piles)	May - August	0	250	<	350	<	5200	800	200	1635	200	5200	1100	200	1635	200	5200
		6	<	<	200	<	3735	350	<50	900	<50	3735	550	<50	900	<50	3735
		10	<	<	<	<	2835	250	<	550	<	2835	335	<	550	<	2835
		15	<	<	<	<	1950	<50	<	300	<	1950	200	<	300	<	1950
	Sept-Nov	0	250	<	350	<	4700	750	200	1550	200	4700	1050	200	1550	200	4700
		6	<	<	200	<	3400	350	<	850	<	3400	500	<	850	<	3400
		10	<	<	<	<	2600	200	<	500	<	2600	300	<	500	<	2600
		15	<	<	<	<	1800	<50	<	300	<	1800	200	<	300	<	1800
	Dec	0	<	<	300	<	5385	1250	<	2185	<	5385	1600	<	2185	<	5385
		6	<	<	<50	<	4135	300	<	1350	<	4135	900	<	1350	<	4135

Table 20. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Shallow Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Founda-tion Type	*Month*	*Sound Reduction Level (dB)*	*Ranges (m) to Injury and TTS thresholds for fish*														
			Fish: No Swim Bladder					*Fish: Swim bladder not involved in hearing*					*Fish: Swim bladder involved in hearing*				
			Mortality and potential mortal injury		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*
			219 dB L_E	*213 dB L_{pk}*	*216 dB L_E*	*213 dB L_{pk}*	*186 dB L_E*	*210 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*	*207 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*
OSS Jacket	Dec	10	<	<	<	<	3385	<	<	900	<	3385	250	<	900	<	3385
		15	<	<	<	<	2600	<	<	200	<	2600	50	<	200	<	2600

Table 21. Acoustic Ranges (m) (95th Percentile) for the Impact Pile Driving at the Shallow Model Site to Injury Thresholds for Fish (FHWG, 2008) for the Atlantic Shores North Construction Period. The Peak (L_E) and Peak Injury (L_{pk}) thresholds are unweighted.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to injury thresholds for fish*			
			Fish ≥2 grams		*Fish <2 grams*	
			Injury		*Injury*	
			187 dB L_E	*206 dB L_{pk}*	*183 dB L_E*	*206 dB L_{pk}*
10-m monopile	May - Aug	0	7235	1150	8650	1150
		6	5350	700	6600	700
		10	4235	450	5350	450
		15	2950	250	3985	250
	Sep-Nov	0	6485	1050	7700	1050
		6	4800	650	5900	650
		10	3800	450	4800	450
		15	2735	250	3600	250
	Dec	0	7570	1150	9050	1150
		6	5620	735	6885	735
		10	4435	400	5620	400
		15	3100	200	4135	200
15-m monopile	May - Aug	0	8720	1235	10435	1235
		6	6600	750	7970	750
		10	5300	500	6600	500
		15	3900	300	4985	300
	Sep-Nov	0	7735	1150	9100	1150
		6	5835	700	7085	700
		10	4750	500	5835	500
		15	3550	300	4535	300
	Dec	0	9185	1300	11170	1300
		6	6885	850	8350	850
		10	5585	600	6885	600
		15	4085	300	5270	300
Jacket (5-m pre-piled pin piles)	May - Aug	0	4450	200	5450	200
		6	3050	50	3985	50
		10	2300	50	3050	50
		15	1500	50	2100	50
	Sep-Nov	0	4050	200	4935	200
		6	2800	50	3600	50
		10	2150	50	2800	50
		15	1400	50	1985	50
	Dec	0	4750	50	5635	50
		6	3550	50	4300	50
		10	2885	50	3550	50
		15	2000	50	2720	50

Table 21. Acoustic Ranges (m) (95th Percentile) for the Impact Pile Driving at the Shallow Model Site to Injury Thresholds for Fish (FHWG, 2008) for the Atlantic Shores North Construction Period. The Peak (L_E) and Peak Injury (L_{pk}) thresholds are unweighted.

Foundation Type	Months	Sound Reduction Level (dB)	Ranges (m) to injury thresholds for fish			
			Fish ≥2 grams		Fish <2 grams	
			Injury		Injury	
			187 dB L_E	206 dB L_{pk}	183 dB L_E	206 dB L_{pk}
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	4950	200	6035	200
		6	3485	100	4450	100
		10	2650	50	3485	50
		15	1800	50	2450	50
	Sep-Nov	0	4485	200	5435	200
		6	3200	50	4050	50
		10	2435	50	3200	50
		15	1685	50	2285	50
	Dec	0	5150	50	6185	50
		6	3935	50	4750	50
		10	3200	50	3935	50
		15	2420	50	3050	50

Table 22. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving of the Deep Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to Injury and TTS thresholds for fish*														
			Fish: No Swim Bladder					*Fish: Swim bladder not involved in hearing*					*Fish: Swim bladder involved in hearing*				
			Mortality and potential mortal injury		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*
			219 dB L_E	*213 dB L_{pk}*	*216 dB L_E*	*213 dB L_{pk}*	*186 dB L_E*	*210 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*	*207 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*
10-m monopile	May - Aug	0	400	500	650	500	11535	1550	1050	3285	1050	11535	2200	1050	3285	1050	11535
		6	150	250	250	250	7485	650	500	1800	500	7485	1050	500	1800	500	7485
		10	50	150	150	150	5650	350	300	1050	300	5650	600	300	1050	300	5650
		15	50	100	50	100	3935	150	150	500	150	3935	250	150	500	150	3935
	Sep-Nov	0	400	500	650	500	9435	1450	950	2950	950	9435	2000	950	2950	950	9435
		6	150	250	250	250	6485	650	500	1600	500	6485	1050	500	1600	500	6485
		10	50	150	150	150	4985	350	300	1050	300	4985	550	300	1050	300	4985
		15	50	100	50	100	3500	150	150	500	150	3500	250	150	500	150	3500
	Dec	0	400	500	735	500	13085	1750	1100	3935	1100	13085	2550	1100	3935	1100	13085
		6	50	150	150	150	8685	735	500	2000	500	8685	1200	500	2000	500	8685
		10	50	50	50	50	6735	250	250	1200	250	6735	600	250	1200	250	6735
		15	50	50	50	50	4700	50	50	500	50	4700	150	50	500	50	4700
15-m monopile	May - Aug	0	850	650	1300	650	15685	2600	1235	4835	1235	15685	3435	1235	4835	1235	15685
		6	300	300	500	300	10400	1300	650	2850	650	10400	1835	650	2850	650	10400
		10	150	200	250	200	7800	700	400	1835	400	7800	1100	400	1835	400	7800
		15	50	100	100	100	5550	300	200	1000	200	5550	500	200	1000	200	5550
	Sep-Nov	0	800	650	1200	650	12870	2350	1150	4250	1150	12870	3050	1150	4250	1150	12870
		6	300	300	500	300	8850	1200	650	2600	650	8850	1700	650	2600	650	8850
		10	150	200	250	200	6800	650	400	1700	400	6800	1050	400	1700	400	6800
		15	50	100	150	100	4935	300	200	900	200	4935	500	200	900	200	4935
	Dec	0	935	650	1435	650	18280	2950	1400	5635	1400	18280	4085	1400	5635	1400	18280
		6	200	200	500	200	12035	1435	650	3300	650	12035	2050	650	3300	650	12035

Table 22. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving of the Deep Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to Injury and TTS thresholds for fish*														
			Fish: No Swim Bladder					*Fish: Swim bladder not involved in hearing*					*Fish: Swim bladder involved in hearing*				
			Mortality and potential mortal injury		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*	*Mortality and potential mortal injury*		*Recoverable Injury*		*TTS*
			219 dB L_E	*213 dB L_{pk}*	*216 dB L_E*	*213 dB L_{pk}*	*186 dB L_E*	*210 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*	*207 dB L_E*	*207 dB L_{pk}*	*203 dB L_E*	*207 dB L_{pk}*	*186 dB L_E*
15-m monopile	Dec (Cont'd)	10	50	150	200	150	9070	750	400	2050	400	9070	1250	400	2050	400	9070
		15	50	50	50	50	6500	200	150	1035	150	6500	500	150	1035	150	6500
Jacket (5-m pre-piled pin piles)	May - Aug	0	50	50	50	50	4500	300	50	850	50	4500	450	50	850	50	4500
		6	50	50	50	50	2700	50	50	350	50	2700	200	50	350	50	2700
		10	50	50	50	50	1850	50	50	200	50	1850	50	50	200	50	1850
		15	50	50	50	50	1050	50	50	50	50	1050	50	50	50	50	1050
	Sep-Nov	0	50	50	50	50	4000	285	50	750	50	4000	400	50	750	50	4000
		6	50	50	50	50	2450	50	50	350	50	2450	200	50	350	50	2450
		10	50	50	50	50	1735	50	50	200	50	1735	50	50	200	50	1735
		15	50	50	50	50	1035	50	50	50	50	1035	50	50	50	50	1035
	Dec	0	50	50	50	50	5335	150	50	1135	50	5335	400	50	1135	50	5335
		6	50	50	50	50	3450	50	50	250	50	3450	50	50	250	50	3450
		10	50	50	50	50	2500	50	50	50	50	2500	50	50	50	50	2500
		15	50	50	50	50	1485	50	50	50	50	1485	50	50	50	50	1485
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	50	50	150	50	5235	400	50	1050	50	5235	600	50	1050	50	5235
		6	50	50	50	50	3250	150	50	450	50	3250	250	50	450	50	3250
		10	50	50	50	50	2250	50	50	250	50	2250	100	50	250	50	2250
		15	50	50	50	50	1300	50	50	50	50	1300	50	50	50	50	1300
	Sep-Nov	0	50	50	150	50	4500	350	50	1035	50	4500	550	50	1035	50	4500
		6	50	50	50	50	2950	150	50	400	50	2950	250	50	400	50	2950
		10	50	50	50	50	2050	50	50	250	50	2050	100	50	250	50	2050
		15	50	50	50	50	1250	50	50	50	50	1250	50	50	50	50	1250

Table 22. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving of the Deep Model Site to the Unmitigated and Mitigated (Three Sound Attenuation Levels) PTS (Peak and SEL) and TTS Thresholds for Fish for the Atlantic Shores North Construction Period (Popper et al. 2014). The SEL (L_E) and Peak Injury (L_{pk}) Thresholds are Unweighted.

Foundation Type	Months	Sound Reduction Level (dB)	Ranges (m) to Injury and TTS thresholds for fish														
			Fish: No Swim Bladder					Fish: Swim bladder not involved in hearing					Fish: Swim bladder involved in hearing				
			Mortality and potential mortal injury		Recoverable Injury		TTS	Mortality and potential mortal injury		Recoverable Injury		TTS	Mortality and potential mortal injury		Recoverable Injury		TTS
			219 dB L_E	213 dB L_{pk}	216 dB L_E	213 dB L_{pk}	186 dB L_E	210 dB L_E	207 dB L_{pk}	203 dB L_E	207 dB L_{pk}	186 dB L_E	207 dB L_E	207 dB L_{pk}	203 dB L_E	207 dB L_{pk}	186 dB L_E
OSS Jacket (Cont'd)	Dec	0	50	50	50	50	6100	300	50	1485	50	6100	600	50	1485	50	6100
		6	50	50	50	50	4035	50	50	400	50	4035	50	50	400	50	4035
		10	50	50	50	50	2985	50	50	50	50	2985	50	50	50	50	2985
		15	50	50	50	50	1885	50	50	50	50	1885	50	50	50	50	1885

Table 23. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to Injury Thresholds for Fish (FHWG, 2008) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) and SEL (L_E) thresholds are unweighted.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to injury thresholds for fish*			
			Fish ≥2 grams		*Fish <2 grams*	
			Injury		*Injury*	
			187 dB L_E	*206 dB L_{pk}*	*183 dB L_E*	*206 dB L_{pk}*
10-m monopile	May - Aug	0	10435	1100	13970	1100
		6	6900	600	9085	600
		10	5300	350	6900	350
		15	3585	200	4935	200
	Sep-Nov	0	8985	1050	11505	1050
		6	6085	550	7835	550
		10	4685	350	6085	350
		15	3235	200	4335	200
	Dec	0	12335	1250	15820	1250
		6	8100	600	10650	600
		10	6285	250	8100	250
		15	4300	150	5900	150
15-m monopile	May - Aug	0	14820	1300	18685	1300
		6	9700	700	12985	700
		10	7250	450	9700	450
		15	5200	250	6835	250
	Sep-Nov	0	12290	1250	15005	1250
		6	8385	700	10785	700
		10	6435	450	8385	450
		15	4550	250	6000	250
	Dec	0	16865	1450	22095	1450
		6	11170	750	14500	750
		10	8435	450	11170	450
		15	6050	150	7900	150
Jacket (5-m pre-piled pin piles)	May - Aug	0	4185	50	5585	50
		6	2450	50	3550	50
		10	1650	50	2450	50
		15	900	50	1500	50
	Sep-Nov	0	3650	50	4900	50
		6	2250	50	3150	50
		10	1550	50	2250	50
		15	885	50	1350	50
	Dec	0	4950	50	6500	50
		6	3200	50	4300	50
		10	2300	50	3200	50
		15	1370	50	2085	50

Table 23. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to Injury Thresholds for Fish (FHWG, 2008) for the Atlantic Shores North Construction Period. The Peak (L_{pk}) and SEL (L_E) thresholds are unweighted.

Foundation Type	Months	Sound Reduction Level (dB)	Ranges (m) to injury thresholds for fish			
			Fish ≥2 grams		Fish <2 grams	
			Injury		Injury	
			187 dB L_E	206 dB L_{pk}	183 dB L_E	206 dB L_{pk}
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	4850	50	6335	50
		6	2985	50	4185	50
		10	2035	50	2985	50
		15	1200	50	1850	50
	Sep-Nov	0	4250	50	5550	50
		6	2700	50	3650	50
		10	1900	50	2700	50
		15	1100	50	1735	50
	Dec	0	5735	50	7300	50
		6	3735	50	4950	50
		10	2735	50	3735	50
		15	1720	50	2500	50

Acoustic ranges to marine mammal and sea turtle regulatory thresholds were calculated for each model site (Monmouth, NJ and Wolfe's Pond, NY). Acoustic ranges to the 95th percentile for marine mammals and sea turtles to PTS and behavioral thresholds for each model site for each modeled month (Table 30) and for fish to PTS, TTS, and behavioral thresholds (Table 31) have been derived for four representative months.

6.5.2 Goal Post Installation/Extraction

Acoustic ranges to the regulatory thresholds for marine mammals, sea turtles, and fish have been calculated based on the results of the acoustic modeling for the vibratory pile driving of the goal post for each of the two model sites. A description of how these ranges were calculated is provided in Section 3.1.1.

Acoustic ranges to marine mammal and sea turtle regulatory thresholds were calculated for each model site (Monmouth, NJ and Wolfe's Pond, NY). Acoustic ranges to the 95th percentile for marine mammals and sea turtles to PTS and behavioral thresholds for each model site for each modeled month (Table 32) and for fish to PTS, TTS, and behavioral thresholds (Table 33) have been derived for four representative months.

Table 24. Acoustic Ranges (m) (95th Percentile) for impact Pile Driving at the Shallow Model Site to Behavioral Thresholds for Marine Mammals (NOAA, 2005), Sea Turtles (DoN, 2017), and Fishes (GARFO, 2022) for the Atlantic Shores North Construction Period.

