SOUTHCOAST WIND

Appendix U2. Underwater Acoustic Modeling of Construction Sound and Animal Exposure Estimation

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SouthCoast Wind

Additional Underwater Acoustic Modeling Scenarios

JASCO Applied Sciences (USA) Inc.

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Executive Summary

SouthCoast Wind Energy LLC (SouthCoast Wind, referred to as the Project) has submitted a Construction and Operations Plan to support the construction, operation, and decommission of the SouthCoast Wind Project (the Project). The Project is being proposed within the Bureau of Ocean Energy Management Renewable Energy Lease Area OCS-A 0521, approximately 127,388 acres (BOEM 2019) in size. The SouthCoast Wind Lease Area is 26 nautical miles (NM; 48 km) south of Martha’s Vineyard and 20 NM (37 km) south of Nantucket. The Project will consist of up to 147 wind turbine generators (WTGs) and up to five offshore substation platforms (OSP), with inter-array cables connecting the WTGs and OSPs. Submarine electrical export cables will pass through Muskeget Channel and Nantucket Sound via export cable corridors (ECCs) to deliver power from the OSPs to the onshore transmission system.

For the purposes of this Underwater Acoustic Assessment, this report assumes the WTGs will be supported by either monopile foundations or pin piled jacket foundations, and the OSPs will be supported by piled jacket foundations. The monopiles are up to 16 m diameter at the mudline. The jacket foundation uses up to 4.5 m diameter pin piles. Hammering of the 16 m monopile and 4.5 m pin pile were selected for quantitative analysis as this installation likely represents the primary maximum underwater noise generated during Project installation considered within the Project Design Envelope (PDE).

The goal of the study was to predict monitoring distances (exposure and acoustic ranges) to regulatory-defined acoustic thresholds associated with injury and behavioral disturbance for various marine fauna, including marine mammals, sea turtles, and fish. Sound generated during pile driving was modeled by characterizing the sound produced at the pile and then calculating how the sound propagates within the surrounding water column. For impact pile driving sounds, time-domain representations of the acoustic pressure waves generated in the water are required to calculate the metrics – sound pressure level (SPL), sound exposure level (SEL), and zero-to-peak pressure level (PK) – used to evaluate potential impacts. JASCO’s animal movement modeling software, JASMINE, was used to integrate the computed sound fields with species-typical movement (e.g., dive patterns) to estimate received sound levels for the modeled marine mammals and sea turtles that may occur near the construction area.

The potential acoustic exposure for marine species was estimated by finding the accumulated sound energy (SEL) and maximum SPL and PK pressure level each animat received over the course of the simulation. Exposure criteria are based on relevant regulatory-defined thresholds (Stadler and Woodbury 2009, GARFO 2020), best available science for fish and sea turtles (Popper et al. 2014), and available relevant scientific understanding for marine mammal behavioral thresholds (Wood et al. 2012). The projected number of animals exposed to sound levels above threshold values was determined by scaling the number of modeled animals (animats) exposed to a criterion in the model to reflect local populations using the Duke University Habitat-based Cetacean Density Models (Roberts et al. 2016, 2021a, 2021b) estimates for each species.

Using the time history of the received levels, exposure ranges accounting for 95 % of exposures above regulatory-defined injury and behavioral disruption thresholds (NMFS 2018, McCauley et al. 2000b, Finneran et al. 2017) were calculated. Fish were considered static receivers, so the acoustic distance to their regulatory thresholds (FHWG Andersson et al. 2007, Wysocki et al. 2007, 2008, Stadler and Woodbury 2009, Mueller-Blenkle et al. 2010, Purser and Radford 2011) were calculated. Exposure ranges (marine mammals) and acoustic ranges (fish) are reported for various levels (0, 6, 10, and 15 dB) of broadband attenuation that could be expected from the use of mitigation systems such as a bubble curtain.

Acronyms and Abbreviations

BOEM	Bureau of Ocean Energy Management
CalTrans	California Department of Transportation
COP	Construction and Operations Plan
dB	decibel
DP	Dynamic Positioning
DPS	Distinct Population Segment
ECC	Export Cable Corridor
EEZ	Exclusive Economic Zone
$ER_{95\%}$	95 % exposure range
ESA	Endangered Species Act
ft	feet
FWRAM	Full Wave Range Dependent Acoustic Model
GARFO	Greater Atlantic Regional Fisheries Office
h	hour
HF	high frequency (cetacean hearing group)
HSD	Hydro Sound Damper
Hz	Hertz
IAC	Inter-Array Cables
in	inch
JASMINE	JASCO Animal Simulation Model Including Noise Exposure
kg	kilogram
kHz	kilohertz
kJ	kilojoule
km	kilometer
LF	low frequency (cetacean hearing group)
m	meter
m/s	meters per second
MF	mid-frequency (cetacean hearing group)
mi	mile
μPa	micropascal
MMPA	Marine Mammal Protection Act
NARW	North Atlantic right whale
NAS	noise abatement system
NM	nautical mile
NMFS	National Marine Fisheries Service (also known as NOAA Fisheries)
NMS	Noise Mitigation System
NOAA	National Oceanic and Atmospheric Administration
NY	New York
OCS	Outer Continental Shelf
OSP	Offshore Substation Platform
PDE	Project Design Envelope
PDSM	Pile Driving Source Model
PK	level of the peak sound pressure
PPA	phocid (pinniped) in air (hearing group)
PPW	phocid (pinniped) in water (hearing group)
Project	the Project SouthCoast Wind
PTS	permanent threshold shift
PW	phocid (seal) in water (hearing group)
rms	root mean square
SEL	sound exposure level
SEL_{cum}	cumulative sound exposure level
SPL	sound pressure level
TTS	temporary threshold shift
WEA	Wind Energy Area
WTG	wind turbine generator

1. Introduction

1.1. Project Background and Overview of Assessed Activity

SouthCoast Wind Energy LLC (SouthCoast Wind) is submitting for approval to the Bureau of Ocean Energy Management (BOEM) a Construction and Operations Plan (COP) to construct, operate, and decommission offshore renewable wind energy facilities within its federal Lease Area OCS-A 0521 (referred to as the Lease Area) along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance facilities. The Lease Area is located offshore of the southern coast of Massachusetts, approximately 26 nautical miles (NM; 48 km) south of Martha's Vineyard and 20 NM (37 km) south of Nantucket. The closest location within the Lease Area to the mainland is 52 NM (96.5 km). The Lease Area is a total of 127,388 acres in size (BOEM 2019). Figure 1 show the Lease Area.

A maximum of 147 wind turbine generators (WTGs) will be installed in the Lease Area, and up to five offshore substation platforms (OSPs), with inter-array cables connecting the WTGs and OSPs. The COP PDE includes three types of foundations that may be used to support the WTGs and OSPs, including monopiles, piled jackets, and suction-bucket jackets. For the purposes of this Underwater Acoustic Assessment, only those foundations which require pile driving will be considered further, namely monopiles and piled jackets.

The WTGs will each be supported by monopile foundations with diameters up to 16 m (53 ft), or jacket foundations with up to four, 4.5 m (~15 ft) diameter pin piles. The OSP(s) will be supported by 16 m diameter monopile foundation or jacket foundations (with 4.5 m diameter pin piles). The WTG and OSP positions have been established based on a 1 × 1 NM (1.9 × 1.9 km) grid oriented along the cardinal directions to maintain a uniform spacing of WTGs and OSPs across all the lease areas within the Massachusetts/ Rhode Island Wind Energy Area.

Underwater noise may be generated by several activities associated with the Project. Impacts of noise on marine fauna for most of these anthropogenic sound sources is expected to be low or very low. There are several potential anthropogenic sound sources associated with the Project; however, the primary sound sources are impact (impulsive) and vibratory (non-impulsive, continuous sound) pile driving during foundation installation in the construction stage. A quantitative assessment of pile driving activities is undertaken here as the primary source of underwater sound associated with the Project.

For the quantitative acoustic analysis, the potential underwater acoustic impacts resulting from the installation of monopile foundations and jacket foundations were modeled. This underwater noise assessment is based on the currently available information; the precise locations, noise sources, and schedule of the construction and operation scenarios is subject to change as the engineering design progresses.

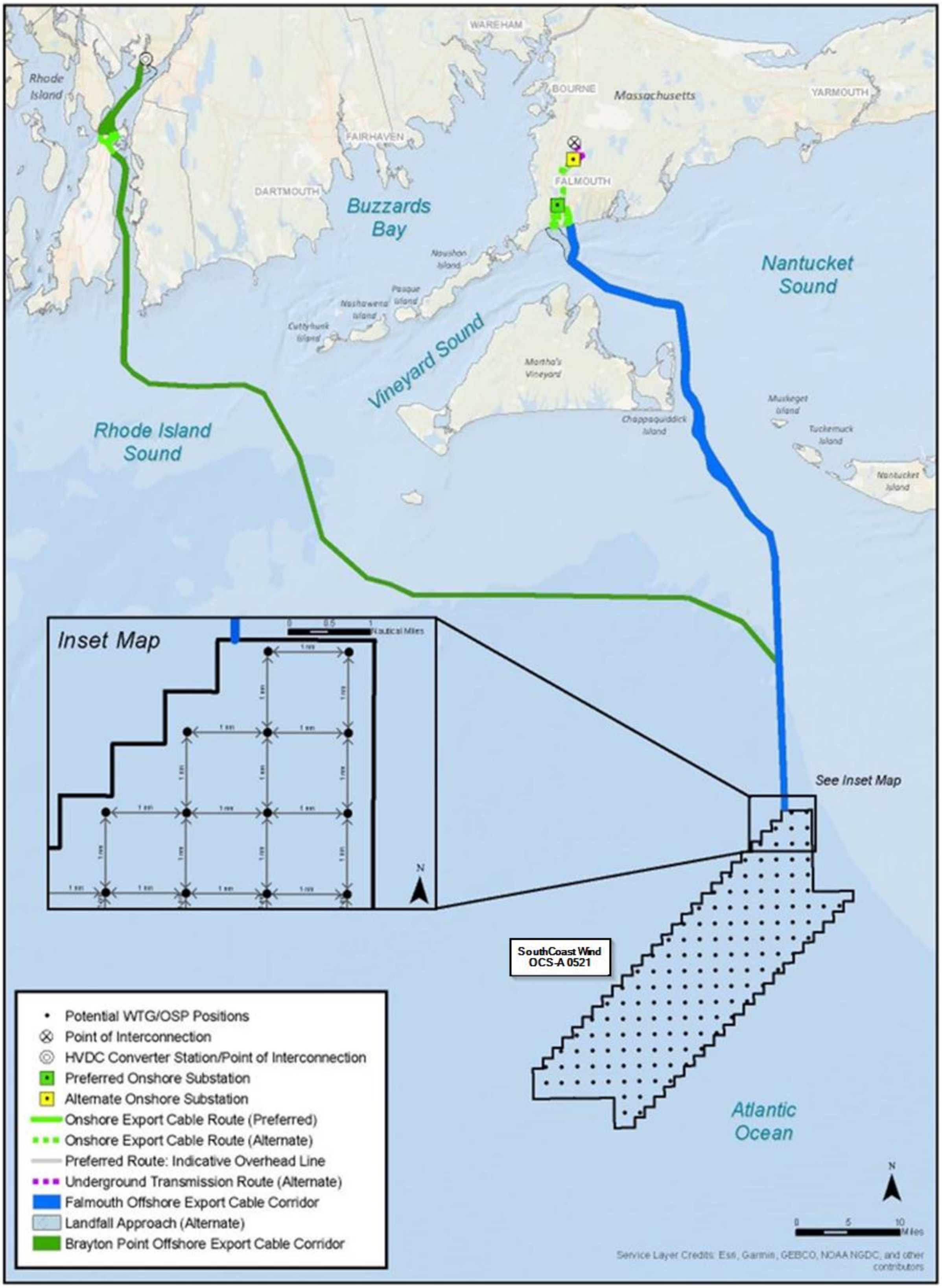

Figure 1. Lease Area and proposed export cable corridors for the SouthCoast Wind Project.

1.2. Modeling Scope and Assumptions

The objectives of this modeling study were to predict the acoustic ranges to regulatory-defined acoustic thresholds associated with injury and behavioral disturbance for various marine fauna (including fish, marine mammals, and sea turtles) that may occur near the Project during pile driving in the construction stage of the Project. JASCO also used the results of animal movement and exposure modeling to estimate potential exposure ranges ($ER_{95\%}$) and exposure numbers for marine mammals and sea turtles.

There are several potential anthropogenic sound sources associated with the Project; however, the primary sound sources are impact (impulsive) and vibratory (non-impulsive, continuous sound) pile driving during foundation installation in the construction stage.

1.2.1. Foundations

A monopile used as a foundation in a wind farm is a single hollow cylinder fabricated from steel that is installed by driving (hammering and vibrating) it into the seabed. The modeled 16 m monopiles represent the largest of potential foundation diameters in the Project Design Envelope (PDE). A jacket foundation, used for OSP or WTG, consists of a large lattice structure supported/secured by pin piles. The pin piles to secure the jacket structure for the Project are 4.5 m diameter straight piles.

The amount of sound generated during pile driving varies with the energy required to drive piles to a desired depth and depends on the sediment resistance encountered. Sediment types with greater resistance require hammers that deliver higher energy strikes and/or an increased number of strikes relative to installations in softer sediment. Maximum sound levels usually occur during the last stage of impact pile driving where the greatest resistance is encountered (Betke 2008).

SouthCoast Wind, in coordination with potential hammer suppliers, provided information on the following:

- A theoretical impact hammer with 6600 kJ maximum energy (NNN 6600) for the installation of monopiles.
- The make and model of an impact hammer (MHU 3500S) for the installation of jacket foundation pin piles
- The make and model of vibratory hammers, HX-CV640, hexa CV640 and S-CV640, single CV640, for initial driving of monopiles and pin piles, respectively, and
- The representative hammering schedules used in the acoustic modeling effort.

Tables 1 and 2 list the number of strikes at each of the hammer energy levels needed to drive the 16 m monopiles and the 4.5 m jacket foundation pin piles using impact pile driving. The letters in parentheses after each energy level differentiate the penetration depths and number of strikes used with the respective maximum hammer energies. Tables 3 and 4 show the installation schedules for monopiles and jacket foundation pin piles using vibratory piling followed by impact piling, including the duration of vibratory piling and the number of strikes for impact pile driving installation.

Sound fields from 16 m monopiles and 4.5 m pin piles were modeled at two representative locations in the Project (L01 and L02) as depicted in Figure 2 and Table 5. The modeling locations were selected as they represent the range of water depths in the Project.

The exposure modeling locations used for both sequential and vibratory operations are shown in Figure 2, and the exposure modeling locations used for concurrent operations are shown in Figure 3. The assumed minimum distance between the OSP and WTG foundations was 2 grid positions, or 2 NM.

Key modeling assumptions for the 16 m monopiles, and 4.5 m pin piles are listed in Table 6, with additional modeling details and input parameters shown in Appendix B.

Table 1. Hammer energy schedule and number of strikes for 16 m monopile under impact pile driving with a 6600 kJ hammer. Letters in parentheses after each energy level differentiate penetration depths and number of strikes.

Energy level (kJ) [a]	Strike count	Pile penetration depth (m)
6600 (a)	2000	10
6600 (b)	2000	10
6600 (c)	3000	15
Total	7000	35
Strike rate (strikes/min)	30	

[a] Acoustic source characteristics were modeled at three pile penetrations (a, b, c) using the full hammer energy.

Table 2. Hammer energy schedule and number of strikes for 4.5 m jacket under impact pile driving with an MHU 3500S hammer. Letters in parentheses after each energy level differentiate penetration depths and number of strikes.

Energy level (kJ) [a]	Strike count	Pile penetration depth (m)
3500 (a)	1333	20
3500 (b)	1333	20
3500 (c)	1334	20
Total	4000	60
Strike rate (strikes/min)	30	

[a] Acoustic source characteristics were modeled at three pile penetrations (a, b, c) using the full hammer energy.

Table 3. Installation schedule for a 16 m monopile using vibratory pile setting (HX-CV640, hexa CV640 hammer) followed by impact hammering (6600 kJ hammer). Letters in parentheses after each energy level differentiate penetration depths and number of strikes.

Hammer type	Hammer model	Pile penetration depth (m)	Time vibratory piling (min)	Hammer energy [a] (kJ)	Strike count
Vibratory	HX-CV640	10	20	-	-
Impact	NNN 6600	10	-	6600 (b)	2000
		15	-	6600 (c)	3000
Total		35	20	-	5000

[a] Acoustic source characteristics were modeled at two pile penetrations (b, c) using the full hammer energy (see Table 1).