Foundation Type	Months	Sound Reduction Level (dB)	Ranges (m) to behavioral thresholds (dB re 1µPa (L_{rms}))		
			Fish	Marine Mammals	Sea Turtles
			150 dB	160 dB	175 dB
10-m monopile	May - Aug	0	11350	7335	3050
		6	8785	5400	1850
		10	7335	4300	1250
		15	5750	3050	700
	Sep-Nov	0	9935	6550	2800
		6	7800	4885	1750
		10	6550	3900	1200
		15	5135	2800	650
	Dec	0	12295	7720	3185
		6	9200	5685	1900
		10	7720	4520	1250
		15	6035	3185	750
15-m monopile	May - Aug	0	12085	7700	3250
		6	9250	5700	2000
		10	7700	4500	1350
		15	6035	3250	800
	Sep-Nov	0	10535	6885	2950
		6	8200	5100	1850
		10	6885	4100	1250
		15	5385	2950	750
	Dec	0	13245	8135	3435
		6	9850	6035	2050
		10	8135	4785	1400
		15	6385	3435	850
Jacket (5-m pre-piled pin piles)	May - Aug	0	5300	2900	750
		6	3835	1850	350
		10	2900	1285	200
		15	2000	750	50
	Sep-Nov	0	4785	2685	700
		6	3450	1700	300
		10	2685	1200	200
		15	1850	700	50

Table 24. Acoustic Ranges (m) (95th Percentile) for impact Pile Driving at the Shallow Model Site to Behavioral Thresholds for Marine Mammals (NOAA, 2005), Sea Turtles (DoN, 2017), and Fishes (GARFO, 2022) for the Atlantic Shores North Construction Period.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to behavioral thresholds (dB re 1µPa (L_{rms}))*		
			Fish	*Marine Mammals*	*Sea Turtles*
			150 dB	*160 dB*	*175 dB*
Jacket (5-m pre-piled)	Dec	0	5450	3450	1200
		6	4185	2500	250
		10	3450	1750	50
		15	2650	1200	50
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	5835	3335	950
		6	4250	2150	435
		10	3335	1550	250
		15	2350	950	150
	Sep-Nov	0	5285	3050	900
		6	3885	2035	400
		10	3050	1450	250
		15	2200	900	100
	Dec	0	5970	3800	1400
		6	4635	2770	350
		10	3800	2050	200
		15	2950	1400	50

Table 25. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to Behavioral Thresholds for Marine Mammals (NOAA, 2005), Sea Turtles (DoN, 2017), and Fishes (GARFO, 2022) for the Atlantic Shores North Construction Period.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to behavioral thresholds (dB re 1µPa (L_{rms}))*		
			Fish	*Marine Mammals*	*Sea Turtles*
			150 dB	*160 dB*	*175 dB*
10-m monopile	May - Aug	0	20535	10860	3735
		6	14225	7035	2035
		10	10860	5450	1300
		15	7585	3735	600
	Sep-Nov	0	16105	9050	3300
		6	11805	6200	1850
		10	9050	4800	1200
		15	6600	3300	600
	Dec	0	24145	12585	4435
		6	16180	8335	2350
		10	12585	6400	1450
		15	8850	4435	600
15-m monopile	May - August	0	22135	12550	4200
		6	16000	8100	2400
		10	12550	6150	1500
		15	8820	4200	800
	Sep-Nov	0	17870	10320	3785
		6	13135	6970	2200
		10	10320	5400	1400
		15	7450	3785	700
	Dec	0	27245	13935	4985
		6	18640	9270	2785
		10	13935	7100	1700
		15	9950	4985	800
Jacket (5-m pre-piled pin piles)	May - Aug	0	5350	2300	350
		6	3300	1250	150
		10	2300	700	50
		15	1400	350	50
	Sep-Nov	0	4685	2150	350
		6	3000	1200	150
		10	2150	700	50

Table 25. Acoustic Ranges (m) (95th Percentile) for Impact Pile Driving at the Deep Model Site to Behavioral Thresholds for Marine Mammals (NOAA, 2005), Sea Turtles (DoN, 2017), and Fishes (GARFO, 2022) for the Atlantic Shores North Construction Period.

Foundation Type	*Months*	*Sound Reduction Level (dB)*	*Ranges (m) to behavioral thresholds (dB re 1µPa (L_{rms}))*		
			Fish	*Marine Mammals*	*Sea Turtles*
			150 dB	*160 dB*	*175 dB*
Jacket (5-m pre-piled) (Cont'd)	Sep-Nov	15	1300	350	50
	Dec	0	6235	3035	250
		6	4100	1770	50
		10	3035	1050	50
		15	1935	250	50
OSS Jacket (5-m post-piled pin piles)	May - Aug	0	6085	2835	500
		6	3950	1550	200
		10	2835	1000	50
		15	1750	500	50
	Sep-Nov	0	5300	2600	450
		6	3500	1450	200
		10	2600	900	50
		15	1600	450	50
	Dec	0	7050	3550	400
		6	4750	2135	50
		10	3550	1420	50
		15	2350	400	50

Table 26. Acoustic Ranges (m) (95th Percentile) to the PTS Thresholds for Marine Mammals (NMFS, 2018) and Sea Turtles (DoN, 2017) from Unmitigated Impact Pile Driving for the Installation or Removal of the Conductor Barrel at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. The Peak (Lpk) Thresholds are Unweighted While the SEL (LE) Thresholds are Weighted According to the Hearing Group and are Accumulated over 24-hrs These Ranges are Based on the Assumption of 10 Hours of Pile Driving, Which is the Installation of a Single Conductor Barrel.

Model Site	Season	Ranges (m) to PTS thresholds for marine mammals and sea turtles									
		LFC		MFC		HFC		PW		TU	
		183 dB ($L_{E,LF,24h}$)	219 dB ($L_{pk,0-pk,flat}$)	185 dB ($L_{E,MF,24h}$)	230 dB ($L_{pk,0-pk,flat}$)	155 dB ($L_{E,HF,24h}$)	202 dB ($L_{pk,0-pk,flat}$)	185 dB ($L_{E,PW,24h}$)	218 dB ($L_{pk,0-pk,flat}$)	204 dB ($L_{E,TU,24h}$)	232 dB ($L_{pk,0-pk,flat}$)
Monmouth	April	710	15	35	11	200	28	150	16	91	11
	Jul	370	16	48	11	250	28	132	16	86	11
	Oct	595	15	35	11	150	28	93	16	86	11
	Dec	820	16	35	11	150	28	134	16	129	11
Wolfe's Pond	April	400	11	26	6	200	16	200	11	61	6
	Jul	385	11	30	6	350	16	150	11	51	6
	Oct	300	11	26	6	150	16	150	11	46	6
	Dec	250	11	21	6	150	16	150	11	51	6

Table 27. Acoustic Ranges (m) (95th Percentile) to the PTS (Peak and SEL) and TTS Thresholds for Fish (Popper et al. 2014) from Unmitigated Impact Pile Driving for the Installation or Removal of the Conductor Barrel at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. The SEL (LE) and Peak Injury (Lpk) Thresholds are Unweighted. These Ranges are Based on the Assumption of 10 Hours of Pile Driving, Which is the Installation of a Single Conductor Barrel.

Model Site	Season	Ranges (m) to Injury and TTS thresholds for fish														
		Fish: No Swim Bladder					Fish: Swim bladder not involved in hearing					Fish: Swim bladder involved in hearing				
		Mortality and potential mortal injury		Recoverable Injury		TTS	Mortality and potential mortal injury		Recoverable Injury		TTS	Mortality and potential mortal injury		Recoverable Injury		TTS
		219 dB L_E	***213 dB L_{pk}***	***216 dB L_E***	***213 dB L_{pk}***	***186 dB L_E***	***210 dB L_E***	***207 dB L_{pk}***	***203 dB L_E***	***207 dB L_{pk}***	***186 dB L_E***	***207 dB L_E***	***207 dB L_{pk}***	***203 dB L_E***	***207 dB L_{pk}***	***186 dB L_E***
Monmouth	April	40	16	51	16	795	75	25	150	25	795	86	25	150	25	795
	Jul	35	16	45	16	555	68	21	93	21	555	76	21	93	21	555
	Oct	38	16	48	16	695	70	21	134	21	695	81	21	134	21	695
	Dec	36	16	46	16	850	76	21	167	21	850	90	21	167	21	850
Wolfe's Pond	April	21	11	26	11	300	41	11	76	11	300	51	11	76	11	300
	Jul	21	11	26	11	285	36	11	61	11	285	41	11	61	11	285
	Oct	21	11	26	11	235	36	11	56	11	235	41	11	56	11	235
	Dec	21	11	26	11	200	36	11	61	11	200	46	11	61	11	200

Table 28. Acoustic Ranges (m) (95th Percentile) to Injury Thresholds for Fish (FHWG, 2008) from Unmitigated Impact Pile Driving for the Installation or Removal of the Conductor Barrel at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. The Peak (L_{pk}) and SEL (L_E) thresholds are unweighted. These Ranges are Based on the Assumption of 10 hours of Pile Driving, Which is the Installation of a Single Conductor Barrel.

Model Site	Season	Ranges (m) to injury thresholds for fish			
		Fish ≥2 grams		Fish <2 grams	
		Injury		Injury	
		187 dB L_E	*206 dB L_{pk}*	*183 dB L_E*	*206 dB L_{pk}*
Monmouth	April	725	25	910	25
	Jul	470	25	690	25
	Oct	610	25	830	25
	Dec	800	25	900	25
Wolfe's Pond	April	300	11	385	11
	Jul	250	11	350	11
	Oct	200	11	285	11
	Dec	200	11	250	11

Table 29. Acoustic Ranges (m) (95th Percentile) to Behavioral Thresholds for Marine Mammals (NOAA, 2005), Sea Turtles (DoN, 2017), and Fishes (GARFO, 2022) from Unmitigated Impact Pile Driving for the Installation or Removal of the Conductor Barrel at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months.

Model Site	Season	*Ranges (m) to behavioral thresholds (dB re 1µPa (L_{rms}))*		
		Fish	Marine Mammals	Sea Turtles
		150 dB	160 dB	175 dB
Monmouth	April	540	185	51
	Jul	370	150	46
	Oct	475	185	50
	Dec	630	220	51
Wolfe's Pond	April	250	132	30
	Jul	200	75	26
	Oct	150	70	26
	Dec	185	76	26

Table 30. Acoustic Ranges (m) (95th Percentile) to PTS and Behavioral Thresholds for Marine Mammals and Sea Turtles Resulting from Unmitigated Vibratory Pile Driving for the Atlantic Shores North Cofferdam Installation and Removal at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. Ranges Were Determined Assuming 43.4 Minutes of Daily Activity at the Wolfe's Pond, NJ Location and 109.2 Minutes at the Monmouth, NY Location.

Model Site	***Month***	***Ranges to PTS Thresholds (m)***					***Range to Behavioral Thresholds (m)***	
		Marine Mammal and Turtle Hearing Groups					***Marine Mammals***	***Sea Turtles***
		LFC	***MFC***	***HFC***	***PW***	***TU***		
		199 dB ($L_{E,LF,24h}$)	***198 dB ($L_{E,MF,24h}$)***	***173 dB ($L_{E,HF,24h}$)***	***201 dB ($L_{E,PW,24h}$)***	***220 dB ($L_{E,TU,24h}$)***	***120 dB ($L_{p,rms}$)***	***175 dB ($L_{p,rms}$)***
Monmouth	April	<50	0	<50	<50	0	2050	0
	Jul	<50	0	<50	<50	0	1850	0
	Oct	<50	0	<50	<50	0	1550	0
	Dec	<50	0	<50	<50	0	1350	0
Wolfe's Pond	April	<50	0	<50	<50	0	1000	0
	Jul	<50	0	<50	<50	0	1650	0
	Oct	<50	0	<50	<50	0	650	0
	Dec	<50	0	<50	<50	0	450	0

Table 31. Acoustic Ranges (m) (95th Percentile) to the PTS, TTS, and Behavioral Thresholds for Fish Resulting from Unmitigated Vibratory Pile Driving for the Atlantic Shores North Cofferdam Installation or Removal at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. Ranges Were Determined Assuming 43.4 Minutes of Daily Activity at the Wolfe's Pond Location and 109.2 Minutes at the Monmouth Location.

Model Site	*Representative Month*	*Ranges (m) to Thresholds for Fish with Swim Bladder Involved in Hearing*		*Ranges (m) to Behavioral Threshold for Fishes < or ≥ 2 g (150 dB $L_{p,rms}$)*
		Injury (170 dB, L_{rms})	*TTS (158 dB, L_{rms})*	
Monmouth, NJ	April	<50	50	50
	July	<50	50	50
	October	<50	50	50
	December	<50	50	50
Wolfe's Pond, NY	April	<50	50	50
	July	<50	50	50
	October	<50	50	50
	December	<50	50	50

Table 32. Acoustic Ranges (m) (95th Percentile) to PTS and Behavioral Thresholds for Marine Mammals and Sea Turtles Resulting from Unmitigated Vibratory Pile Driving for the Atlantic Shores North Goal Post Installation and Removal at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. Ranges Were Determined Assuming 4 Hours of Daily Activity at Either Location.

Model Site	*Month*	*Ranges to PTS Thresholds (m)*					*Range to Behavioral Thresholds (m)*	
		Marine Mammal and Turtle Hearing Groups					*Marine Mammals*	*Sea Turtles*
		LFC	*MFC*	*HFC*	*PW*	*TU*		
		199 dB ($L_{E,LF,24h}$)	*198 dB ($L_{E,MF,24h}$)*	*173 dB ($L_{E,HF,24h}$)*	*201 dB ($L_{E,PW,24h}$)*	*220 dB ($L_{E,TU,24h}$)*	*120 dB ($L_{p,rms}$)*	*175 dB ($L_{p,rms}$)*
Monmouth	April	46	0	21	16	6	12385	11
	Jul	41	0	21	16	6	6170	11
	Oct	41	0	21	16	6	9755	11
	Dec	41	0	16	16	6	9435	11
Wolfe's Pond	April	66	0	21	16	6	2235	6
	Jul	66	0	21	16	6	2985	6
	Oct	56	0	16	16	6	1335	6
	Dec	51	0	16	16	6	985	6

Table 33. Acoustic Ranges (m) (95th Percentile) to the PTS, TTS, and Behavioral Thresholds for Fish Resulting from Unmitigated Vibratory Pile Driving for the Atlantic Shores North Goal Post Installation or Removal at the Monmouth, NJ and Wolfe's Pond, NY Modeling Sites for Four Representative Months. Ranges Were Determined Assuming 4 Hours of Daily Activity at Either Location.

Model Site	***Representative Month***	***Ranges (m) to Thresholds for Fish with Swim Bladder Involved in Hearing***		***Ranges (m) to Behavioral Threshold for Fishes < or ≥ 2 g (150 dB $L_{p,rms}$)***
		Injury (170 dB, L_{rms})	***TTS (158 dB, L_{rms})***	
Monmouth, NJ	April	16	61	250
	July	16	61	250
	October	16	51	250
	December	16	56	250
Wolfe's Pond, NY	April	16	76	250
	July	16	71	250
	October	16	61	200
	December	16	60	150

6.6 Exposure-based Ranges to Thresholds for Impact Pile Driving

Exposure-based ranges to regulatory thresholds for marine mammals and sea turtles were calculated for the unmitigated and mitigated (three sound attenuation levels of 6, 10, and 15 dB) sound levels for each model site (shallow and deep) based on the animat modeling of marine mammal and sea turtle acoustic exposures to impact pile driving sources. Exposure-based ranges to the 95th percentile for injury and behavior thresholds for the shallow and deep model sites for each impact pile driving model scenario have been derived for marine mammals and sea turtles (Tables 34 through 49).