Table 4. Installation schedule for a 4.5 m jacket pile using vibratory pile setting (S-CV640, single CV640 hammer) followed by impact hammering (MHU 3500S hammer). Letters in parentheses after each energy level differentiate penetration depths and number of strikes.

Hammer type	Hammer model	Pile penetration depth (m)	Time vibratory piling (min)	Hammer energy [a] (kJ)	Strike count
Vibratory	S-CV640	20	90	-	-
Impact	MHU 3500S	20	-	3500 (b)	1333
		20	-	3500 (c)	1334
Total		60	90	-	2667

[a] Acoustic source characteristics were modeled at two pile penetrations (b, c) using the full hammer energy (see Table 2).

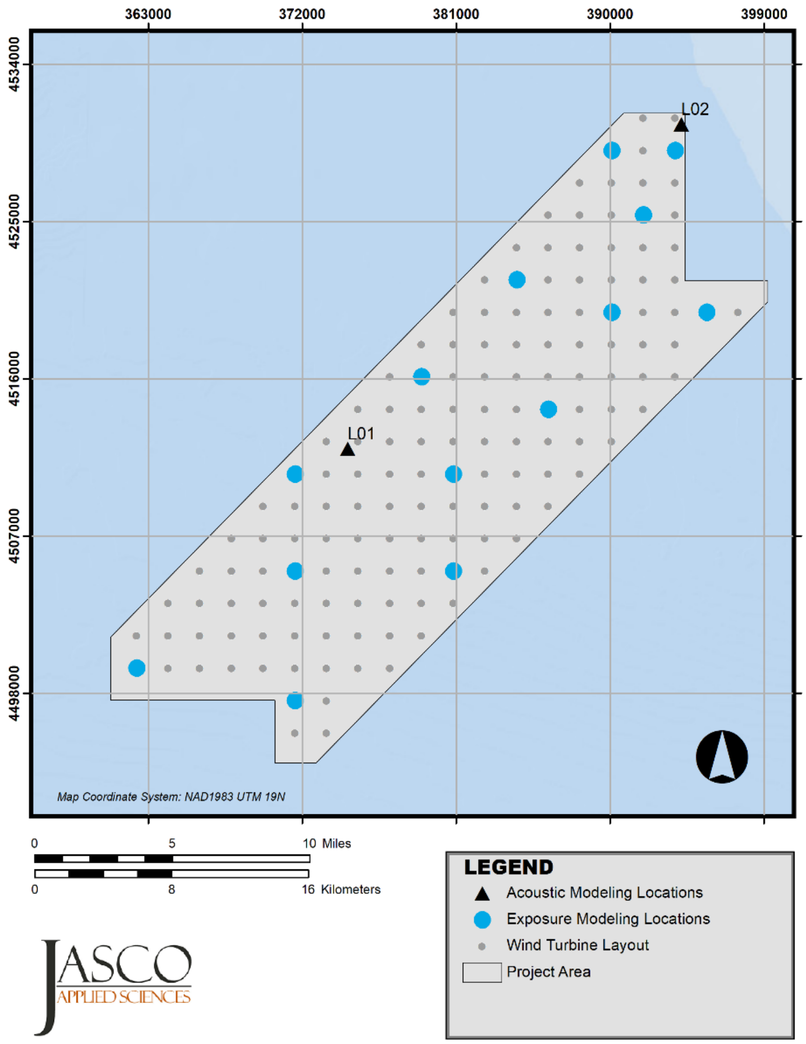

Figure 2. Lease Area with acoustic modeling locations and the animal movement modeling locations used for sequential and vibratory operations.

Table 5. Acoustic modeling locations and water depth for the monopile and jacket foundations.

Modeling site	Latitude	Longitude	UTM Zone 19 N		Depth (m) [a]
			Easting	Northing	
L01	40.7491	-70.4846	374669.03	4511967.1	53
L02	40.9192	-70.2568	394171	4530547	37.6

[a] Vertical datum for water depth is Earth Gravitational Model 1996 (EGM96).

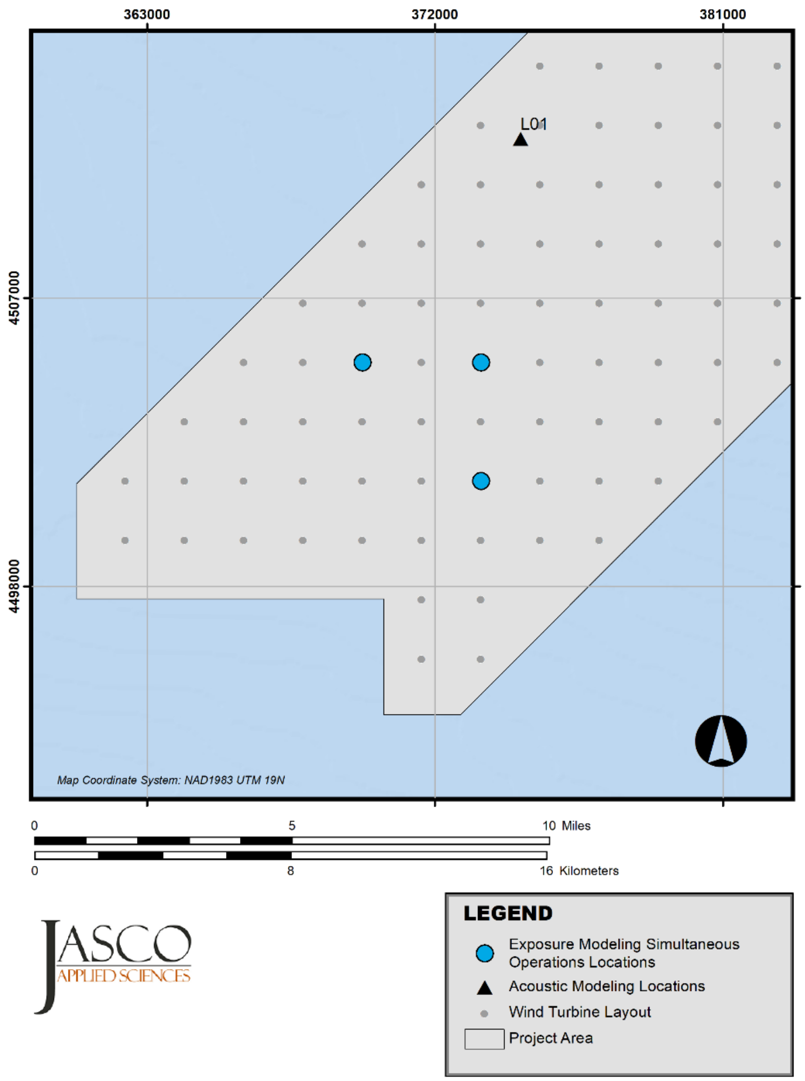

Figure 3. Lease Area with acoustic modeling locations and the animal movement modeling locations used for concurrent operations.

Table 6. Key piling assumptions used in underwater acoustic modeling.

Foundation type	Modeled maximum impact hammer energy (kJ)	Pile length (m)	Pile diameter (m)	Pile wall thickness (mm)	Seabed penetration (m)	Number of piles per day [a]
Monopile	6600	105	9 to 16 (tapered)	16.6	35	1, 2
Jacket	3500	63	4.5	5	60	4

[a] This column is presenting the number of piles for WTGs and OSPs. During concurrent piling operations, up to 8 total piles per day could be installed, as described in the construction schedules (Section 1.2.2), and as included in the exposure estimations (Section 4.3).

1.2.2. Modeling Scenario and Pile Construction Schedules

Construction schedules are difficult to predict because of factors like weather and installation variation related to drivability. The SouthCoast Wind Lease Area will consist of two ~1,200 MW projects. To allow some flexibility in the final design and during installation operations, two proposed construction schedules, separated by year and the “2 pile driving” foundation type(s) (Monopile, Jacket) (four schedules total) were used for each project to calculate potential impacts to marine mammals and sea turtles during pile installation. Both schedules assume buildout of Project 1 during year 1 and buildout of Project 2 during year 2. Each schedule provides a conservative approach on the number of monopile and/or jacket foundations that could be installed per month. Tables 7–10 show the number of pile driving days per month each year for each of the three cases as well as monthly totals for number of piles driven and number of days of piling. The three cases are:

- Impact and vibratory pile driving,
- Concurrent impact pile driving, and
- Sequential impact pile driving.

Table 7. Construction Schedule 1 (monopile), year 1: The number of potential days of pile installation per month for each case, by year and for the buildout of Project 1, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact	Sequential impact		Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG monopile	WTG monopile	WTG monopile & OSP jacket piles	WTG monopile	WTG monopile			
	2 piles per day	1 pile per day	1 piles per day & 4 piles per day	2 piles per day	1 pile per day			
May	0	0	0	0	**2**	**2**	0	**2**
June	0	0	0	**1**	**8**	**10**	0	**10**
July	0	0	0	**3**	**10**	**16**	0	**16**
August	0	0	0	**4**	**10**	**18**	0	**18**
September	0	0	0	**3**	**9**	**15**	0	**15**
October	0	0	**3**	**1**	**3**	**8**	**12**	**20**
November	0	0	0	0	**1**	**1**	0	**1**
December	0	0	0	0	**1**	**1**	0	**1**
Total	**0**	**0**	**3**	**12**	**44**	**71**	**12**	**83**

Table 8. Construction Schedule 1 (monopile), year 2: The number of potential days of pile installation per month for each case, by year and for the buildout of Project 2, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact	Sequential impact		Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG monopile	WTG monopile	WTG monopile & OSP jacket piles	WTG monopile	WTG monopile			
	2 piles per day	1 pile per day	1 piles per day & 4 piles per day	2 piles per day	1 pile per day			
May	0	0	0	0	**2**	**2**	0	**2**
June	0	0	0	**3**	**6**	**12**	0	**12**
July	0	0	0	**3**	**6**	**12**	0	**12**
August	0	0	0	**3**	**6**	**12**	0	**12**
September	0	0	0	**3**	**6**	**12**	0	**12**
October	0	0	**3**	**3**	**6**	**15**	**12**	**27**
November	0	0	0	0	**2**	**2**	0	**2**
December	0	0	0	0	**1**	**1**	0	**1**
Total	**0**	**0**	**3**	**15**	**35**	**68**	**12**	**80**

Table 9. Construction Schedule 2 (monopile), year 1: The number of potential days of pile installation per month for each case, by year and for the buildout of Project 1, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact	Sequential impact		Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG monopile	WTG monopile	WTG monopile & OSP jacket piles	WTG monopile	WTG monopile			
	2 piles per day	1 pile per day	1 piles per day & 4 piles per day	2 piles per day	1 pile per day			
May	0	0	0	0	**2**	**2**	0	**2**
June	**2**	**6**	0	0	0	**10**	0	**10**
July	**4**	**5**	0	0	0	**13**	0	**13**
August	**5**	**6**	0	0	0	**16**	0	**16**
September	**4**	**4**	0	0	0	**12**	0	**12**
October	**3**	**3**	**3**	0	0	**12**	**12**	**24**
November	0	**1**	0	0	0	**1**	0	**1**
December	0	0	0	0	0	0	0	**0**
Total	**18**	**25**	**3**	0	**2**	**66**	**12**	**78**

Table 10. Construction Schedule 2 (monopile), year 2: The number of potential days of pile installation per month for each case, by year and for the buildout of Project 2, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact	Sequential impact		Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG monopile	WTG monopile	WTG monopile & OSP jacket piles	WTG monopile	WTG monopile			
	2 piles per day	1 pile per day	1 piles per day & 4 piles per day	2 piles per day	1 pile per day			
May	0	0	0	0	**2**	**2**	0	**2**
June	**2**	**4**	0	0	0	**8**	0	**8**
July	**6**	**4**	0	0	0	**16**	0	**16**
August	**7**	**4**	0	0	0	**18**	0	**18**
September	**6**	**4**	0	0	0	**16**	0	**16**
October	**3**	**2**	**3**	0	0	**11**	**12**	**23**
November	0	**1**	0	0	0	**1**	0	**1**
December	0	0	0	0	**1**	**1**	0	**1**
Total	**24**	**19**	**3**	0	**3**	**73**	**12**	**85**

Table 11. Construction Schedule 3 (jacket), year 1: The number of potential days of pile installation per month for each case, by year and for the buildout of Project 1, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact		Sequential impact			Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG jacket piles	WTG monopile	Piles for WTG jacket & OSP jacket	WTG monopile & OSP jacket piles	WTG jacket piles	OSP jacket piles	WTG monopile			
	4 piles per day	2 piles per day	4 piles per day & 4 piles per day	2 piles per day & 4 piles per day	4 piles per day	4 piles per day	2 piles per day			
May	0	0	0	0	**8**	0	0	0	**32**	**32**
June	0	0	0	0	**10**	0	0	0	**40**	**40**
July	0	0	0	0	**12**	0	0	0	**48**	**48**
August	0	0	0	0	**14**	0	0	0	**56**	**56**
September	0	0	0	0	**12**	0	0	0	**48**	**48**
October	0	0	**4**	0	**12**	0	0	**16**	**64**	**80**
November	0	0	0	0	**10**	0	0	0	**40**	**40**
December	0	0	0	0	**3**	0	0	0	**12**	**12**
Total	**0**	**0**	**4**	**0**	**81**	**0**	**0**	**12**	**340**	**356**

Table 12. Construction Schedule 3 (jacket), year 2: The number of potential days of pile installation per month for each case by year and for the buildout of Project 2, used to estimate the total number of marine mammal and sea turtle acoustic exposures above threshold criteria.

Month	Vibratory with impact		Concurrent impact		Sequential impact			Total number of monopiles	Total number of jacket piles	Total number of piles
	WTG jacket piles	WTG monopile	Piles for WTG jacket & OSP jacket	WTG monopile & OSP jacket piles	WTG jacket piles	OSP jacket piles	WTG monopile			
	4 piles per day	2 piles per day	4 piles per day & 4 piles per day	2 piles per day & 4 piles per day	4 piles per day	4 piles per day	2 piles per day			
May	0	0	0	0	**5**	0	0	0	**20**	**20**
June	**9**	0	0	0	0	0	0	0	**36**	**36**
July	**9**	0	0	0	0	0	0	0	**36**	**36**
August	**9**	0	0	0	0	0	0	0	**36**	**36**
September	**9**	0	0	0	0	0	0	0	**36**	**36**
October	**6**	0	**4**	0	0	0	0	**16**	**40**	**56**
November	**6**	0	0	0	0	0	0	0	**24**	**24**
December	0	0	0	0	**5**	0	0	0	**20**	**20**
Total	**48**	**0**	**4**	**0**	**10**	**0**	**0**	**16**	**248**	**264**

2. Methods

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

For impact and vibratory pile driving sounds, time-domain representations of the acoustic pressure waves generated in the water are required for calculating SPL, SEL, and PK. The source signatures associated with installation of each of the modeled 16 m monopile and 4.5 m pin pile locations are predicted using a finite-difference model that determines the physical vibration of the pile caused by pile driving equipment. The sound field radiating from the pile is simulated as a vertical array of point sources.

For this study, synthetic pressure waveforms were computed using a Full Waveform Range-dependent Acoustic Model (FWRAM), which is JASCO's acoustic propagation model capable of producing time-domain waveforms (see Appendix F.2). The sound propagation modeling incorporated site-specific environmental data including bathymetry, sound speed in the water column, and seabed geoacoustics in the proposed construction area (see Appendix F.1). Animal movement modeling integrated the estimated sound fields with species-typical behavioral parameters (e.g., dive patterns) in JASMINE to estimate received sound levels for the modeled animals (animats) that may occur in the construction area. Animats that exceed pre-defined acoustic thresholds/criteria (e.g., NMFS 2018) are identified and the distance for the exceedances determined.

2.1. Acoustic Environment

The SouthCoast Wind Lease Area is located in the continental shelf environment characterized by predominantly sandy seabed sediments. Water depths in the Lease Area vary between 37 to 64 m (121 to 210 ft). During the summer months (June-August), the average temperature of the upper 10 to 15 m (32.8 to 49.2 ft) of the water column is higher, resulting in an increased surface layer sound speed. This creates a downward refracting environment in which propagating sound interacts with the seafloor more than in a well-mixed environment. Increased wind mixing combined with a decrease in solar energy in the fall and winter months (September-February) results in a sound speed profile that is more uniform with depth. The shoulder months between summer and winter vary between the two. Both average summer and winter sound speed profiles representative of the area for the proposed activities were chosen for the acoustic propagation modeling. See Appendix F.1 for more details on the environmental parameters used in acoustic propagation and exposure modeling.

2.2. Modeling Acoustic Sources

2.2.1. Impact Pile Driving

Piles deform when driven with impact hammers, creating a bulge that travels down the pile and radiates sound into the surrounding air, water, and seabed. This sound may be received as a direct transmission from the sound source to biological receivers (such as marine mammals, sea turtles, and fish) through the water or as the result of reflected paths from the surface or re-radiated into the water from the seabed (Figure 4). Sound transmission depends on many environmental parameters, such as the sound speeds in water and substrates. It also depends on the sound production parameters of the pile and how it is driven, including the pile material, size (length, diameter, and thickness) and the make and energy of the hammer.