6.7 Acoustic Exposure Estimates for Marine Mammals and Sea Turtles

6.7.1 Impact Pile Driving of Foundations

The number of annual, unmitigated and mitigated (6-, 10-, and 15-dB sound level reduction) acoustic exposure estimates of marine mammals and sea turtles for each of the two years of impact pile driving (monopile and pin piled) construction have been derived for each of the two proposed construction schedules (Table 1) and each model site (Appendix C; Tables C-1 to C-10). These annual acoustic exposures were combined to produce overall, or total, acoustic exposure estimates of marine mammals and sea turtles for unmitigated and mitigated (three sound attenuation levels) for Schedules 1 and 2 (Tables 50 to 52), using the largest acoustic exposures per species from the shallow and deep model sites. Since either of the monopiles (10-m or the 15-m) may be used for Schedule 1, acoustic exposures were estimated separately for both the 10-m and 15-m monopiles for Schedule 1 (Tables 50 and 52). Overall, the highest acoustic exposures were associated with the 15-m monopile for Schedule 1 (Table 50).

6.7.2 Impact Pile Driving of Conductor Barrels

The number of seasonal, unmitigated acoustic exposure estimates of marine mammals for impact pile driving at each of the two representative model sites have been estimated for the installation or extraction of a single conductor barrel (Tables 53 and 54). The overall acoustic exposures for the installation and extraction of all 11 conductor barrels (eight in NJ and three in NY) have also been estimated (Table 55). Although all seasons were modeled for conductor barrel installation/extraction, the calculation of the overall acoustic exposures assumed that installation would occur in winter and extraction would occur in spring. These seasons were chosen for installation and extraction to allow for maximum flexibility in the installation and extraction since these seasons generally have the highest acoustic exposures. Acoustic exposures associated with impact pile driving for conductor barrel installation or removal have been reported herein to two decimal places, so that it appears that most species have 0.00 acoustic exposures or no exposures whereas the actual exposures are typically very, very small and would only be represented if exposures were reported to the fifth or sixth decimal place.

Acoustic exposures for sea turtles due to impact pile driving for conductor barrels were not calculated as sea turtle species are not reasonably expected to be present in the model areas during the modeled seasons of winter and spring. As cold-blooded animals, sea turtles depend upon the temperature of their surrounding environment to maintain their body temperatures. Winter and spring water temperatures off New Jersey and New York are too cold for sea turtle survival, so sea turtles migrate southward into warmer ocean environments during these seasons, only returning northward as the ocean temperatures begin warming.

Table 34. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 10-m Monopile at the Atlantic Shores North Shallow Model Site (Model Scenario 1).

Table 35. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 10-m Monopile at the Atlantic Shores North Shallow Model Site (Model Scenario 1).

Marine Animal Hearing Group	*Marine Animal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September-November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		6517	4830	3755	2737	5778	4432	3452	2449	6701	4833	3871	2845
	Common minke whale		6667	4748	3849	2804	6032	4346	3556	2601	6960	4748	3858	2860
	Humpback whale		6518	4894	3910	2713	5925	4430	3478	2474	6906	4883	3848	2629
	North Atlantic right whale		6674	4883	3849	2602	5876	4405	3478	2371	6788	4998	3784	2450
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		6555	4747	3713	2657	5763	4178	3368	2406	6709	4643	3692	2561
	Atlantic white sided dolphin		6470	4650	3756	2836	5890	4371	3382	2471	6772	4724	3682	2831
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	4910	3760	2962	2112	4478	3437	2742	1991	5833	4052	3010	1980
		Western North Atlantic Offshore Stock	6855	4961	3971	2823	5991	4509	3601	2526	6943	5048	4090	2870
	Long-finned pilot whale		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
	Short beaked common dolphin		6604	4854	3855	2742	5863	4484	3599	2453	6872	4933	4060	2708
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		6592	4770	3737	2540	5968	4314	3320	2391	6738	4753	3632	2467
Phocid Pinnipeds Underwater (PW)	Harbor seal		6604	4764	3882	2687	5858	4275	3427	2349	6675	4793	3951	2664
	Gray seal		6417	4784	3881	2551	5782	4274	3482	2369	6629	4776	3757	2564
Turtles (TU)	Green turtle		2636	1619	822	454	2447	1347	773	331	2719	1422	794	454
	Kemp's ridley turtle		2636	1619	822	454	2447	1347	773	331	2719	1422	794	454
	Leatherback turtle		2636	1619	822	454	2447	1347	773	331	2719	1422	794	454
	Loggerhead turtle		2636	1619	822	454	2447	1347	773	331	2719	1422	794	454

Table 36. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 10-m Monopile at the Atlantic Shores North Deep Model Site (Model Scenario 1).

Marine Animal Hearing Group	*Marine Mammal Species*		*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
			May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
			0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale		113	18	0	0	101	16	0	0	62	0	0	0	4231	1833	764	38	3672	1565	673	19	5127	2325	985	6
	Common minke whale		82	32	0	0	75	32	0	0	46	0	0	0	4361	2276	1097	129	3858	2046	974	90	5371	2800	1382	169
	Humpback whale		43	22	0	0	43	22	0	0	30	0	0	0	5571	3044	1912	562	4728	2662	1719	407	6556	3878	2119	765
	North Atlantic right whale		67	3	0	0	67	3	0	0	9	0	0	0	5525	3190	1760	577	4814	2802	1544	438	6329	3801	2078	748
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		1365	703	318	116	1281	606	318	116	1505	722	356	73	40	0	0	0	35	0	0	0	10	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal		60	13	0	0	60	13	0	0	22	0	0	0	20	0	0	0	20	0	0	0	20	0	0	0
	Gray seal		161	8	0	0	161	8	0	0	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle		0	0	0	0	0	0	0	0	0	0	0	0	912	66	0	0	823	45	0	0	1195	53	0	0
	Kemp's ridley turtle		0	0	0	0	0	0	0	0	0	0	0	0	912	66	0	0	823	45	0	0	1195	53	0	0
	Leatherback turtle		0	0	0	0	0	0	0	0	0	0	0	0	912	66	0	0	823	45	0	0	1195	53	0	0
	Loggerhead turtle		0	0	0	0	0	0	0	0	0	0	0	0	912	66	0	0	823	45	0	0	1195	53	0	0

Table 37. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 10-m Monopile at the Atlantic Shores North Deep Model Site (Model Scenario 1).

Marine Animal Hearing Group	***Marine Mammal Species***	***Behavior (NMFS, 2005)***											
		May-August				***September-November***				***December***			
		0 dB	***6 dB***	***10 dB***	***15 dB***	***0 dB***	***6 dB***	***10 dB***	***15 dB***	***0 dB***	***6 dB***	***10 dB***	***15 dB***
Low Frequency Cetaceans (LFC)	Fin whale	9711	6269	4848	3267	8195	5643	4269	2885	11310	7427	5686	3928
	Common minke whale	9793	6416	4824	3240	8297	5737	4310	2933	11260	7644	5788	3864
	Humpback whale	9817	6496	4897	3343	8290	5745	4391	2978	11586	7675	5891	3961
	North Atlantic right whale	9822	6552	4951	3301	8299	5777	4408	2999	11531	7695	5949	3926
	Sei whale	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin	9487	6404	4792	3265	8169	5623	4385	2950	11055	7533	5788	3846
	Atlantic white sided dolphin	9492	6327	4798	3270	8271	5626	4316	2925	11265	7558	5757	3785
	Common bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0
	Common bottlenose dolphin – Western North Atlantic Offshore Stock	9359	6388	4769	3270	8119	5584	4276	2968	11012	7452	5725	3899
	Long-finned pilot whale	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
	Short beaked common dolphin	9177	6278	4692	3246	8062	5616	4274	3000	11073	7409	5675	3851
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise	9699	6492	4821	3235	8255	5658	4336	2944	11169	7502	5705	3863
Phocid Pinnipeds Underwater (PW)	Harbor seal	9677	6482	4912	3299	8321	5758	4398	2917	11211	7610	5835	3955
	Gray seal	9615	6458	4773	3237	8222	5714	4322	2973	11161	7692	5805	3893
Turtles (TU)	Green turtle	3352	1793	829	376	3000	1618	724	290	4007	1966	977	376
	Kemp's ridley turtle	3352	1793	829	376	3000	1618	724	290	4007	1966	977	376
	Leatherback turtle	3352	1793	829	376	3000	1618	724	290	4007	1966	977	376

	Loggerhead turtle	3352	1793	829	376	3000	1618	724	290	4007	1966	977	376

Table 38. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 15-m Monopile at the Atlantic Shores North Shallow Model Site (Model Scenario 2).

Marine Animal Hearing Group	*Marine Mammal Species*	*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
		May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
		0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale	256	73	52	0	243	73	52	0	223	0	0	0	2234	940	378	11	1616	795	331	11	2578	1012	467	0
	Common minke whale	0	0	0	0	0	0	0	0	0	0	0	0	3023	1390	44	0	2580	1245	0	0	3335	1512	160	0
	Humpback whale	261	63	28	0	261	63	28	0	202	0	0	0	3729	1828	1188	331	3129	1626	1033	302	4253	2281	1250	365
	North Atlantic right whale	158	33	33	0	158	33	33	0	87	0	0	0	3976	2065	1091	306	3377	1688	925	232	4407	2418	1267	324
	Sei whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin	38	0	0	0	29	0	0	0	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	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	20	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin – Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise	1332	864	584	351	1302	830	539	347	1334	988	723	111	0	0	0	0	0	0	0	0	0	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal	85	3	3	0	144	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gray seal	293	80	24	0	291	80	24	0	154	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle	0	0	0	0	0	0	0	0	0	0	0	0	911	218	23	0	766	214	13	0	1001	153	0	0
	Kemp's ridley turtle	0	0	0	0	0	0	0	0	0	0	0	0	911	218	23	0	766	214	13	0	1001	153	0	0
	Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	911	218	23	0	766	214	13	0	1001	153	0	0
	Loggerhead turtle	0	0	0	0	0	0	0	0	0	0	0	0	911	218	23	0	766	214	13	0	1001	153	0	0

Table 39. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 15-m Monopile at the Atlantic Shores North Shallow Model Site (Model Scenario 2).

Marine Animal Hearing Group	*Marine Mammal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September-November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		6960	5099	4057	2939	6076	4617	3682	2576	7277	5145	4250	2987
	Common minke whale		7096	4955	4028	3001	6339	4485	3682	2691	7428	5155	4151	3160
	Humpback whale		7102	5044	4091	2855	6168	4583	3615	2711	7454	5130	4117	2838
	North Atlantic right whale		6891	5256	3962	2835	6320	4600	3622	2541	7423	5427	4106	2882
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		6783	4960	3888	2783	6042	4331	3541	2525	7104	5065	3857	2718
	Atlantic white sided dolphin		6881	4787	3961	2863	6084	4482	3510	2735	7223	5093	4138	2905
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	5247	3938	3189	2477	4627	3681	2832	2107	6173	4491	3467	2440
		Western North Atlantic Offshore Stock	7045	5226	4187	2987	6347	4697	3780	2749	7389	5321	4342	3058
	Long-finned pilot whale		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
	Short beaked common dolphin		6933	5085	4208	2836	6205	4672	3740	2684	7183	5281	4228	3076
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		6949	4837	3966	2738	6248	4440	3358	2514	7304	5002	4042	2706
Phocid Pinnipeds Underwater (PW)	Harbor seal		6928	4983	4027	2858	6187	4497	3465	2608	7268	5024	4196	2865
	Gray seal		6748	4934	3953	2631	6038	4402	3594	2478	7150	5093	3946	2534
Turtles (TU)	Green turtle		3037	1745	936	585	2662	1596	895	541	3112	1828	1102	606
	Kemp's ridley turtle		3037	1745	936	585	2662	1596	895	541	3112	1828	1102	606
	Leatherback turtle		3037	1745	936	585	2662	1596	895	541	3112	1828	1102	606
	Loggerhead turtle		3037	1745	936	585	2662	1596	895	541	3112	1828	1102	606

Table 40. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 15-m Monopile at the Atlantic Shores North Deep Model Site (Model Scenario 2).

Marine Animal Hearing Group	*Marine Mammal Species*		*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
			May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
			0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale		185	62	0	0	185	62	0	0	168	0	0	0	5461	2586	1298	322	4480	2288	1217	256	6350	3406	1597	337
	Common minke whale		225	42	0	0	225	42	0	0	106	0	0	0	5923	3270	1953	507	4915	2682	1624	465	7150	3903	2236	619
	Humpback whale		76	54	0	0	76	54	0	0	47	0	0	0	7435	4367	2833	1450	6211	3862	2380	1177	8577	5464	3734	1866
	North Atlantic right whale		118	4	0	0	118	4	0	0	10	0	0	0	7181	4576	2933	1230	6224	3799	2513	1107	8587	5343	3407	1487
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		1670	809	531	186	1594	796	531	186	1812	934	531	89	72	0	0	0	61	0	0	0	22	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal		176	65	0	0	176	65	0	0	36	0	0	0	194	0	0	0	194	0	0	0	189	0	0	0
	Gray seal		250	39	17	0	250	39	6	0	150	0	0	0	167	0	0	0	103	0	0	0	172	0	0	0
Turtles (TU)	Green turtle		0	0	0	0	0	0	0	0	0	0	0	0	1880	470	1	0	1748	361	0	0	2534	450	0	0
	Kemp's ridley turtle		0	0	0	0	0	0	0	0	0	0	0	0	1880	470	1	0	1748	361	0	0	2534	450	0	0
	Leatherback turtle		0	0	0	0	0	0	0	0	0	0	0	0	1880	470	1	0	1748	361	0	0	2534	450	0	0
	Loggerhead turtle		0	0	0	0	0	0	0	0	0	0	0	0	1880	470	1	0	1748	361	0	0	2534	450	0	0

Table 41. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a 15-m Monopile at the Atlantic Shores North Deep Model Site (Model Scenario 2).

Marine Animal Hearing Group	*Marine Mammal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September-November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		11184	7245	5434	3832	9203	6302	4931	3303	12858	8368	6349	4405
	Common minke whale		11222	7293	5516	3750	9482	6359	4906	3312	12987	8505	6400	4354
	Humpback whale		11371	7351	5605	3905	9406	6487	4999	3427	13199	8492	6569	4453
	North Atlantic right whale		11391	7509	5641	3764	9577	6543	4972	3312	13092	8520	6550	4511
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		10759	7186	5461	3746	9011	6331	4893	3380	12239	8382	6442	4421
	Atlantic white sided dolphin		11084	7372	5542	3747	9160	6292	4777	3418	12447	8539	6474	4299
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	10723	7131	5446	3756	9015	6281	4857	3380	12430	8212	6365	4347
	Long-finned pilot whale		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
	Short beaked common dolphin		10737	7208	5409	3769	8825	6263	4755	3359	12450	8215	6222	4220
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		10938	7267	5460	3735	9072	6343	4885	3325	12497	8481	6422	4341
Phocid Pinnipeds Underwater (PW)	Harbor seal		11029	7377	5701	3765	9320	6402	4963	3362	12553	8430	6378	4511
	Gray seal		10839	7364	5569	3724	9191	6370	4806	3316	12485	8456	6351	4395
Turtles (TU)	Green turtle		3924	2129	1323	570	3478	2024	1134	558	4513	2539	1518	592
	Kemp's ridley turtle		3924	2129	1323	570	3478	2024	1134	558	4513	2539	1518	592
	Leatherback turtle		3924	2129	1323	570	3478	2024	1134	558	4513	2539	1518	592
	Loggerhead turtle		3924	2129	1323	570	3478	2024	1134	558	4513	2539	1518	592

Table 42. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a Jacket Foundation (Comprised of Four 5-m Pre-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Shallow Model Site (Model Scenario 3).

Marine Animal Hearing Group	*Marine Mammal Species*	*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
		May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
		0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	11	0	0	0	0	0	0	0
	Common minke whale	0	0	0	0	0	0	0	0	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	370	8	0	0	323	0	0	0	199	0	0	0
	North Atlantic right whale	0	0	0	0	0	0	0	0	0	0	0	0	325	2	0	0	289	0	0	0	212	0	0	0
	Sei whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Common Bottlenose dolphin – Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise	99	0	0	0	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gray seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kemp’s ridley turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0

Table 43. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a Jacket Foundation (Comprised of Four 5-m Pre-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Shallow Model Site (Model Scenario 3).

Marine Animal Hearing Group	*Marine Mammal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September - November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		2556	1521	1036	571	2403	1418	998	520	2897	1679	1349	965
	Common minke whale		2702	1654	1098	0	2346	1561	1001	0	3131	2221	1542	858
	Humpback whale		2710	1342	1062	541	2401	1338	1040	492	3043	1880	1232	1008
	North Atlantic right whale		2439	1487	1060	429	2370	1414	996	369	2676	2061	1535	1036
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		2459	1530	1042	600	2250	1413	1010	532	2684	1792	1289	976
	Atlantic white sided dolphin		2742	1549	1118	604	2341	1458	972	466	2974	2002	1499	1004
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	2097	1412	829	425	1858	1353	766	425	2109	1427	994	714
		Western North Atlantic Offshore Stock	2726	1692	971	0	2450	1587	971	0	3167	2233	1603	553
	Long-finned pilot whale		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
	Short beaked common dolphin		2548	1644	1119	0	2393	1531	1084	0	3005	2117	1636	988
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		2559	1508	1062	569	2278	1362	1032	517	2616	1838	1354	1007
Phocid Pinnipeds Underwater (PW)	Harbor seal		2608	1520	1088	544	2424	1357	990	518	3043	1989	1281	924
	Gray seal		2435	1556	1041	587	2322	1424	1015	416	2816	2043	1389	980
Turtles (TU)	Green turtle		564	183	69	0	509	166	41	0	804	96	0	0
	Kemp's ridley turtle		564	183	69	0	509	166	41	0	804	96	0	0
	Leatherback turtle		564	183	69	0	509	166	41	0	804	96	0	0
	Loggerhead turtle		564	183	69	0	509	166	41	0	804	96	0	0

Table 44. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a Jacket Foundation (Comprised of Four 5-m Pre-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Deep Model Site (Model Scenario 3).

Marine Animal Hearing Group	*Marine Mammal Species*	*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
		May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
		0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0
	Common minke whale	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	11	0	0	0	3	0	0	0
	Humpback whale	0	0	0	0	0	0	0	0	0	0	0	0	547	0	0	0	393	0	0	0	811	0	0	0
	North Atlantic right whale	0	0	0	0	0	0	0	0	0	0	0	0	396	0	0	0	282	0	0	0	437	0	0	0
	Sei whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Common bottlenose dolphin – Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans	Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gray seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kemp's ridley turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0

Table 45. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of a Jacket Foundation (Comprised of Four 5-m Pre-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Deep Model Site (Model Scenario 3).

Marine Animal Hearing Group	*Marine Mammal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September - November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		2121	1139	628	206	1929	1007	611	203	2694	1376	870	201
	Common minke whale		2136	1134	605	282	1995	1038	603	262	2593	1509	970	224
	Humpback whale		2107	1034	645	81	1978	1006	602	81	2586	1423	824	67
	North Atlantic right whale		2019	1129	581	145	1958	1022	529	136	2615	1551	902	11
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		1991	1118	608	229	1866	1026	546	229	2648	1470	990	151
	Atlantic white sided dolphin		2112	1129	660	270	1942	1072	564	222	2683	1583	991	189
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	2110	1099	657	275	2041	1071	563	264	2679	1383	905	84
	Long-finned pilot whale		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
	Short beaked common dolphin		2152	1055	611	256	1997	1001	592	256	2603	1532	930	91
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		2056	1029	624	142	1850	984	588	142	2579	1408	875	94
Phocid Pinnipeds Underwater (PW)	Harbor seal		2070	1111	587	135	1839	1039	587	135	2601	1352	699	0
	Gray seal		2109	903	576	261	1953	883	552	259	2497	1367	713	122
Turtles (TU)	Green turtle		93	1	0	0	93	1	0	0	1	0	0	0
	Kemp’s ridley turtle		93	1	0	0	93	1	0	0	1	0	0	0
	Leatherback turtle		93	1	0	0	93	1	0	0	1	0	0	0
	Loggerhead turtle		93	1	0	0	93	1	0	0	1	0	0	0

Table 46. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of an OSS Jacket Foundation (Comprised of Four 5-m Post-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Shallow Model Site (Model Scenario 4).

Marine Animal Hearing Group	*Marine Mammal Species*		*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
			May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
			0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale		0	0	0	0	0	0	0	0	0	0	0	0	196	0	0	0	104	0	0	0	0	0	0	0
	Common minke whale		0	0	0	0	0	0	0	0	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	696	43	0	0	521	34	0	0	572	0	0	0
	North Atlantic right whale		0	0	0	0	0	0	0	0	0	0	0	0	674	50	0	0	558	32	0	0	563	0	0	0
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		156	26	0	0	156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gray seal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kemp's ridley turtle		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leatherback turtle		0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0

Table 47. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of an OSS Jacket Foundation (Comprised of Four 5-m Post-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Shallow Model Site (Model Scenario 4).

Marine Animal Hearing Group	*Marine Mammal Species*		*Behavior (NMFS, 2005)*											
			May-August				*September-November*				*December*			
			0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale		2998	1687	1260	808	2734	1573	1098	681	3216	2252	1520	1107
	Common minke whale		3159	2021	1324	782	2840	1866	1307	398	3418	2332	1955	1281
	Humpback whale		2939	1826	1208	666	2776	1549	1170	653	3198	2239	1626	1050
	North Atlantic right whale		3004	1844	1323	620	2643	1820	1319	605	3230	2346	1767	1062
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		2809	1862	1311	770	2673	1635	1160	707	3054	2139	1560	1102
	Atlantic white sided dolphin		2927	1899	1329	728	2798	1779	1296	693	3163	2466	1700	1260
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	2462	1654	1211	707	2105	1451	1040	599	2507	1781	1311	781
		Western North Atlantic Offshore Stock	3026	1955	1365	807	2824	1767	1279	787	3444	2449	1812	1226
	Long-finned pilot whale		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
	Short beaked common dolphin		3058	2000	1421	684	2742	1863	1316	636	3263	2394	1859	1280
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		2703	1919	1315	791	2582	1605	1132	678	2704	2120	1519	1088
Phocid Pinnipeds Underwater (PW)	Harbor seal		3012	1790	1207	718	2712	1726	1181	698	3357	2104	1719	1091
	Gray seal		2757	1867	1222	717	2457	1773	1202	652	2972	2224	1760	1082
Turtles (TU)	Green turtle		647	259	164	33	635	259	95	0	911	96	0	0
	Kemp’s ridley turtle		647	259	164	33	635	259	95	0	911	96	0	0
	Leatherback turtle		647	259	164	33	635	259	95	0	911	96	0	0
	Loggerhead turtle		647	259	164	33	635	259	95	0	911	96	0	0

Table 48. PTS Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of an OSS Jacket Foundation (Comprised of Four 5-m Post-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Deep Model Site (Model Scenario 4).

Marine Animal Hearing Group	*Marine Mammal Species*		*PTS (NOAA, 2018) - PK*												*PTS (NOAA, 2018) - SEL*											
			May-August				*September - November*				*December*				*May-August*				*September - November*				*December*			
			0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB	0 dB	6 dB	10 dB	15 dB
Low Frequency Cetaceans (LFC)	Fin whale		0	0	0	0	0	0	0	0	0	0	0	0	59	0	0	0	59	0	0	0	23	0	0	0
	Common minke whale		0	0	0	0	0	0	0	0	0	0	0	0	291	0	0	0	191	0	0	0	358	0	0	0
	Humpback whale		0	0	0	0	0	0	0	0	0	0	0	0	970	42	0	0	828	21	0	0	1234	7	0	0
	North Atlantic right whale		0	0	0	0	0	0	0	0	0	0	0	0	907	0	0	0	712	0	0	0	1047	0	0	0
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0
	Common bottlenose dolphin	Western North Atlantic Northern Migratory	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phocid Pinnipeds Underwater (PW)	Harbor seal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gray seal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turtles (TU)	Green turtle		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Kemp’s ridley turtle		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leatherback turtle		0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0

Table 49. Behavior Exposure Ranges (m) for Unmitigated and Mitigated (Three Sound Attenuation Levels) Impact Pile Driving of an OSS Jacket Foundation (Comprised of Four 5-m Post-Piled Pin Piles) in a 24-hr Period at the Atlantic Shores North Deep Model Site (Model Scenario 4).

Marine Animal Hearing Group	*Marine Mammal Species*	*Behavior (NMFS, 2005)*											
		May-August				*September-November*				*December*			
		0 dB	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*	*0 dB*	*6 dB*	*10 dB*	*15 dB*
Low Frequency Cetaceans (LFC)	Fin whale	2486	1332	855	413	2326	1268	809	356	3119	1828	1173	331
	Common minke whale	2534	1373	768	410	2356	1247	758	371	3127	1823	1111	281
	Humpback whale	2542	1314	866	277	2295	1129	790	275	3227	1821	1102	76
	North Atlantic right whale	2535	1419	891	353	2234	1257	825	319	3136	1804	1120	11
	Sei whale	0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin	2589	1379	836	375	2298	1267	752	279	3119	1805	1234	209
	Atlantic white sided dolphin	2548	1378	848	335	2304	1307	777	316	3165	1740	1127	238
	Common bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	0	0	0	0	0	0	0	0	0	0	0	0
	Common bottlenose dolphin – Western North Atlantic Offshore Stock	2603	1351	839	369	2349	1262	773	362	3166	1838	1244	286
	Long-finned pilot whale	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
	Short beaked common dolphin	2469	1401	911	415	2277	1314	795	380	3125	1944	1210	331
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale	0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise	2558	1368	807	227	2345	1286	761	208	3120	1738	1104	178
Phocid Pinnipeds Underwater (PW)	Harbor seal	2533	1392	814	216	2298	1250	814	216	2935	1717	1202	196
	Gray seal	2417	1378	834	391	2335	1348	731	338	3058	1944	1239	259
Turtles (TU)	Green turtle	351	1	0	0	351	1	0	0	1	0	0	0
	Kemp’s ridley turtle	351	1	0	0	351	1	0	0	1	0	0	0
	Leatherback turtle	351	1	0	0	351	1	0	0	1	0	0	0
	Loggerhead turtle	351	1	0	0	351	1	0	0	1	0	0	0

Table 50. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Include Four Post-Piled Pin Piles), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	*Marine Animal Species*		*Injury*								*Behavior*			
			Peak (L_{pk})				*SEL (L_E)*				*SPL (L_p)*			
			Sound Attenuation Level (dB)								*Sound Attenuation Level (dB)*			
			0	*6*	*10*	*15*	*0*	*6*	*10*	*15*	*0*	*6*	*10*	*15*
Low Frequency Cetaceans (LFC)	Common minke whale		5.4	2.4	0.0	0.0	123.9	61.4	31.9	9.8	173.5	123.7	104.6	79.8
	Fin whale		1.3	0.6	0.2	0.0	37.5	15.9	8.3	1.5	62.9	48.4	39.4	28.3
	Humpback whale		1.4	0.8	0.3	0.0	28.8	14.4	7.8	3.2	23.0	17.1	14.5	10.8
	North Atlantic right whale		0.1	0.0	0.0	0.0	3.2	1.6	0.9	0.4	3.4	2.3	1.8	1.3
	Sei whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.9	20.9	15.0	9.9
	Atlantic white sided dolphin		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	310.2	181.9	127.5	82.0
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2577.8	1842.2	1318.3	890.4
		Western North Atlantic Offshore Stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12082.1	7639.6	5572.1	3651.8
	Long finned pilot whale		0.0	0.0	0.0	0.0	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	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	1957.3	1245.0	915.0	624.0
	Short-finned pilot whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sperm whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High Frequency Cetaceans (HFC)	Harbor porpoise		45.1	30.8	18.8	7.7	2.3	0.0	0.0	0.0	411.2	238.3	162.2	108.6

Table 50. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Include Four Post-Piled Pin Piles), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	*Marine Animal Species*	*Injury*								*Behavior*			
		Peak (L_{pk})				*SEL (L_E)*				*SPL (L_p)*			
		Sound Attenuation Level (dB)								*Sound Attenuation Level (dB)*			
		0	*6*	*10*	*15*	*0*	*6*	*10*	*15*	*0*	*6*	*10*	*15*
Phocid Pinnipeds Underwater (PW)	Gray seal	37.0	12.4	5.9	0.0	13.0	0.0	0.0	0.0	1937.8	1127.1	753.5	472.2
	Harbor seal	28.0	13.5	1.2	0.0	25.0	0.0	0.0	0.0	3454.5	1840.8	1240.4	694.9
Turtles (TU)	Green turtle	0.0	0.0	0.0	0.0	1212.3	398.0	46.8	0.0	3394.8	1614.4	1212.0	888.3
	Kemp's ridley turtle	0.0	0.0	0.0	0.0	86.2	28.1	3.4	0.0	242.7	115.8	86.3	63.0
	Leatherback turtle	0.0	0.0	0.0	0.0	2001.0	663.8	74.1	0.0	5549.1	2622.1	1990.5	1471.4
	Loggerhead turtle	0.0	0.0	0.0	0.0	1392.9	457.0	51.5	0.0	3868.4	1839.6	1390.7	1021.1

Table 51. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (10-m Monopiles and OSS Jackets, Which Include Four Post-Piled Pin Piles), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	*Marine Animal Species*		*Injury*								*Behavior*			
			Peak (L_{pk})				*SEL (L_E)*				*SPL (L_p)*			
			Sound Attenuation Level (dB)								*Sound Attenuation Level (dB)*			
			0	***6***	***10***	***15***	***0***	***6***	***10***	***15***	***0***	***6***	***10***	***15***
Low Frequency Cetaceans (LFC)	Common minke whale		2.4	1.5	0	0	55.8	23.2	10.4	2.3	138.4	92.5	70.7	48.6
	Fin whale		0.6	0.2	0.0	0	15.5	6.0	2.5	0.1	45.0	31.1	24.1	15.5
	Humpback whale		0.6	0.4	0.1	0	15.3	6.3	3.3	1.0	21.4	15.5	11.5	7.5
	North Atlantic right whale		0.0	0.0	0.0	0	1.6	0.7	0.3	0.1	2.9	1.9	1.4	0.9
	Sei whale		0	0	0	0	0	0	0	0	0	0	0	0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.0	0	0	0	0	0	0	0	21.5	12.7	8.9	5.4
	Atlantic white sided dolphin		0	0	0	0	0	0	0	0	199.1	112.5	76.9	45.1
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	4.8	0	0	0	0	0	0	0	1667.5	1139.0	794.3	524.3
		Western North Atlantic Offshore Stock	0	0	0	0	0	0	0	0	7603.1	4617.3	3217.5	1979.3
	Long finned pilot whale		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
	Short-beaked common dolphin		0	0	0	0	0	0	0	0	1242.3	752.2	543.0	344.7
	Short-finned pilot whale		0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale		0	0	0	0	0	0	0	0	0	0	0	0
High Frequency Cetaceans (HFC)	Harbor porpoise		27.1	15.5	7.8	3.2	1.0	0	0	0	294.2	161.1	109.1	64.7