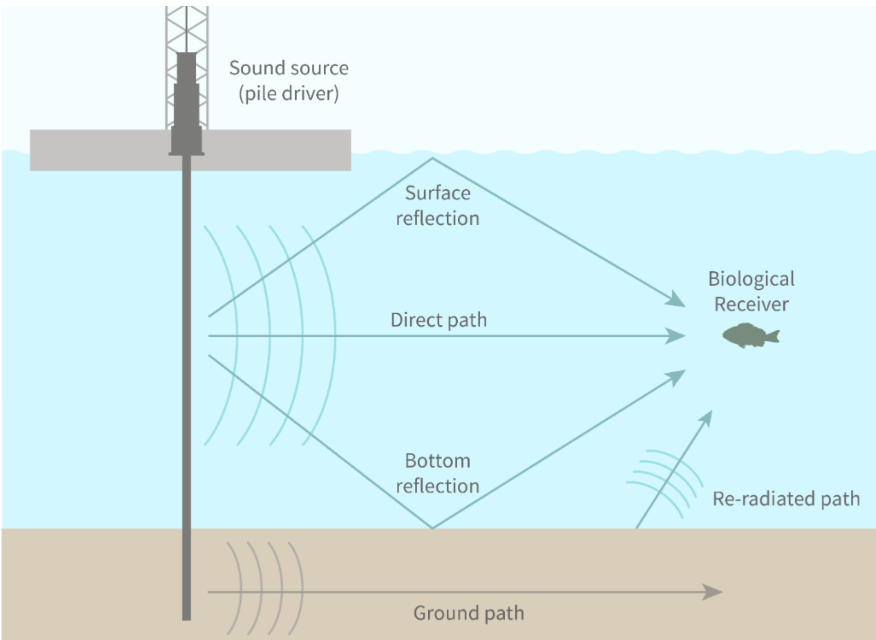

Figure 4. Sound propagation paths associated with pile driving (adapted from Buehler et al. 2015).

JASCO's physical model of pile vibration and near-field sound radiation (MacGillivray 2014) was used in conjunction with the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010) to predict source levels associated with impact pile driving activities. Piles are modeled assuming a vertical installation using a finite-difference structural model of pile vibration based on thin-shell theory. The sound radiating from the pile itself was simulated using a vertical array of discrete point sources. These models account for several parameters that describe the operation—pile type, material, size, and length—the pile driving equipment, and approximate pile penetration depth. See Appendix E for a more detailed description.

Jacket foundation piles are assumed to be pre- and post-piled. Pre-piling means that the jacket structure will be set on pre-installed piles. Post-piling means that the jacket structure is placed on the seafloor and piles are subsequently driven through guides at the base of each leg. These jacket foundations will also radiate sound as the piles are driven. To account for the larger radiating area including the jacket structure, the broadband sound level estimated for the jacket piles was increased by 2 dB for post-piling scenarios.

Forcing functions were computed for the 16 m monopile and 4.5 m jacket foundations, using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). The model assumed direct contact between the representative hammers, helmets, and piles (i.e., no cushion material, which provides a more conservative estimate). The forcing functions serve as the inputs to JASCO's pile driving source model (PDSM) used to estimate an equivalent acoustic source represented by a linear array of monopoles evenly distributed along the pile and detailed in Appendix E. Sound propagation of the impact pile driving source signature is performed using FWRAM and modeling details are described in Appendix F. Decidecade band levels at 10 m from the source for each pile type, hammer energy and modeled location, using an average summer and winter sound speed profiles are provided in Section 4.1.1.

2.2.2. Vibratory Pile Driving

During the vibratory pile driving stage, piles are driven into the substrate due to longitudinal vibration motion at the hammer's operational frequency and corresponding amplitude. This causes the soil to liquefy allowing the pile to penetrate into the seabed.

One second long vibratory forcing functions were computed for the 16 m monopile and 4.5 m jacket foundations, using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). The model assumed the use of 32 clamps with total weight of 2102.4 kN for the monopile and 4 clamps with total weight of 213.56 kN for the jacket piles, connecting the hammer to the piles. No cushion between hammer and pile was used. Non-linearities were introduced to the vibratory forcing functions based on the decay rate observed in data measured during vibratory pile driving of smaller diameter piles (Quijano et al. 2017). The resulting forcing functions serve as inputs to JASCO's Pile Driving Source Model (PDSM) used to estimate an equivalent acoustic source represented by a linear array of monopoles evenly distributed along the pile and detailed in Appendix E. Sound propagation of the vibratory pile driving source signature is performed using FWRAM and modeling details are described in Appendix F. Decidecade band levels at 10 m from the source for each pile type, hammer energy, and modeled location, using an average summer and winter sound speed profiles are provided in Section 4.1.2.

2.3. Noise Mitigation

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

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

A recent analysis by Bellmann et al. (2020) of NASs performance measured during impact driving for wind farm foundation installation provides expected performance for common NASs configurations. Measurements with a single bubble curtain and an air supply of 0.3 m^3/min resulted in 7 to 11 dB of broadband attenuation for optimized systems in up to 131 ft (40 m) water depth. Increased air flow (0.5 m^3/min) may improve the attenuation levels up to 11 to 13 dB (M. Bellmann, personal communication, 2019). Double bubble curtains add another local impedance change and, for optimized systems, can achieve 15 to 16 dB of broadband attenuation (measured in up to 131.25 ft [40 m] water depth). The IHC-NMS can provide 15 to 17 dB of attenuation but is currently limited to piles <8 m diameter. Other NASs, such as the AdBm NMS, achieved 6 to 8 dB (M. Bellmann, personal communication, 2019), but HSDs were measured at 10 to 12 dB attenuation and are independent of depth (Bellmann et al. 2020). Systems may be deployed in series to achieve higher levels of attenuation.

The NAS must be chosen, tailored, and optimized for site-specific conditions. NAS performance of 10 dB broadband attenuation was chosen for this study as an achievable reduction of sound levels produced during pile driving when one NAS is in use, noting that a 10 dB decrease means the sound energy level is reduced by 90 %. For exposure modeling, several levels of attenuation were included for comparison purposes.

The studies and measurements referenced above are from impact pile driving. We are not aware of similar publicly available studies on the performance of NASs for vibratory pile driving of very large piles used in the installation of offshore wind farm foundations. However, the effectiveness of a bubble curtain and a passive resonator were evaluated for the installation of smaller piles (1.2 m diameter) using vibratory driving during the Port of Anchorage modernization project (Austin et al. 2016). Measurements were taken with and without the use of NASs and it was found that the near-source broadband levels decreased by approximately 9 and 8 dB for the bubble curtain and passive resonator, respectively. Sound level attenuation was also observed to decrease with distance, indicating that some energy was propagating through the sediment and re-entering the water column at longer distances.

The primary sound production of both vibratory and impact pile driving occurs in the frequency range of ~20 to ~300 Hz. NASs performance was found to be better for impact pile driving (~ 12 dB attenuation) relative to vibratory pile driving (~ 9dB attenuation) (Austin et al. 2016). For this assessment the same attenuation values were applied for both pile driving methods.

2.4. Acoustic Criteria for Marine Fauna

The following acoustic criteria, derived from the current US regulatory acoustic criteria, were used for this study (further details on these criteria are in Sections 2.4.1 and 2.4.2):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted 24-hour accumulated sound exposure levels (SEL; L_E) were from the US National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for marine mammal injury thresholds.
2. Sound pressure level (SPL; L_p) for marine mammal behavioral thresholds were based on the unweighted NOAA (2005) and the Wood et al. (2012) criteria. The latter incorporates the M-weighting functions defined in Southall et al. (2007).
3. Injury thresholds for fish (PK and SEL) were derived from the Fisheries Hydroacoustic Working Group (FHWG 2008) and Stadler and Woodbury (2009).
4. Injury thresholds for fish (PK and SEL) were obtained from Popper et al. (2014) for fish without swim bladders, fish with swim bladders not involved in hearing, and fish with swim bladders involved in hearing.
5. Behavioral thresholds for fish were developed by the NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) (Andersson et al. 2007, Wysocki et al. 2007, Mueller-Blenkle et al. 2010, Purser and Radford 2011)
6. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; L_E) from Finneran et al. (2017) were used for the onset of permanent threshold shift (PTS) for sea turtles.
7. Behavioral response thresholds for sea turtles were obtained from McCauley et al. (2000a), which was confirmed in Finneran et al. (2017).

2.4.1. Acoustic Criteria–Marine Mammals

The Marine Mammal Protection Act (MMPA) prohibits the take of marine mammals. The term “take” is defined as: to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. MMPA regulations define harassment in the following two categories relevant to the Project construction and operations:

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

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

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

Based on observations of mysticetes (Malme et al., 1983, 1984; Richardson et al., 1986, 1990), sound levels thought to elicit disruptive behavioral response are described using the SPL metric (NMFS and NOAA 2005). NOAA Fisheries (NMFS) currently uses a behavioral response threshold of unweighted SPL 160 dB re 1 µPa for marine mammals exposed to impulsive sounds (NOAA 2005). The unweighted SPL 120 dB re 1 µPa threshold is used for all marine mammals exposed to continuous sounds (NMFS 2023). Alternative thresholds used in acoustic assessments include a graded probability of response approach and take into account the frequency-dependence of animal hearing sensitivity (Wood et al., 2012). The 160 dB threshold is used for impact pile driving and 120 dB threshold is used for vibratory pile driving in this assessment as per NOAA guidance (2019).

The publication of ISO 18405 Underwater Acoustics–Terminology (ISO 2017) provided a dictionary of underwater bioacoustics (the previous standard was ANSI and ASA S1.1-2013). In the remainder of this report, we follow the definitions and conventions of ISO (2017) except where stated otherwise (Table 13).

Table 13. Summary of relevant acoustic terminology used by US regulators and in the modeling report.

Metric	NMFS (2018)	ISO (2017)	
		Main text	Equations/tables
Sound pressure level	n/a	SPL	L_p
Peak pressure level	PK	PK	L_{pk}
Cumulative sound exposure level	SELcum [a]	SEL	L_E

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

2.4.1.1. Marine Mammal Hearing Groups

Current data and predictions show that marine mammal species differ in their hearing capabilities, in absolute hearing sensitivity as well as frequency band of hearing (Richardson et al. 1995, Wartzok and Ketten 1999, Southall et al. 2007, Au and Hastings 2008). While hearing measurements are available for a small number of species based on captive animal studies, there are no direct measurements of many odontocetes or any mysticetes. As a result, hearing distances for many odontocetes are grouped with similar species, and predictions for mysticetes are based on other methods including: anatomical studies and modeling (Houser et al. 2001, Parks et al. 2007, Tubelli et al. 2012, Cranford and Krysl 2015); vocalizations (see reviews in Richardson et al. 1995, Wartzok and Ketten 1999, Au and Hastings 2008); taxonomy; and behavioral responses to sound (Dahlheim and Ljungblad 1990, see review in Reichmuth et al. 2007). In 2007, Southall et al. proposed that marine mammals be divided into hearing groups. This division was updated in 2016 and 2018 by NOAA Fisheries using more recent best available science (Table 14).

Southall et al. (2019) published an updated set of Level A sound exposure criteria (including the onset of temporary threshold shift [TTS] and permanent threshold shift [PTS] in marine mammals). While the authors propose a new nomenclature and classification for the marine mammal functional hearing groups, the proposed thresholds and weighting functions do not differ in effect from those proposed by NOAA Fisheries (2018). The new hearing groups proposed by Southall et al. (2019) have not yet been adopted by NOAA. The NOAA Fisheries (NMFS 2018) hearing groups presented in Table 14 are used in this analysis.

Table 14. Marine mammal hearing groups (Sills et al. 2014, NMFS 2018).

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

[a] The generalized hearing distance is for all species within a group. Individual hearing will vary.

2.4.1.2. Marine Mammal Auditory Weighting Functions

The potential for anthropogenic sound to affect marine mammals is largely dependent on whether the sound occurs at frequencies that an animal can hear well unless the acoustic pressure is so high that it could cause physical tissue damage. Auditory (frequency) weighting functions reflect an animal's ability to hear a sound (Nedwell & Turnpenny, 1998; Nedwell et al., 2007). Auditory weighting functions have been proposed for marine mammals, specifically associated with PTS thresholds expressed in metrics that consider what is known about marine mammal hearing (e.g., SEL) (e.g., Erbe et al., 2016; Finneran, 2016; Southall et al., 2007). The most recement frequency weighting functions reflect the group's susceptibility to noise-induced hearing loss (Finneran 2016). Marine mammal auditory weighting functions for all hearing groups (Table 14) published by Finneran (2016) are included in the NMFS (2018) Technical Guidance for use in conjunction with corresponding permanent threshold shift (PTS [Level A]) onset acoustic criteria (Table 15, See Appendix D for a detailed description of the weighting functions).

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

2.4.1.3. Marine Mammal Auditory Injury Exposure Criteria

Injury to the hearing apparatus of a marine mammal may result from brief exposure to an intense sound or from longer fatiguing sound exposures. Damage to hearing from brief exposure to intense sounds is independent of the duration of the signal and the peak pressure (PK) metric is used to assess the potential risk of injury. For longer-duration exposures, a measure of the total received sound energy is needed. The sound exposure level (SEL) metric is proportional to sound energy and is calculated by summing over the duration of the received signal. A PTS in hearing is considered injurious, but there are no published data on the sound levels that cause PTS in marine mammals. There are data that indicate the received sound levels at which temporary threshold shift, TTS, occurs, and PTS onset may be extrapolated from the TTS onset level and an assumed growth function (Southall et al. 2007). The NMFS (2018) criteria incorporate the best available science to estimate PTS onset in marine mammals from instantaneous peak (PK) sound pressure levels and sound energy accumulated over 24 h (SEL; L_E) (Table 15).

Different types of sounds affect the ear differently, where impulsive sounds are known to be more damaging than non-impulsive sounds. For this reason, there are lower thresholds for exposure to impulsive sounds than non-impulsive sounds (Table 15). In some cases, an animal may be exposed to a combination of impulsive and non-impulsive sounds, or an impulsive sound may follow exposure to a non-impulsive sound. When concurrent sounds of different type are received, the sound energy from all sources should be summed and the threshold for impulsive sounds used because the resultant sound can be thought of as impulses within a background of non-impulsive sound. When impulsive sound (such as impact pile driving) follows exposure to non-impulsive sound (such as vibratory pile driving), evaluation of potential effects of the non-impulsive sound (vibratory pile driving) is evaluated first and then the potential effect of the impulsive sound (impact pile driving). The sound energy from the exposure to non-impulsive sound (vibratory pile driving), however, should be included in the total received energy during the impulsive sound (impact pile driving) if the non-impulsive sound occurs within the time window of evaluation (24 h). See section 2.6 for further details on how the different sound source types are evaluated using injury and behavior criteria.

Table 15. Summary of relevant permanent threshold shift (PTS) onset acoustic thresholds for marine mammal hearing groups (NMFS 2018).

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

[a] Dual metric acoustic thresholds for impulsive sounds: Of these two metrics, the one with the larger acoustic isopleth or the larger exposure effect is used to assess PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds have also been considered.

2.4.1.4. Marine Mammal Behavioral Response Exposure Criteria

Numerous studies on marine mammal behavioral responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioral reactions. It is recognized that the context in which sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison et al. 2012). Due to the complexity and variability of marine mammal behavioral responses to acoustic exposure, NOAA has not yet released technical guidance for determining potential behavioral responses of marine mammals exposed to sounds (NMFS 2018). NOAA's National Marine Fisheries Service (NMFS) currently uses a step function to assess behavioral impact for intermittent sources, like impact pile driving, at SPL 160 dB re 1 µPa and for continuous sources, like vibratory pile driving, at SPL 120 dB re 1 µPa (NOAA 2005).

An extensive review of behavioral responses to sound was undertaken by Southall et al. (2007, their Appendix B). Southall et al. (2007) found varying responses for most marine mammals between an SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit dose-response functions. Wood et al. (2012). proposed a graded probability of response to seismic sounds using a frequency weighted SPL metric. The frequency weighting function was taken from the earlier Southall et al. (2007) paper. Wood et al. (2012) also designated behavioral response categories for sensitive species (including harbor porpoises and beaked whales) and for migrating mysticetes. For this analysis, both the unweighted NOAA (2005) and the frequency-weighted Wood et al. (2012) criteria are used to estimate Level B exposures to impulsive pile-driving sounds (Table 16).