Table 51. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (10-m Monopiles and OSS Jackets, Which Include Four Post-Piled Pin Piles), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	***Marine Animal Species***	***Injury***								***Behavior***			
		Peak (L_{pk})				***SEL (L_E)***				***SPL (L_p)***			
		Sound Attenuation Level (dB)								***Sound Attenuation Level (dB)***			
		0	***6***	***10***	***15***	***0***	***6***	***10***	***15***	***0***	***6***	***10***	***15***
Phocid Pinnipeds Underwater (PW)	Gray seal	15.8	5.6	1.9	0	0	0	0	0	1302.2	715.2	464.8	278.5
	Harbor seal	10.0	3.2	1.1	0	4.8	0	0	0	2384.5	1260.2	804.5	443.6
Turtles (TU)	Green turtle	0.0	0.0	0.0	0.0	440.3	112.6	0.0	0.0	2314.5	1179.7	788.0	515.5
	Kemp's ridley turtle	0.0	0.0	0.0	0.0	31.2	8.1	0.0	0.0	165.3	84.8	56.4	36.7
	Leatherback turtle	0.0	0.0	0.0	0.0	730.2	182.3	0.0	0.0	3788.2	1905.3	1281.1	847.0
	Loggerhead turtle	0.0	0.0	0.0	0.0	505.7	126.1	0.0	0.0	2647.5	1339.5	899.2	589.5

Table 52. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Each Include Four Pre- and Post-Piled Pin Piles, Respectively), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	***Marine Animal Species***		***Injury***								***Behavior***			
			Peak (L_{pk})				***SEL (L_E)***				***SPL (L_p)***			
			Sound Attenuation Level (dB)								***Sound Attenuation Level (dB)***			
			0	***6***	***10***	***15***	***0***	***6***	***10***	***15***	***0***	***6***	***10***	***15***
Low Frequency Cetaceans (LFC)	Common minke whale		0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	61.6	34.5	20.1	9.4
	Fin whale		0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	22.0	14.0	10.4	4.7
	Humpback whale		0.0	0.0	0.0	0.0	1.9	0.1	0.0	0.0	8.3	6.6	5.3	3.2
	North Atlantic right whale		0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.0	0.6	0.4	0.3
	Sei whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	6.0	4.5	2.1
	Atlantic white sided dolphin		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.5	44.5	27.2	13.6
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1021.3	697.1	528.3	362.2
		Western North Atlantic Offshore Stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2412.1	1207.5	711.7	303.9
	Long finned pilot whale		0.0	0.0	0.0	0.0	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	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	437.7	229.2	129.6	43.1
	Short-finned pilot whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sperm whale		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 52. Overall Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Each Include Four Pre- and Post-Piled Pin Piles, Respectively), Assuming that all Foundations are Installed at Either the Deep or the Shallow Model Site.

Marine Animal Hearing Group	*Marine Animal Species*	*Injury*								*Behavior*			
		Peak (L_{pk})				*SEL (L_E)*				*SPL (L_p)*			
		Sound Attenuation Level (dB)								*Sound Attenuation Level (dB)*			
		0	*6*	*10*	*15*	*0*	*6*	*10*	*15*	*0*	*6*	*10*	*15*
High Frequency Cetaceans (HFC)	Harbor porpoise	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.9	59.4	45.1	23.2
Phocid Pinnipeds Underwater (PW)	Gray seal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	395.2	242.5	177.1	99.4
	Harbor seal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	506.4	317.5	213.1	127.8
Turtles (TU)	Green turtle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1168.3	600.9	361.1	12.2
	Kemp's ridley turtle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.7	43.7	26.4	1.0
	Leatherback turtle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1856.9	948.8	564.8	15.0
	Loggerhead turtle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1320.4	673.7	401.5	12.5

Table 53. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Conductor Barrel Installation or Removal via Impact Pile Driving at the Atlantic Shores North Monmouth, NJ Representative Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	Marine Mammal Species		Seasonal Exposures Per Day and Per Conductor Barrel											
			PTS (L_E)				*PTS (L_{pk})*				*Behavior (L_p)*			
			Winter	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.04
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency	Harbor porpoise		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 53. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Conductor Barrel Installation or Removal via Impact Pile Driving at the Atlantic Shores North Monmouth, NJ Representative Model Site, with No Sound Attenuation Applied.

Cetaceans (HFC)													
Phocid Pinnipeds Underwater (PW)	Gray seal*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Harbor seal*	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01

Table 54. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Conductor Barrel Installation or Removal via Impact Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	Marine Mammal Species		Seasonal Exposures Per Day and Per Conductor Barrel											
			PTS (L_E)				PTS (L_{pk})				Behavior (L_p)			
			Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency	Harbor porpoise		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 54. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Conductor Barrel Installation or Removal via Impact Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Model Site, with No Sound Attenuation Applied.

Cetaceans (HFC)													
Phocid Pinnipeds Underwater (PW)	Gray seal*	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Harbor seal*	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00

Table 55. Overall Acoustic Exposure Estimates of Marine Mammals Based on Installation and Extraction of 11 Conductor Barrels (Eight in NJ and Three in NY) via Impact Pile Driving during the Project, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	Marine Mammal Species		Acoustic Exposures								
			Installation: Winter			Extraction: Spring			Project Overall		
			L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.12	0.00	0.00	0.10	0.01	0.00	0.22
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gray seal*		0.01	0.00	0.00	0.02	0.00	0.01	0.03	0.00	0.01

Table 55. Overall Acoustic Exposure Estimates of Marine Mammals Based on Installation and Extraction of 11 Conductor Barrels (Eight in NJ and Three in NY) via Impact Pile Driving during the Project, with No Sound Attenuation Applied.

Phocid Pinnipeds Underwater (PW)	Harbor seal*	0.06	0.00	0.12	0.09	0.00	0.10	0.15	0.00	0.21

6.7.3 Vibratory Pile Driving of Cofferdam

The number of seasonal, unmitigated acoustic exposure estimates of marine mammals for vibratory pile driving at each of the two representative cofferdam model sites have been estimated for the installation or extraction of a single cofferdam (Tables 56 and 57). The overall acoustic exposures for the installation and extraction of all six cofferdams (four in NJ and two in NY) have also been estimated (Table 58). Although all seasons were modeled for cofferdam installation/extraction, the calculation of the overall acoustic exposures assumed that installation would occur in winter and extraction would occur in spring. These seasons were chosen for installation and extraction to allow for maximum flexibility in the installation and extraction of cofferdams since these seasons generally have the highest acoustic exposures. Acoustic exposures associated with vibratory pile driving for cofferdam installation or removal have been reported herein to two decimal places, so that it appears that most species have 0.00 acoustic exposures or no exposures whereas the actual exposures are typically very, very small and would only be represented if exposures were reported to the fifth or sixth decimal place.

Acoustic exposures for sea turtles due to vibratory pile driving for cofferdams were not calculated as sea turtle species are not reasonably expected to be present in the cofferdam model areas during the modeled seasons of winter and spring. As cold-blooded animals, sea turtles depend upon the temperature of their surrounding environment to maintain their body temperatures. Winter and spring water temperatures off New Jersey and New York are too cold for sea turtle survival, so sea turtles migrate southward into warmer ocean environments during these seasons, only returning northward as the ocean temperatures begin warming.

6.7.4 Vibratory Pile Driving of Goal Posts

The number of seasonal, unmitigated acoustic exposure estimates of marine mammals for vibratory pile driving at each of the two representative model sites have been estimated for the installation or extraction of a single goal post (Tables 59 and 60). The overall acoustic exposures for the installation and extraction of all 11 goal posts (eight in NJ and three in NY) have also been estimated (Table 61). Although all seasons were modeled for goal post installation/extraction, the calculation of the overall acoustic exposures assumed that installation would occur in winter and extraction would occur in spring. These seasons were chosen for installation and extraction to allow for maximum flexibility in the installation and extraction since these seasons generally have the highest acoustic exposures. Acoustic exposures associated with vibratory pile driving for goal post installation or removal have been reported herein to two decimal places, so that it appears that most species have 0.00 acoustic exposures or no exposures whereas the actual exposures are typically very, very small and would only be represented if exposures were reported to the fifth or sixth decimal place.

Acoustic exposures for sea turtles due to vibratory pile driving for goal posts were not calculated as sea turtle species are not reasonably expected to be present in the model areas during the modeled seasons of winter and spring. As cold-blooded animals, sea turtles depend upon the temperature of their surrounding environment to maintain their body temperatures.

Table 56. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Cofferdam Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Monmouth, NJ Representative Cofferdam Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*		*Seasonal Exposures (Per Cofferdam, Assuming 2 Days of Installation or Removal)*							
			PTS (L_E)				*Behavior (L_p)*			
			Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.73	1.83	3.86	3.21
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.04	0.07	0.00	0.07
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 56. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Cofferdam Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Monmouth, NJ Representative Cofferdam Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*	*Seasonal Exposures (Per Cofferdam, Assuming 2 Days of Installation or Removal)*							
		PTS (L_E)				*Behavior (L_p)*			
		Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
High Frequency Cetaceans (HFC)	Harbor porpoise	0.00	0.00	0.00	0.00	0.13	0.28	0.00	0.00
Phocid Pinnipeds Underwater (PW)	Gray seal	0.00	0.00	0.00	0.00	0.27	0.65	0.50	0.39
	Harbor seal	0.00	0.00	0.00	0.00	0.68	1.47	1.13	0.88

Table 57. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Cofferdam Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Cofferdam Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*		*Seasonal Exposures (Per Cofferdam, Assuming 2 Days of Installation or Removal)*							
			PTS (L_E)				*Behavior (L_p)*			
			Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.01	0.07	0.30	0.06
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 57. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Cofferdam Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Cofferdam Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*	*Seasonal Exposures (Per Cofferdam, Assuming 2 Days of Installation or Removal)*							
		PTS (L_E)				*Behavior (L_p)*			
		Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
High Frequency Cetaceans (HFC)	Harbor porpoise	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Phocid Pinnipeds Underwater (PW)	Gray seal	0.00	0.00	0.00	0.00	0.06	0.38	0.50	0.23
	Harbor seal	0.00	0.00	0.00	0.00	0.14	0.85	1.12	0.51

Table 58. Overall Acoustic Exposure Estimates of Marine Mammals Based on Installation and Extraction of Six Cofferdams (Four in NJ and Two in NY) via Vibratory Pile Driving during the Project, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*		*Acoustic Exposures*					
			Installation: Winter		*Extraction: Spring*		*Project Overall*	
			L_E	L_p	L_E	L_p	L_E	L_p
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.01	0.00	0.17	0.00	0.17
	Fin whale		0.00	0.01	0.00	0.02	0.00	0.03
	Humpback whale		0.00	0.03	0.00	0.01	0.00	0.04
	North Atlantic right whale		0.00	0.01	0.00	0.01	0.00	0.02
	Sei whale		0.00	0.01	0.00	0.01	0.00	0.02
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.02	0.00	0.06	0.00	0.09
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	2.95	0.00	7.45	0.00	10.40
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.18	0.00	0.31	0.00	0.49
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		0.00	0.54	0.00	1.13	0.00	1.68
	Gray seal*		0.00	1.19	0.00	3.37	0.01	4.56

Table 58. Overall Acoustic Exposure Estimates of Marine Mammals Based on Installation and Extraction of Six Cofferdams (Four in NJ and Two in NY) via Vibratory Pile Driving during the Project, with No Sound Attenuation Applied.

Phocid Pinnipeds Underwater (PW)	Harbor seal*	0.01	3.00	0.01	7.56	0.02	10.56

Table 59. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Goal Post Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Monmouth, NJ Representative Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	***Marine Mammal Species***	***Seasonal Exposures (Per Goal Post, Assuming 4 hrs of Installation or Removal)***							
		PTS (L_E)				***Behavior (L_p)***			
		Winter	***Spring***	***Summer***	***Fall***	***Winter***	***Spring***	***Summer***	***Fall***
Low Frequency Cetaceans (LFC)	Common minke whale	0.00	0.00	0.00	0.00	0.03	1.01	0.03	0.04
	Fin whale	0.00	0.00	0.00	0.00	0.15	0.18	0.02	0.04
	Humpback whale	0.00	0.00	0.00	0.00	0.16	0.19	0.01	0.10
	North Atlantic right whale	0.00	0.00	0.00	0.00	0.05	0.06	0.00	0.01
	Sei whale	0.00	0.00	0.00	0.00	0.05	0.06	0.00	0.02
MF Cetaceans (MFC)	Atlantic spotted dolphin	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
	Atlantic white sided dolphin	0.00	0.00	0.00	0.00	0.20	0.40	0.01	0.18
	Common bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	13.71	25.16	16.74	46.69
	Long finned pilot whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	Short-beaked common dolphin	0.00	0.00	0.00	0.00	1.51	1.65	0.04	1.54
MFC (Cont'd)	Short-finned pilot whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
High Frequency Cetaceans (HFC)	Harbor porpoise	0.00	0.00	0.00	0.00	3.29	5.61	0.01	0.03
Phocid Pinnipeds Underwater (PW)	Gray seal	0.00	0.00	0.00	0.00	6.89	10.97	1.89	5.40
	Harbor seal	0.00	0.00	0.00	0.00	15.47	24.64	4.25	12.13

Table 60. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Goal Post Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*		*Seasonal Exposures (Per Goal Post, Assuming 4 hrs of Installation or Removal)*							
			PTS (L_E)				*Behavior (L_p)*			
			Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fin whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Humpback whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.02	0.13	0.43	0.11
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 60. Seasonal Acoustic Exposure Estimates of Marine Mammals Based on Goal Post Installation or Removal via Vibratory Pile Driving at the Atlantic Shores North Wolfe's Pond, NY Representative Model Site, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	*Marine Mammal Species*	*Seasonal Exposures (Per Goal Post, Assuming 4 hrs of Installation or Removal)*							
		PTS (L_E)				*Behavior (L_p)*			
		Winter	*Spring*	*Summer*	*Fall*	*Winter*	*Spring*	*Summer*	*Fall*
High Frequency Cetaceans (HFC)	Harbor porpoise	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00
Phocid Pinnipeds Underwater (PW)	Gray seal	0.00	0.00	0.00	0.00	0.10	0.53	0.46	0.36
	Harbor seal	0.00	0.00	0.00	0.00	0.23	1.19	1.03	0.81

Table 61. Overall Acoustic Exposure Estimates of Marine Mammals Based on Installation and Extraction of 11 Goal Posts (Eight in NJ and Three in NY) via Vibratory Pile Driving during the Project, with No Sound Attenuation Applied.

Marine Mammal Hearing Group	Marine Mammal Species		Acoustic Exposures					
			Installation: Winter		Extraction: Spring		Project Overall	
			L_E	L_p	L_E	L_p	L_E	L_p
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	1.18	0.00	1.44	0.00	2.62
	Fin whale		0.00	1.31	0.00	1.50	0.00	2.81
	Humpback whale		0.00	0.42	0.00	0.51	0.00	0.93
	North Atlantic right whale		0.00	0.41	0.00	0.51	0.00	0.92
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	1.58	0.00	3.20	0.00	4.78
	Atlantic white sided dolphin		0.00	1.18	0.00	1.44	0.00	2.62
	Common bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	109.72	0.00	201.70	0.00	311.42
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.09	0.00	0.02	0.00	0.11
	Short-beaked common dolphin		0.00	12.12	0.00	13.24	0.00	25.37
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.03	0.00	0.09	0.00	0.12
High Frequency Cetaceans (HFC)	Harbor porpoise		0.00	26.35	0.00	44.98	0.00	71.33
Phocid Pinnipeds Underwater (PW)	Gray seal*		0.00	55.39	0.00	89.31	0.00	144.70
	Harbor seal*		0.00	124.44	0.00	200.66	0.00	325.10

Winter and spring water temperatures off New Jersey and New York are too cold for sea turtle survival, so sea turtles migrate southward into warmer ocean environments during these seasons, only returning northward as the ocean temperatures begin warming.

7 Discussion

7.1 Sound Attenuation Levels for Mitigation

7.2 Sources of Uncertainty

Sources of uncertainties inherent in the modeling presented herein include animal densities, animal movements, and the pile driving spectrum.

7.2.1 Animal Density

Animal density estimates are a source of uncertainty in modeling and analysis as they can result in large effects on the calculated number of acoustically exposed animals. The fidelity of animal density estimates improves as additional population level data are collected and both collection and analysis methodologies are refined.

Marine mammal density estimates used in this analysis were taken from the MGEL (2022), the methodology of which is based on Roberts et al. (2016). Sea turtle density estimates are based on DiMatteo et al. (2023), which represent recently updated density models for the Project area and Atlantic waters. These density estimates for marine mammals and sea turtles are the most recent and best available data for the Project area. Both density datasets were extrapolated over large ocean areas and averaged monthly or seasonally.

7.2.2 Animal Movements

The movement parameters used to create the animat paths during the AIM simulations are based on the most recent and most complete reported values of real sea turtle and marine mammal swim and diving behavior (Appendix B, Table B-1). However, the recorded range of behavior may not be complete as little information is known about the movements of some marine mammal and sea turtle species. This uncertainty is considered to have a small potential to affect the number of exposed animals.

7.2.3 Source Spectra

The derivation of pile driving source spectra for the pile driving hammers used for both impact and vibratory pile driving relied on modeled information or use of surrogate data for similar hammers and pile diameters. Although these source spectra represent the best available estimations for the Project scenarios, they would never be as robust as measured source data.

7.2.4 Acoustic Propagation Modeling

The Project will span multiple seasons, with the modeled construction period represented by three seasons or monthly periods, although the third season only is represented by one month (December). Two sites within the Project lease area were selected to best represent the environment of the Project area as there is little bathymetric difference across the Project area while two nearshore model sites were selected to represent the vibratory pile driving to install or remove cofferdams.

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9 List of Preparers

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APPENDIX A: ACOUSTIC CONCEPTS AND TERMINOLOGY

This section provides a review of some of the relevant concepts in acoustics, particularly underwater acoustics, to assist readers in understanding some of the concepts and terminology used in this report. Sound is the result of particles vibrating to create mechanical waves that travel through a medium, such as air or water. These waves create pressure changes that vary in space and time, resulting in time-varying pressure disturbances that oscillate above and below the ambient pressure.

The intensity of a plane sound wave in the far field is proportional to the square of its pressure (p):

$$I = p^2/\rho c$$

where ρ is the density of the medium (e.g., water) and c is the speed of sound in that medium.

Two types of level are in widespread use in underwater acoustics, the level of a field quantity and the level of a power quantity. In underwater acoustics, it is conventional to express both types of level in decibels (dB). When expressed in decibels, the level L_F of a field quantity F is:

$$L_F = 20 \log_{10}(F/F_0) \text{ dB}$$

where F_0 is the reference value of the field quantity. Similarly, the level L_P of a power quantity P is

$$L_P = 10 \log_{10}(P/P_0) \text{ dB}$$

Where P_0 is the reference value of the power quantity.

Care must be taken when reporting and reading sound levels in decibels to ensure that measurements are properly described. To compare sound levels given in decibels to one another, a standard reference intensity or reference pressure must be used. In underwater acoustics, the standard reference pressure (p_0) for SPL is 1 microPascal (μPa) and the decibel level is expressed as “dB re 1 μPa”.

In addition to units, the acoustic measurement type must be considered. Measurement type refers to how the pressure was measured. Changing the” type” of measurement can significantly change the reported sound level of a given continuous sound (e.g., peak-to-peak (pk-pk) versus zero-to peak (0-pk) versus root-mean-square (RMS)). RMS, 0-pk, and pk-pk sound pressure levels (SPL_{rms}, $SPL_{0\text{-}pk}$, $SPL_{pk\text{-}pk}$, respectively) are the most common sound measurement types. RMS measures are essentially an average of the intensity over a given amount of time. RMS measures are most appropriate for longer (i.e., non-impulsive) signals but are considered in impact assessments as described below. Impulsive signals, such as those from impact pile driving, are often quantified as 0-pk or pk-pk measurements.

Real-world measured acoustic signals include noise, making it difficult to define a start and end point of an impulsive signal. A typical approach to deal with this issue is to use the portion (in time) of the signal that includes from the 5th to the 95th percentile of the energy in the signal.

Zero-to-peak or peak-peak measurements simply measure the maximum absolute amplitude of the signal, without consideration of the duration of the signal and avoid this problematic issue. Sound exposure level (SEL), another common measurement type, also avoids the problem by specifying a fixed time value.

SEL, appropriate for all signal types, is the integral over a specified time interval of the sound energy produced from a source. These values are reported with units of dB re 1 μPa^{2}s where s is seconds. SEL can be the energy accumulated over a given time period, indicated as L_E(cum), or it can be the energy integrated over a single pile driving strike (single strike), indicated as L_E(ss).

The statistical average of a certain acoustic signal (including noise) as analyzed in terms of its frequency content, is called its spectrum. Spectral density describes the distribution over frequency of the power (applicable to continuous signals) or energy (applicable to finite-duration signals) in a signal. Power spectral densities are reported in dB re 1μPa^2/Hz and energy spectral densities in dB re 1μPa^{2}s/Hz. Integration of spectral density over a frequency band describes the total power or energy in that band and is referred to as a "band level". Band levels are frequently presented in third-octave bands in bioacoustics to approximate the bandwidths of mammalian auditory systems (Figures A-1 and A-2). SPL band levels are reported in dB re 1μPa and SEL band levels in dB re 1μPa^{2}s. Broadband levels sum the band levels over a specified frequency range and are reported in dB referenced to the same reference levels as the band levels. Figure A-2 shows an example of third-octave band levels and the associated broadband level.

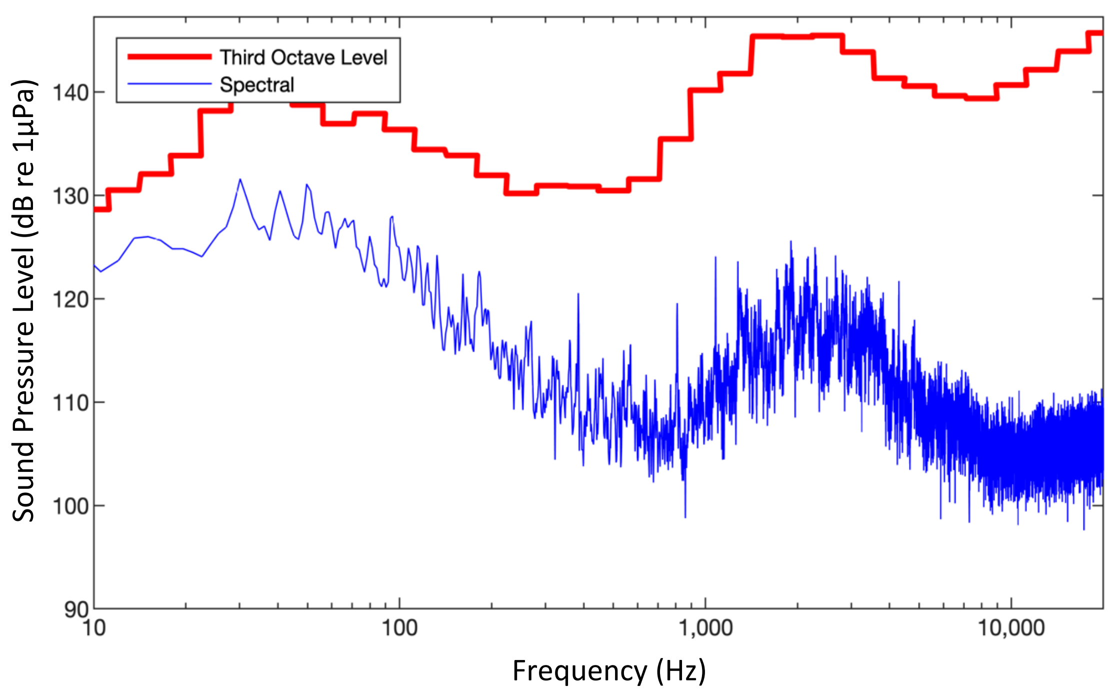

Figure A-1. Comparison of a spectral (blue) level and it associated third-octave band level (red) spectra.

SOUND METRIC DEFINITIONS

- **RMS Sound Pressure Level (SPL_{rms} or L_P)**—Defined as an integral over a specified time interval (*T*) of squared sound pressure time series (*p(t)*) divided by the duration of the time interval and the reference pressure (p_{ref}) for a specified frequency range.

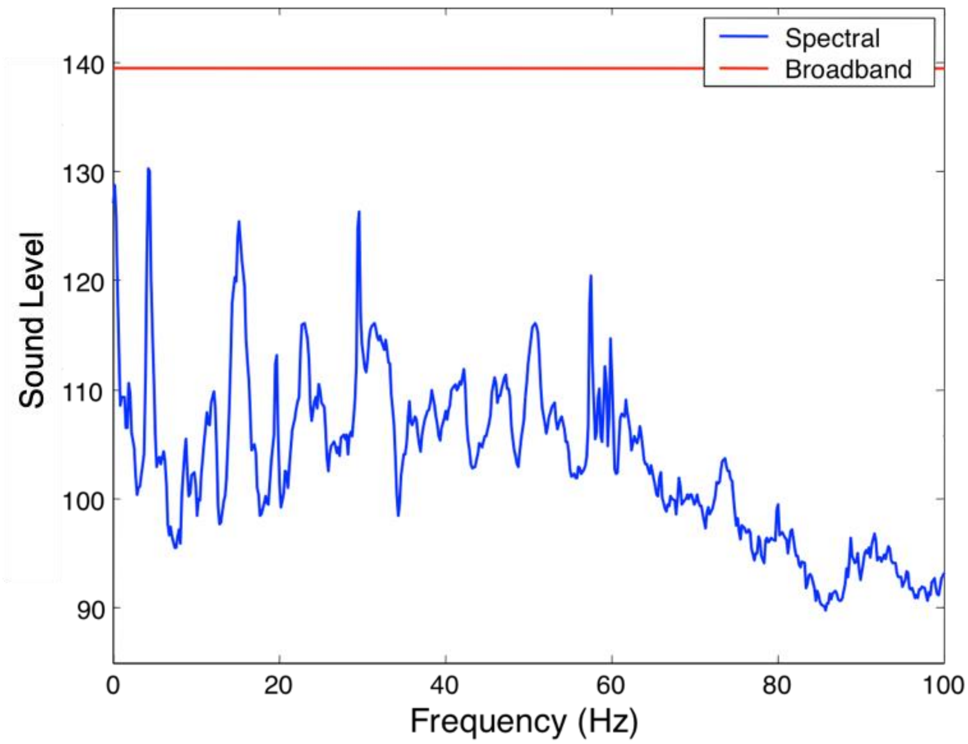

Figure A-2. Comparison of spectral and associated broadband source levels. A sample sound spectrum is shown in blue, which has a maximum spectral level of 130 dB re 1μPa²/Hz. The broadband level is the integration of all the energy from all frequencies, which in this example is 139 dB re 1μPa.

Continuous sources, such as vibratory piling driving, thruster operations, and shipping are commonly described in terms of an RMS sound pressure level (L_p).

$$L_P \text{ (dB re 1 μPa)} = 20\, log_{10}\left(\sqrt{\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt}/p_{ref}\right)$$

For impulsive signals, such as from impact pile driving, the measurement period is defined as the time period that contains 90 percent of the sound energy ($T=T_{90}$) (Madsen, 2005).

- **Sound Exposure Level (SEL or L_E)**—Sound exposure level (SEL) specifies the sound pressure over a time interval or event and for a specified frequency range and is expressed in dB re 1 μPa²s. The SEL for a single event is computed from the time-integral of the squared pressure over a specified time period, *T*:

$$L_E \text{ (dB re 1 μPa}^2\text{•s)} = 10\, log_{10}\left(\int_T p^2(t)dt\ /\ p_{ref}^2\right)$$

Where L_E represents the total acoustic energy received at a given location.

Unless otherwise stated, SELs for pulse noise sources (i.e., impact hammer pile driving) presented in this report refer to a single pulse. The time period, *T*, used here for impulsive sources is 0.1 s; which leads to the following conversion between SEL and SPL:

$$SEL = SPL_{rms} + 10 \times \log_{10}(0.1) = SPL_{rms} - 10$$

L_E can be calculated as a cumulative metric over periods with multiple acoustic events. In the case of impulsive sources like impact piling, L_E can represent the summation of energy from multiple pulses, which is written L_E (cum), denoting that it represents the cumulative sound exposure over some duration. The sound exposure level over a 24-hour period is often used in the assessment of marine mammal and fish behavior, and is written as $L_{E,\,24h}$.

The cumulative SEL (dB re 1 µPa^2·s) can be computed by summing (in linear units) the L_E of the N individual events:

$$L_E\,(\text{cum}) = 10\, log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{Ei}}{10}}\right)$$

- **Peak Level (L_{pk})—**Maximum noise level over a given event is expressed as L_{pk}. and is calculated using the maximum variation of the absolute value of the pressure from zero within the wave. The peak level is commonly used as a descriptor for impulsive sound sources. The L_{pk} can be calculated using the formula below where *t* is time:

$$L_{pk}\,(\text{dB re 1 µPa}) = 20\, log_{10}\left[\frac{max(|p(t)|)}{p_{ref}}\right]$$

Pulses are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures.

- **Sound Exposure Spectral Density**—The SEL integral over time can also be written (Parseval's Theorem) as the integral over frequency of the sound exposure spectral density, E_f. E_f is single-sided (i.e., includes only positive frequencies), while P(f) is double-sided (i.e., includes both positive and negative frequencies). It is for this reason that the bounds change for the integral over E_f in the following equation:

$$\int_{-\infty}^{\infty} p^2(t)dt = \int_{-\infty}^{\infty} |P(f)|^2\, df = \int_{0}^{\infty} E_f\, df$$

P(f) is the Fourier transform of p(t).

Source levels are presented in this report in sound exposure band levels—i.e., the integral of E_f over third-octave bands--reported in dB re 1 µPa^2·m^{2}s, at a reference distance of 1 m.

Literature Cited

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Appendix B: Animat Modeling Parameters

B-1. Parameters that Define Animat Movement in AIM

Animals move through four dimensions: three-dimensional space and time. Several parameters are used in AIM to produce simulated movements that accurately represent expected real animal movement patterns. This section provides short descriptions of the various parameters, with nominal values as examples of how the parameters are implemented in AIM. The actual values used in the animat modeling of the pile driving activities for the Project and the literature from which that information was obtained are detailed in this appendix (Table B-1). Table B-1 represents a portion of MAI's ongoing effort to review existing literature and obtain relevant dive and swim information for marine mammal and sea turtle species. When scientific papers or reports contain numeric descriptions of movement behaviors (e.g., dive times), these numeric values are added to MAIs Animat Movement Library. This compendium of movement values for each marine mammal and sea turtle species are then interpreted by an MAI subject matter expert to derive a set of summary values that represent each species/modeling group/behavioral state.