Table 16. Wood et al. (2012) and NOAA (2005) acoustic sound pressure level (SPL) thresholds used to evaluate potential behavioral impacts to marine mammals. Probabilities are not additive.

Marine mammal group	Species	Frequency weighted probabilistic response (L_p; dB re 1 µPa)				Un-weighted probabilistic response, intermittent (L_p; dB re 1 µPa)	Un-weighted probabilistic response, continuous (L_p; dB re 1 µPa)
		>120	>140	>160	>180	160	120
Sensitive odontocetes	Harbor porpoise	50 %	90 %	–	–	100 %	100 %
Migrating mysticete whales	Minke whale Sei whale	10 %	50 %	90 %	–	100 %	100 %
All other species		–	10 %	50 %	90 %	100 %	100 %

2.4.2. Acoustic Thresholds for Evaluating Potential Impacts to Sea Turtles and Fish

In a cooperative effort between Federal and State transportation and resource agencies, interim criteria were developed to assess the potential for injury to fish exposed to pile driving sounds (Stadler & Woodbury, 2009) and described by the Fisheries Hydroacoustic Working Group (FHWG 2008). Injury and behavioral response levels for fish were based on past literature that was compiled in NMFS (2023) for assessing the potential effects to Endangered Species Act (ESA) listed animals exposed to elevated levels of underwater sound from pile driving. Dual acoustic thresholds for physiological injury to fish are 206 dB re 1 µPa PK and either 187 dB re 1 µPa^2·s SEL (>2 grams [g] fish weight) or 183 dB SEL (<2 g fish weight) (FHWG 2008) (Table 17). The behavioral threshold for fish is ≥150 dB SPL.

A technical report by an American National Standards Institute (ANSI) registered committee (Popper et al. 2014) reviewed available data and suggested metrics and methods for estimating acoustic impacts for fish. Their report includes thresholds for potential injury but does not define sound levels that may result in behavioral response, though does indicate a high likelihood of response near impact pile driving (tens of meters), moderate response at intermediate distances (hundreds of meters), and low response far (thousands of meters) from the pile (Popper et al. 2014).

Injury, impairment, and behavioral thresholds for sea turtles were developed for use by the US Navy (Finneran et al. 2017) based on exposure studies (e.g., McCauley et al. 2000b). Dual criteria (PK and SEL) have been suggested for PTS and TTS, along with auditory weighting functions published by Finneran et al. (2017) used in conjunction with SEL thresholds for PTS and TTS for impulsive sounds. The weighted SEL threshold criterion for non-impulsive sounds (vibratory pile driving) is 220 dB re 1 µPa^2·s. The behavioral threshold recommended in the GARFO acoustic tool (GARFO 2020) is an SPL of 175 dB re 1 µPa (McCauley et al. 2000b, Finneran et al. 2017) (Table 17).

Table 17. Acoustic metrics and thresholds for fish and sea turtles currently used by NMFS and Bureau of Ocean Energy Management (BOEM) for impulsive pile driving.

Faunal group	Onset of physical Injury		Behavior
	L_{pk}	L_E	L_p
Fish equal to or greater than 2 g [a]	206	187	150
Fish less than 2 g [a]		183	
Fish without swim bladder [b]	213	216	-
Fish with swim bladder not involved in hearing [b]	207	203	-
Fish with swim bladder involved in hearing [b]	207	203	-
Sea turtles [c,d]	232	204	175

L_{pk} – peak sound pressure (dB re 1 µPa), L_E – sound exposure level (dB re 1 µPa^2·s), L_p – root mean square sound pressure (dB re 1 µPa).

A dash indicates that distances could not be calculated because thresholds were not reached.

PTS = permanent threshold shift; TTS = temporary threshold shift, which are recoverable hearing effects.

[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).

[b] Popper et al. (2014), used by BOEM

[c] Finneran et al. (2017), use by BOEM

[d] McCauley et al. (2000b), use by BOEM

2.5. Animal Movement Modeling and Exposure Estimation

JASMINE was used to estimate the probability of exposure of animals to sound arising from pile driving operations during construction of the Project. Sound exposure models such as JASMINE use simulated animals (animats) to sample the predicted 3-D sound fields with movement rules derived from animal observations. An overview of the exposure modeling process using JASMINE is shown in Figure 5.

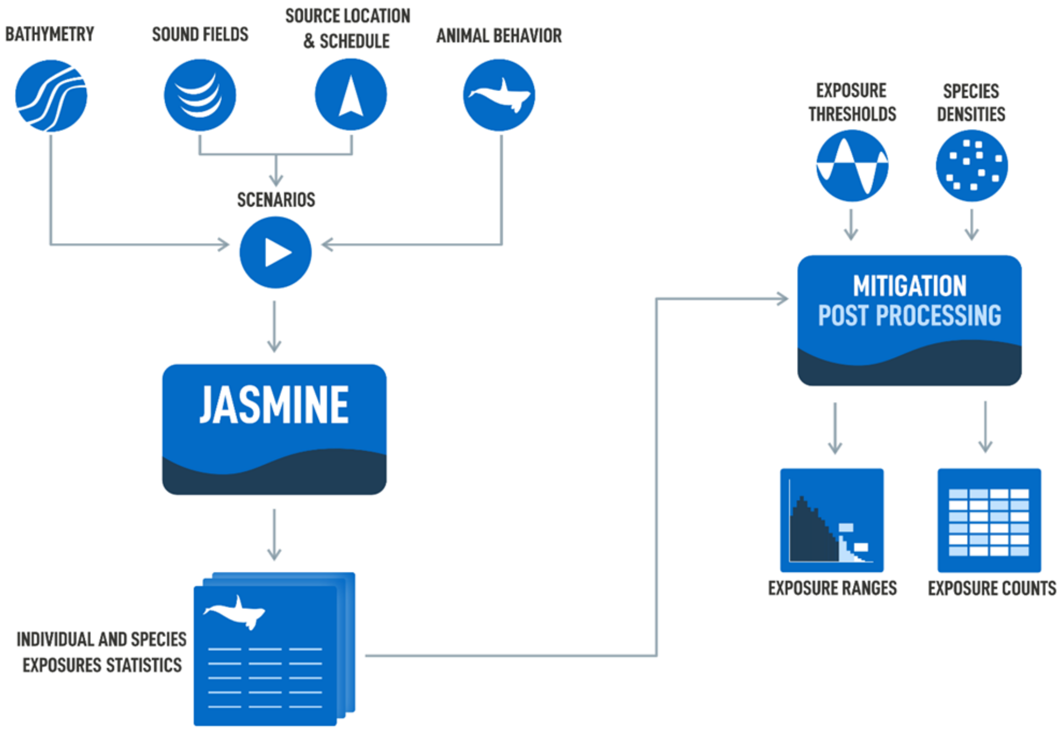

Figure 5. Exposure modeling process overview.

The parameters used for forecasting realistic behaviors (e.g., diving, foraging, and surface times) were determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species (see Appendix G). The predicted sound fields were sampled by the model receiver in a way that real animals are expected to by programming animats to behave like marine species that may be present near the Project. The output of the simulation is the exposure history for each animat within the simulation. An individual animat's sound exposure levels are summed over a specified duration, i.e., 24 h (see Appendix G), to determine its total received acoustic energy (SEL) and maximum received PK and SPL. These received levels are then compared to the threshold criteria described in Section 2.4 within each analysis period. Appendix G provides fuller description of animal movement modeling and the parameters used in the JASMINE simulations. Due to shifts in animal density and seasonal sound propagation effects, the number of animals predicted to be impacted by the pile driving operations is sensitive to the number of foundations installed during each month. JASMINE can be used to simulate aversive behaviors, where animals respond to sound. A subset of scenarios was run with aversion and these results are provided for demonstration purposes only (see Section 4.3.1.1).

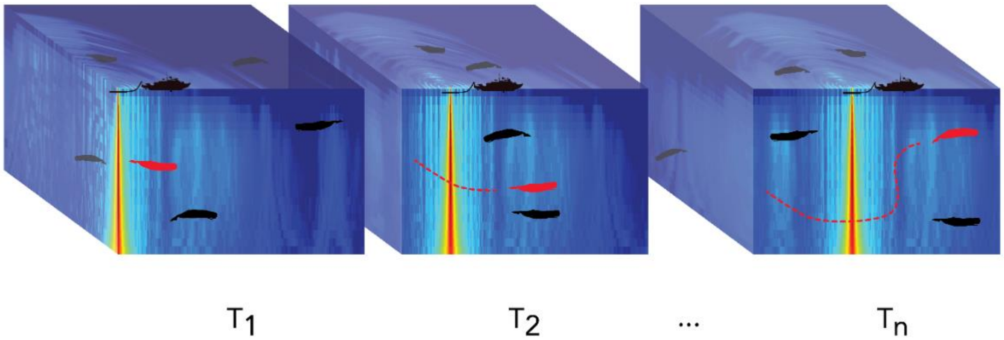

Figure 6. Depiction of animats in an environment with a moving sound field. Example animat (red) shown moving with each time step. The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

2.5.1. Implementing Pile Installation Schedules in JASMINE

Exposure modeling locations were chosen to represent expected construction activity in the lease area over a seven-day period. The pile installation schedules for both sequential and concurrent scenarios are described in Section 1.2.2.