B-2. Marine Mammal Diving Patterns

Diving parameters, such as time limits, depth limits, heading variance, and speed, are specified for each animat in the AIM model (Figure B-1). As an example, a dive pattern is presented that consists of a shallow, respiratory sequence (Figure B-1) followed by a deeper, longer dive (bottom row of Figure B-1). The horizontal component of the dive is handled with the “heading variance” term, which allows the animal to change course up to a certain number of degrees at each movement step. For this example, the animal can change course 20° during a shallow dive and 10° during a deep dive (Figure B-1). Using the defined diving parameters, AIM generates realistic dive patterns (Figure B-2).

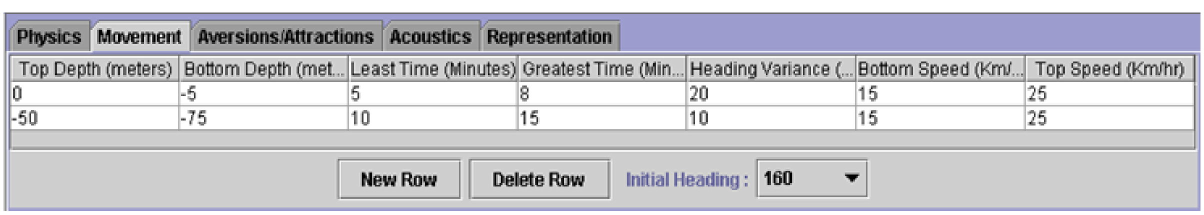


Figure B-1. Example of AIM marine mammal movement parameters, with the top row showing the parameters of a shallow, respiratory dive (diving from surface to 5 m for 5 to 8 min) and the bottom row showing a deeper, longer dive (diving between 50 and 75 m for 10 to 15 min).

B-3. Aversions

In addition to movement patterns, animats can be programmed to avoid certain environmental characteristics (Figure B-3). For example, aversions can be used to constrain an animal to a particular depth regime. (e.g., an animat can be constrained to waters between 2,000 and 5,000 m deep). An animat will continue to turn until the aversion is satisfied. In this example,

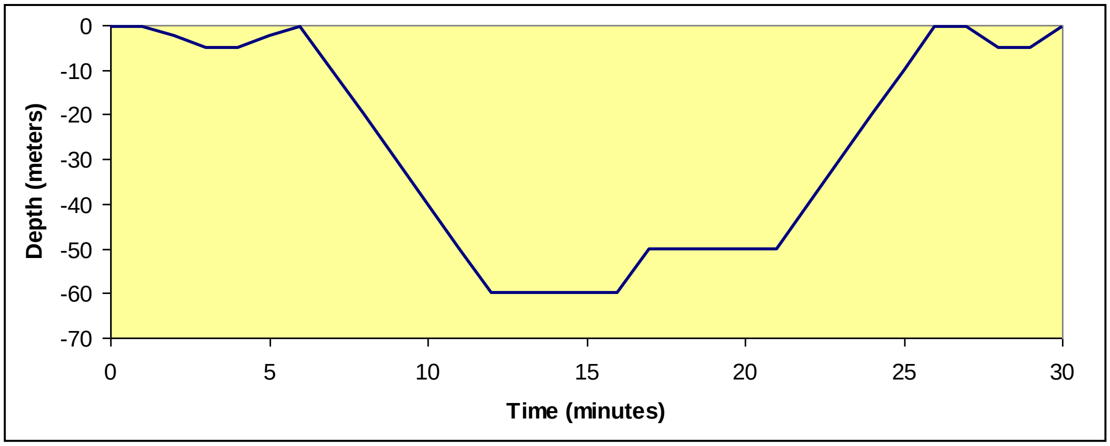
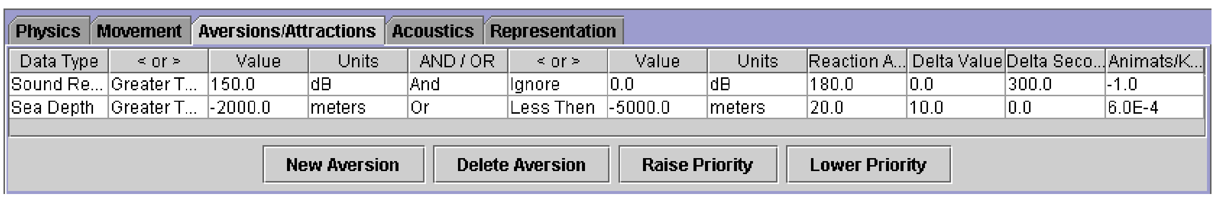


Figure B-2. Marine mammal dive pattern based on animat data in Figure B-1. The animat makes a shallow dive from the surface to 5 m for approximately 6 min, surfaces, and then makes a deep dive to 60 m for about 5 min, changes depth to 50 m for another 5 min, and then surfaces.



Data Type	< or >	Value	Units	AND / OR	< or >	Value	Units	Reaction A...	Delta Value	Delta Seco...	Animats/K...
Sound Re...	Greater T...	150.0	dB	And	Ignore	0.0	dB	180.0	0.0	300.0	-1.0
Sea Depth	Greater T...	-2000.0	meters	Or	Less Then	-5000.0	meters	20.0	10.0	0.0	6.0E-4

Figure B-3. Example of depth aversion parameters for modeling of marine mammal movements.

animat makes 20° turns in water depths shallower than 2,000 m or deeper than 5,000 m to remain within that depth range.

B-4. Heading Variance

There is little data that summarizes movement in terms of heading variance, or the amount the course of the animal changes per unit time. Therefore, the default value used in the modeling is 30 degrees. Exceptions are made for migratory animals, which tend to have more linear travel; therefore, these animals typically are assigned a value of 10 degrees. Foraging animals tend to have less linear travel, as they may be trying to remain within a food patch. Therefore, foraging animals are assigned a higher heading variance value, typically 45 to 60 degrees.

These types of data have been reported in the literature as “linearity”, “tortuosity” and “meander” (Soule and Wilcock, 2013). “Meander” is defined as the ratio of the total distance along the smoothed path to the net distance traveled; a value of 1 would indicate a straight path.

B-5. Residency

The amount of time that an animal spends in an area can have a tremendous influence on how the animal samples an acoustic field. For example, individuals displaying high residency in the area of a localized noise source will experience higher exposures than animals that transit once through that area. However, since the animat exposure models are run for a 24-hour period, in accordance with the NMFS 24-hour reset rule, the effect of residency in animat modeling is minimized.

B-6. Parameters of Marine Mammal Movement Behaviors Used in Impact Analysis

Dive and swim speed information for each marine mammal or marine mammal group is a critical component of accurately and realistically modeling marine mammal movements when assessing potential exposure to underwater acoustic sound. All parameters except speed use a uniform distribution between the minimum and maximum values. Speed parameters include the minimum and maximum as well as the statistical distribution used to select speed values. Options include a normal distribution and a gamma distribution. When gamma distributions are specified, they are typically the result of fitting to an existing dataset. The mean of the normal distribution is also the mean of the minimum and maximum speed. The minimum and maximum values are four standard deviations below or above the distribution mean. Dive and swim parameters for marine mammals potentially occurring in the Project modeled area are summarized in Table B-1.

Table B-1. Animat movement (dive and swim) parameters of the marine mammal and sea turtle species of interest in the modeling area for the Atlantic Shores North Project; multiple entries in a single cell represent multiple modeled diving states of the species. The underlying statistic distribution is uniform for all parameters except speed, which uses either a normal or user-specified gamma distribution. Literature references for each type of information are listed numerically in the row below the relevant species, with full literature citations in numerical order following this tabular information.

Modeled Species/Species Group	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle (°)*	*Dive Depth in Meters Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (m)/ Reaction Angle*
Fin Whale	2/4	64/54	20/40 (25) 20/40 (25) 50/150 (22) 50/150 (22) 150/527 (6)	2/4 2/4 5/8 5/8 10/18	30/300 90/300 30/300 90/300 90/300	1/16	Normal	10/ reflect
Literature References	[1-4].	[5]	[3-9]	[1, 3-6, 8, 10]	[11, 12]	[8, 11, 13-15]		[13, 16-19]
Humpback Whale	1/2	75	10/40 (75) 10/40 (25)	5/10 5/10	90/300 10/300	2/12	Normal	10/ reflect
Literature References	[20-22]		[20, 21, 23-25]	[20-22]	[26, 27]	[26, 28-30]		[31-33]
Common Minke Whale	1/3	75	20/120 (50) 20/120 (50)	2/6 2/6	90/90 90/300	1/18	Gamma (3,2)	20 / reflect
Literature References	[34]		[35-38]	[34, 36, 37, 39-42]		[34, 43, 44]	[34]	[34, 45, 46]
North Atlantic Right Whale (Foraging)	1/1	75	10/200 (10) 10/35 (90)	1/10 1/7	90/60 30/300	2/5	Normal	10
Literature References	[47, 48]		[48-53]	[48, 49, 54]	[55]	[49, 55, 56]		[57, 58]
Sei Whale	2/4	90/75	10/40 (40) 10/40 (40) 50/267 (10)	2/11	30/300 90/300 30/300	1/20	Gamma (5,1)	50 / reflect

Table B-1. Animat movement (dive and swim) parameters of the marine mammal and sea turtle species of interest in the modeling area for the Atlantic Shores North Project; multiple entries in a single cell represent multiple modeled diving states of the species. The underlying statistic distribution is uniform for all parameters except speed, which uses either a normal or user-specified gamma distribution. Literature references for each type of information are listed numerically in the row below the relevant species, with full literature citations in numerical order following this tabular information.

Modeled Species/Species Group	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle (°)*	*Dive Depth in Meters Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (m)/ Reaction Angle*
			50/267 (10)		90/300			
Literature References	[59]		[60, 61]	[59, 62, 63]	[63, 64]	[64-67, 205]		
Atlantic Spotted Dolphin	1/1	75	Day: 5/25 (50) Night: 10/400 (10) Night: 10/100(40)	1/4	30	2/15	Gamma (5,1)	10/ reflect
Literature References			[68-71]	[69, 71-73]		[72, 74-76]		[77, 78]
Atlantic White-sided Dolphin	1/1		25/125 (50) 25/125 (50)	1/3	30/300 90/300	2/9	Normal	10/ reflect
Literature References	[79]			[79]		[80][81]		
Common Bottlenose Dolphin (Offshore)	1/1	75	6/50 (40) 6/50(40) 50/100 (5) 200/250(5) 250/500(10)	1/2 1/2 2/3 3/4 4/6	90/300 90/90 30/300 90/300 90/300	2/16	Normal	20 /reflect
Literature References	[102-104]		[102, 105, 106]	[103, 106]		[103, 107-110]		[77, 111, 112]
Common Bottlenose Dolphin (Coastal)	1/1	75	15/98	1/3	90/300 (50) 90/90 (50)	2/16	Normal	5-20/ reflect

Table B-1. Animat movement (dive and swim) parameters of the marine mammal and sea turtle species of interest in the modeling area for the Atlantic Shores North Project; multiple entries in a single cell represent multiple modeled diving states of the species. The underlying statistic distribution is uniform for all parameters except speed, which uses either a normal or user-specified gamma distribution. Literature references for each type of information are listed numerically in the row below the relevant species, with full literature citations in numerical order following this tabular information.

Modeled Species/Species Group	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle (°)*	*Dive Depth in Meters Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (m)/ Reaction Angle*
Literature References	[102-104]		[102, 105, 106]	[103, 106]		[103, 107-110]		[77, 111, 112]
Common (Short-beaked) Dolphin	1/1	75	50/200 (50) 50/200 (50)	1/5	30/300 90/90	2/16	Normal	20/ reflect
Literature References			[113, 114]	[115]		[116, 117]		[118, 119]
Harbor Porpoise	1/1	75	1/10 (35) 10/40 (45) 40/100 (15) 100/230 (5)	1/4	43/30	2/8	Normal	10/ reflect
Literature References	[120, 121]		[120, 122]	[120-123]	[121]	[80, 120-124]		[125-127]
Pilot Whales	1/1	75	10/100 (40) 10/100 (40) 10/1000 (20)	1/10 1/10 5/21	90/90 90/300 30/300	2/12	Normal	50/ reflect
Literature References	[143]		[92, 144-148]	[143-149]		[144, 148-152]		[77, 119, 153]
Risso's Dolphin	1/3	75	150/1000 (40) 150/1000 (60)	2/12	90/300 30/300	2/12	Normal	100/ reflect
Literature References	[154, 155]		[155, 156]	[154, 156]		[150, 154]		[77, 119, 157]

Table B-1. Animat movement (dive and swim) parameters of the marine mammal and sea turtle species of interest in the modeling area for the Atlantic Shores North Project; multiple entries in a single cell represent multiple modeled diving states of the species. The underlying statistic distribution is uniform for all parameters except speed, which uses either a normal or user-specified gamma distribution. Literature references for each type of information are listed numerically in the row below the relevant species, with full literature citations in numerical order following this tabular information.

Modeled Species/Species Group	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle (°)*	*Dive Depth in Meters Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (m)/ Reaction Angle*
Sperm Whale	8/11	75	600/1000 (50) 600/1000 (50)	35/65	30/300 90/300	1/8	Normal	100/reflect
Literature References	[162, 163]	[164]	[92, 165-172]	[92, 165, 171]	[167, 173-175]	[162, 167, 173, 176-179]		[77, 180-182]
Gray Seal	1/1		10/200 (50) 10/200 (50)	4/8	90/90 30/300	1/4	Normal	10/reflect
Literature References	[183]		[184]	[185]		[185, 186]		
Harbor Seal	1/1		1/1 (35) 5/20 (15) 50/150 (25) 50/150 (25)	1/2 1/2 4/7 1/4	10/300 30/300 90/90 30/300	1/4	Normal	10/reflect
Literature References	[187, 188]		[187-191]	[187-190, 192]		[187, 188]		[188, 189]
Sea Turtle (representative of commonly occurring turtles)**	1/2		15/266 (50) 15/266 (50)	2/92	10/300 180/300	0/4.5	Normal	10/reflect
Literature References			[193-198]	[198-203]	[198, 204]	[199, 204]		

Table B-1. Animat movement (dive and swim) parameters of the marine mammal and sea turtle species of interest in the modeling area for the Atlantic Shores North Project; multiple entries in a single cell represent multiple modeled diving states of the species. The underlying statistic distribution is uniform for all parameters except speed, which uses either a normal or user-specified gamma distribution. Literature references for each type of information are listed numerically in the row below the relevant species, with full literature citations in numerical order following this tabular information.

Modeled Species/Species Group	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle (°)*	*Dive Depth in Meters Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (m)/ Reaction Angle*

**Leatherback turtle's dive/swim information was used to represent all commonly occurring sea turtle species in the project area since more information on their dive and swim behaviors is available.

Table B-1 Literature Cited (Numerically As Presented In Table B-1)

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Appendix C: Annual Acoustic Exposure Tables

Table C-1. Year 1 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Includes Four Post-Piled Pin Piles) for the Shallow Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	15.65	3.37	0.04	0.00	39.64	35.02	31.96	20.13
	Fin whale		0.73	0.15	0.11	0.00	7.65	2.61	0.83	0.03	26.81	21.46	17.28	12.23
	Humpback whale		0.96	0.53	0.18	0.00	7.40	3.93	2.65	1.07	9.91	8.14	6.52	5.36
	North Atlantic right whale		0.05	0.02	0.02	0.00	0.86	0.36	0.22	0.08	1.53	1.17	0.81	0.54
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.38	8.99	7.21	5.35
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.42	74.80	56.30	39.40
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	14.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1743.76	1247.87	894.55	602.36
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3050.83	2079.83	1527.02	935.40
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	509.59	385.95	290.51	201.85
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		31.29	21.76	13.58	4.20	0.00	0.00	0.00	0.00	113.56	78.07	65.88	51.45
Phocid Pinnipeds Underwater (PW)	Gray seal		22.62	7.51	1.96	0.00	0.00	0.00	0.00	0.00	625.08	437.30	320.04	218.46
	Harbor seal		6.55	0.73	0.73	0.00	0.00	0.00	0.00	0.00	1105.18	718.12	475.47	295.23
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	653.48	272.50	30.06	0.00	1694.46	1089.38	827.41	605.21
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	43.89	18.20	2.09	0.00	116.00	74.46	56.07	40.67
	Leatherback turtle		0.00	0.00	0.00	0.00	1101.33	463.69	47.43	0.00	2830.85	1821.55	1401.88	1024.19
	Loggerhead turtle		0.00	0.00	0.00	0.00	758.53	316.23	32.72	0.00	1940.95	1250.96	959.55	703.53

Table C-2. Year 1 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Includes Four Post-Piled Pin Piles) for the Deep Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		2.85	1.26	0.00	0.00	65.17	32.31	16.77	5.17	91.21	65.18	55.17	42.04
	Fin whale		0.85	0.35	0.00	0.00	25.02	10.70	5.55	0.97	41.74	32.21	26.38	18.95
	Humpback whale		0.33	0.27	0.00	0.00	20.60	10.43	5.67	2.37	16.52	12.28	10.45	7.74
	North Atlantic right whale		0.02	0.00	0.00	0.00	2.54	1.27	0.73	0.28	2.59	1.81	1.44	1.03
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.30	14.42	10.40	6.83
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	209.72	123.45	86.74	55.93
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8115.91	5152.97	3760.07	2463.56
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1431.37	913.62	674.85	458.46
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		29.93	14.14	8.80	3.39	1.38	0.00	0.00	0.00	293.56	171.77	116.02	78.05
Phocid Pinnipeds Underwater (PW)	Gray seal		21.79	5.87	3.30	0.00	7.90	0.00	0.00	0.00	1242.29	726.43	486.71	304.06
	Harbor seal		17.11	8.05	0.00	0.00	16.03	0.00	0.00	0.00	2213.46	1183.17	798.14	451.09
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	819.09	210.53	7.83	0.00	2273.96	990.99	563.65	303.02
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	55.15	14.23	0.58	0.00	154.32	66.49	37.95	20.24
	Leatherback turtle		0.00	0.00	0.00	0.00	1374.04	350.38	10.80	0.00	3775.55	1675.82	945.50	515.93
	Loggerhead turtle		0.00	0.00	0.00	0.00	951.81	241.94	7.71	0.00	2611.11	1156.91	653.08	354.28

Table C-3. Year 2 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Includes Four Post-Piled Pin Piles) for the Shallow Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	14.15	3.06	0.04	0.00	35.55	31.38	28.74	18.17
	Fin whale		0.41	0.09	0.07	0.00	3.76	1.35	0.44	0.02	13.78	10.91	8.88	6.28
	Humpback whale		0.39	0.23	0.08	0.00	2.85	1.45	1.01	0.40	3.97	3.32	2.70	2.12
	North Atlantic right whale		0.02	0.01	0.01	0.00	0.24	0.10	0.06	0.03	0.46	0.35	0.24	0.16
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.24	3.79	3.02	2.28
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.28	35.53	26.71	18.43
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	6.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	834.06	594.32	423.73	288.02
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1480.07	1009.41	743.17	453.52
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	188.52	140.99	107.17	72.38
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		13.80	9.07	5.27	3.52	0.00	0.00	0.00	0.00	45.63	34.04	29.03	21.22
Phocid Pinnipeds Underwater (PW)	Gray seal		14.35	4.86	1.32	0.00	0.00	0.00	0.00	0.00	346.98	246.41	181.41	123.68
	Harbor seal		3.97	0.50	0.50	0.00	0.00	0.00	0.00	0.00	616.80	407.49	271.12	167.57
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	309.53	125.48	16.73	0.00	818.10	525.01	384.58	283.08
	Kemp's ridley turtle		0.00	0.00	0.00	0.00	24.43	9.90	1.32	0.00	64.33	41.30	30.26	22.33
	Leatherback turtle		0.00	0.00	0.00	0.00	493.56	200.09	26.68	0.00	1242.80	800.56	588.65	447.21
	Loggerhead turtle		0.00	0.00	0.00	0.00	347.25	140.78	18.77	0.00	917.15	588.61	431.19	317.54

Table C-4. Year 2 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 1 (15-m Monopiles and OSS Jackets, Which Includes Four Post-Piled Pin Piles) for the Deep Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		2.57	1.14	0.00	0.00	58.73	29.12	15.15	4.63	82.30	58.53	49.43	37.72
	Fin whale		0.44	0.21	0.00	0.00	12.48	5.21	2.74	0.51	21.17	16.22	13.07	9.35
	Humpback whale		0.13	0.12	0.00	0.00	8.17	4.00	2.10	0.88	6.44	4.77	4.06	3.07
	North Atlantic right whale		0.01	0.00	0.00	0.00	0.71	0.35	0.20	0.08	0.76	0.53	0.40	0.29
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.61	6.43	4.60	3.06
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.44	58.43	40.72	26.04
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3966.23	2486.61	1812.00	1188.19
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	525.95	331.35	240.12	165.51
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		12.59	5.86	3.88	2.02	0.95	0.00	0.00	0.00	117.65	66.53	46.22	30.57
Phocid Pinnipeds Underwater (PW)	Gray seal		13.24	3.97	2.65	0.00	5.08	0.00	0.00	0.00	695.51	400.65	266.84	168.16
	Harbor seal		10.91	5.46	0.00	0.00	8.93	0.00	0.00	0.00	1241.09	657.67	442.27	243.77
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	393.18	103.18	5.58	0.00	1120.80	465.01	270.49	139.43
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	31.03	8.14	0.44	0.00	88.41	36.69	21.35	11.00
	Leatherback turtle		0.00	0.00	0.00	0.00	626.95	164.52	8.89	0.00	1773.57	739.39	431.31	222.32
	Loggerhead turtle		0.00	0.00	0.00	0.00	441.11	115.75	6.26	0.00	1257.26	521.67	303.46	156.42

Table C-5. Year 1 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Includes Four Pre- and Post-Piled Pin Piles, Respectively) for the Shallow Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.19	9.36	4.10	0.10
	Fin whale		0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	14.20	9.19	6.88	3.13
	Humpback whale		0.00	0.00	0.00	0.00	1.32	0.05	0.00	0.00	5.90	4.78	3.78	2.27
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.59	0.43	0.32	0.21
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.35	4.37	3.28	1.50
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.56	29.73	18.13	9.00
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	687.01	475.07	360.01	245.20
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1124.55	585.74	254.42	16.76
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.12	114.97	61.46	4.18
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	59.93	41.77	31.80	17.15
Phocid Pinnipeds Underwater (PW)	Gray seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	251.01	155.82	114.31	63.46
	Harbor seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	321.37	204.16	135.92	79.19
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	787.06	404.42	241.77	7.92
	Kemp's ridley turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	54.86	28.35	17.08	0.67
	Leatherback turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1310.64	672.14	399.10	12.40
	Loggerhead turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	893.34	453.69	267.91	7.83

Table C-6. Year 1 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Includes Four Pre- and Post-Piled Pin Piles, Respectively) for the Deep Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	32.49	18.20	10.60	4.96
	Fin whale		0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	14.54	8.58	4.65	1.35
	Humpback whale		0.00	0.00	0.00	0.00	1.08	0.01	0.00	0.00	5.37	3.28	1.95	0.48
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.79	0.45	0.21	0.02
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.94	2.52	1.50	0.88
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.86	20.09	10.69	4.52
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1641.75	823.54	481.32	203.12
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	319.46	168.41	95.08	30.09
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.72	22.85	12.62	3.46
Phocid Pinnipeds Underwater (PW)	Gray seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	198.58	95.45	70.03	26.45
	Harbor seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	265.38	127.47	49.42	20.49
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.38	29.81	0.00	0.00
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.47	2.06	0.00	0.00
	Leatherback turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150.57	50.30	0.00	0.00
	Loggerhead turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.38	33.77	0.00	0.00

Table C-7. Year 2 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Includes Four Pre- and Post-Piled Pin Piles, Respectively) for the Shallow Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.01	8.36	3.66	0.07
	Fin whale		0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	7.48	4.78	3.53	1.61
	Humpback whale		0.00	0.00	0.00	0.00	0.62	0.05	0.00	0.00	2.40	1.86	1.54	0.96
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.17	0.12	0.09	0.05
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45	1.68	1.25	0.63
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.92	14.74	9.06	4.61
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	334.26	222.07	168.28	117.02
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	541.19	285.12	114.78	7.39
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.92	40.26	20.77	0.38
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		0.94	0.01	0.00	0.00	0.00	0.00	0.00	0.00	25.98	17.58	13.28	6.02
Phocid Pinnipeds Underwater (PW)	Gray seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	144.15	86.67	62.84	35.91
	Harbor seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.06	113.34	77.23	48.60
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	381.28	196.46	119.34	4.23
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.86	15.36	9.32	0.32
	Leatherback turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	546.28	276.67	165.72	2.56
	Loggerhead turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	427.09	220.01	133.62	4.70

Table C-8. Year 2 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Impact Pile Driving Installation Schedule 2 (Jackets and OSS Jackets, Which Includes Four Pre- and Post-Piled Pin Piles, Respectively) for the Deep Model Site.

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	29.15	16.33	9.47	4.48
	Fin whale		0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	7.42	4.48	2.41	0.77
	Humpback whale		0.00	0.00	0.00	0.00	0.48	0.01	0.00	0.00	2.16	1.31	0.82	0.22
	North Atlantic right whale		0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.22	0.13	0.05	0.01
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.89	0.99	0.58	0.33
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.50	9.83	5.41	2.50
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	770.35	383.97	230.36	100.78
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.25	60.84	34.49	13.05
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.68	8.38	5.12	1.96
Phocid Pinnipeds Underwater (PW)	Gray seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	111.01	51.21	39.31	16.94
	Harbor seal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	146.16	68.60	26.00	13.36
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.28	13.93	0.00	0.00
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.36	1.09	0.00	0.00
	Leatherback turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.41	20.11	0.00	0.00
	Loggerhead turtle		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.41	15.60	0.00	0.00

Table C-9. Year 1 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on the Maximum Case Impact Pile Driving Installation (15-m Monopiles and Maximum Exposures per Species from Either Model Site).

Marine Animal Hearing Group	Marine Mammal Species	Injury								Behavior			
		Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
		Sound Attenuation Level (dB)											
		0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale	2.85	1.26	0.00	0.00	65.17	32.31	16.77	5.17	91.21	65.18	55.17	42.04
	Fin whale	0.85	0.35	0.11	0.00	25.02	10.70	5.55	0.97	41.74	32.21	26.38	18.95
	Humpback whale	0.96	0.53	0.18	0.00	20.60	10.43	5.67	2.37	16.52	12.28	10.45	7.74
	North Atlantic right whale	0.05	0.02	0.02	0.00	2.54	1.27	0.73	0.28	2.59	1.81	1.44	1.03
	Sei whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.30	14.42	10.40	6.83
	Atlantic white sided dolphin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	209.72	123.45	86.74	55.93
	Common Bottlenose dolphin – Western North Atlantic Northern Migratory Coastal Stock	14.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1743.76	1247.87	894.55	602.36
	Common Bottlenose dolphin – Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8115.91	5152.97	3760.07	2463.56
	Long finned pilot whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1431.37	913.62	674.85	458.46
	Short-finned pilot whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise	31.29	21.76	13.58	4.20	1.38	0.00	0.00	0.00	293.56	171.77	116.02	78.05
Phocid Pinnipeds Underwater (PW)	Gray seal	22.62	7.51	3.30	0.00	7.90	0.00	0.00	0.00	1242.29	726.43	486.71	304.06
	Harbor seal	17.11	8.05	0.73	0.00	16.03	0.00	0.00	0.00	2213.46	1183.17	798.14	451.09
Turtles (TU)	Green turtle	0.00	0.00	0.00	0.00	819.09	272.50	30.06	0.00	2273.96	1089.38	827.41	605.21
	Kemp's ridley turtle	0.00	0.00	0.00	0.00	55.15	18.20	2.09	0.00	154.32	74.46	56.07	40.67
	Leatherback turtle	0.00	0.00	0.00	0.00	1374.04	463.69	47.43	0.00	3775.55	1821.55	1401.88	1024.19
	Loggerhead turtle	0.00	0.00	0.00	0.00	951.81	316.23	32.72	0.00	2611.11	1250.96	959.55	703.53

Table C-10. Year 2 Acoustic Exposure Estimates of Marine Mammals and Sea Turtles for the Atlantic Shores North Project Based on Maximum Case Impact Pile Driving Installation (15-m Monopiles and Maximum Exposures Per Species from Either Model Site).

Marine Animal Hearing Group	Marine Mammal Species		Injury								Behavior			
			Peak (L_{pk})				SEL (L_E)				SPL (L_p)			
			Sound Attenuation Level (dB)											
			0	6	10	15	0	6	10	15	0	6	10	15
Low Frequency Cetaceans (LFC)	Common minke whale		2.57	1.14	0.00	0.00	58.73	29.12	15.15	4.63	82.30	58.53	49.43	37.72
	Fin whale		0.44	0.21	0.07	0.00	12.48	5.21	2.74	0.51	21.17	16.22	13.07	9.35
	Humpback whale		0.39	0.23	0.08	0.00	8.17	4.00	2.10	0.88	6.44	4.77	4.06	3.07
	North Atlantic right whale		0.02	0.01	0.01	0.00	0.71	0.35	0.20	0.08	0.76	0.53	0.40	0.29
	Sei whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF Cetaceans (MFC)	Atlantic spotted dolphin		0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.61	6.43	4.60	3.06
	Atlantic white sided dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.44	58.43	40.72	26.04
	Common Bottlenose dolphin	Western North Atlantic Northern Migratory Coastal Stock	6.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	834.06	594.32	423.73	288.02
		Western North Atlantic Offshore Stock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3966.23	2486.61	1812.00	1188.19
	Long finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Risso's dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Short-beaked common dolphin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	525.95	331.35	240.12	165.51
	Short-finned pilot whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sperm whale		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Frequency Cetaceans (HFC)	Harbor porpoise		13.80	9.07	5.27	3.52	0.95	0.00	0.00	0.00	117.65	66.53	46.22	30.57
Phocid Pinnipeds Underwater (PW)	Gray seal		14.35	4.86	2.65	0.00	5.08	0.00	0.00	0.00	695.51	400.65	266.84	168.16
	Harbor seal		10.91	5.46	0.50	0.00	8.93	0.00	0.00	0.00	1241.09	657.67	442.27	243.77
Turtles (TU)	Green turtle		0.00	0.00	0.00	0.00	393.18	125.48	16.73	0.00	1120.80	525.01	384.58	283.08
	Kemp’s ridley turtle		0.00	0.00	0.00	0.00	31.03	9.90	1.32	0.00	88.41	41.30	30.26	22.33
	Leatherback turtle		0.00	0.00	0.00	0.00	626.95	200.09	26.68	0.00	1773.57	800.56	588.65	447.21
	Loggerhead turtle		0.00	0.00	0.00	0.00	441.11	140.78	18.77	0.00	1257.26	588.61	431.19	317.54