The hammering schedule for each foundation type is determined from pile driving parameters. For a single pile, the installation time is calculated using the blow rate and blow count at each hammer energy level. A pile installation schedule is created for the simulation by assigning each strike of the pile to a time in the simulation, along with the closest associated sound field for that pile type and scenario. When multiple piles are driven per day, the same hammering schedule is used for the additional piles, with a delay between piles to allow for vessel movement and set up. Figure 7 displays a sequential operations scenario where one pile is installed at a time from one vessel. Figure 9 displays a concurrent operations scenario where two piles are installed simultaneously with two vessels operating, followed by another two piles simultaneously installed later in the day.

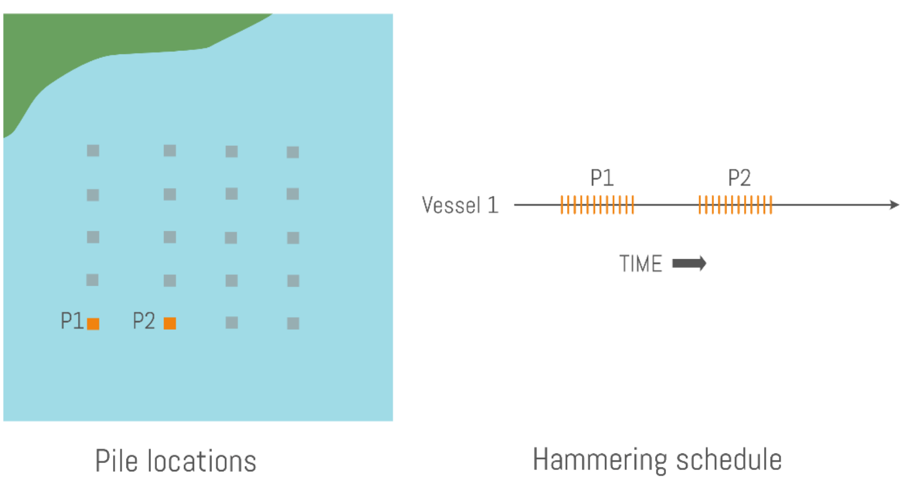

Figure 7. Pile installation schedule for sequential operations. Vertical orange tick marks show conceptual representations of each hammer strike.

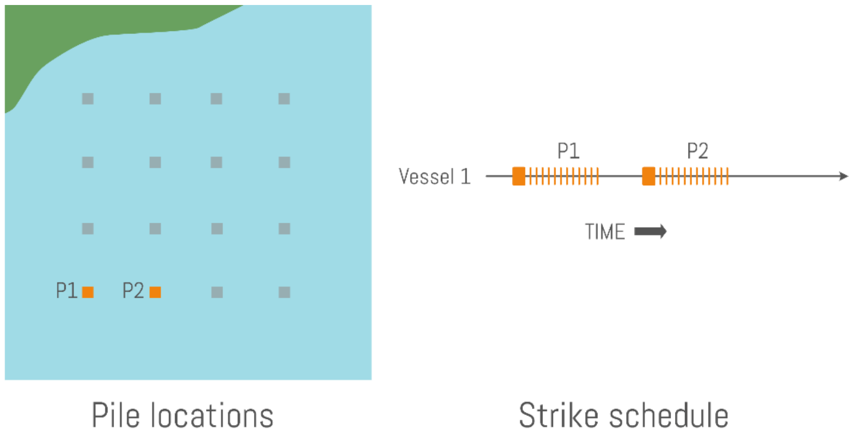

Figure 8. Pile installation schedule for vibratory operations. Vertical orange tick marks show conceptual representations of each hammer strike. Solid orange bars preceding the tick marks indicate periods of vibratory pile driving.

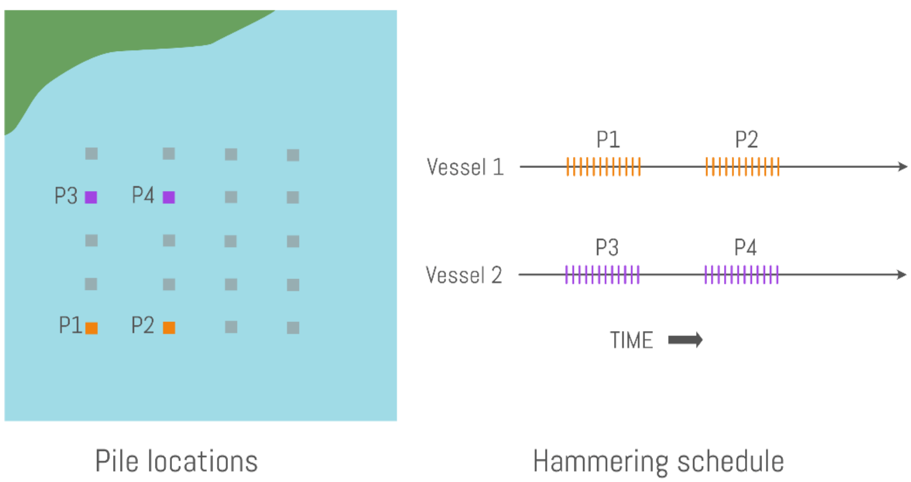

Figure 9. Pile installation schedule for concurrent operations. Vertical orange and purple tick marks show conceptual representations of each hammer strike.

2.6. Summing Different Source Types

When evaluating the potential for injury, the total received dose of SEL over each 24 h period is assessed. Vibratory setting of piles followed by impact pile driving is being considered for the Project for the installation of both monopile and jacket foundations. Although the potential to induce hearing loss is low during vibratory driving, it does introduce some SEL exposure that must be considered in the 24 h SEL estimates. For this reason, acoustic ranges from the combined sound energy from vibratory and impact pile driving were computed. These results are presented in Appendix G. The PTS onset SEL thresholds are lower for impact piling than for vibratory piling (Section 2.4.1.3) so, to be conservative, when estimating acoustic ranges and animats exposed to potentially injurious sound levels from both activities, the lower (impulsive) SEL criteria were applied.

Exposure to sound above a behavioral SPL response threshold is a simpler because it does not require integrating square pressure over long time periods. This calculation is done separately for vibratory and impact pile driving because these two sound sources use different thresholds, and they are temporally separated. The numbers of animats exposed above these thresholds are calculated individually and then these numbers are combined to get total behavioral exposures. Individual animats that are exposed above behavioral thresholds for both vibratory and impact pile driving are only counted once to avoid over-estimation.

2.7. Estimating Monitoring Zones for Mitigation

Monitoring zones for mitigation purposes have traditionally been estimated by determining the acoustic distance to injury and behavioral thresholds (see Section 2.4). The traditional method assumes that all receivers (animals) in the area remain stationary for the duration of the sound event. Because where an animal is in a sound field and the pathway it takes through the sound field as it evolves over time determines the received level for each animal, treating animals as stationary may not produce realistic estimates for the monitoring zones.

Animal movement and exposure modeling can be used to account for the movement of receivers when estimating distances for monitoring zones. The distance to the closest point of approach (CPA) for each of the species-specific animats (simulated animals) during a simulation is recorded and then the CPA distance that accounts for 95 % of the animats that exceed an acoustic impact threshold is determined (Figure 10). The $ER_{95\%}$ (95 % exposure radial distance) is the horizontal distance that includes 95 % of the CPAs of animats exceeding a given impact threshold. $ER_{95\%}$ is reported for marine mammals and sea turtles. If used as an exclusion zone, keeping animals farther away from the source than the $ER_{95\%}$ will reduce exposure estimates by 95 %.

Unlike marine mammals and sea turtles for which animal movement modeling was performed, fish were considered static (not moving) receivers, so exposure ranges were not calculated. Instead, the acoustic ranges to fish impact criteria thresholds were calculated by determining the isopleth at which thresholds could be exceeded (Appendix F.3).

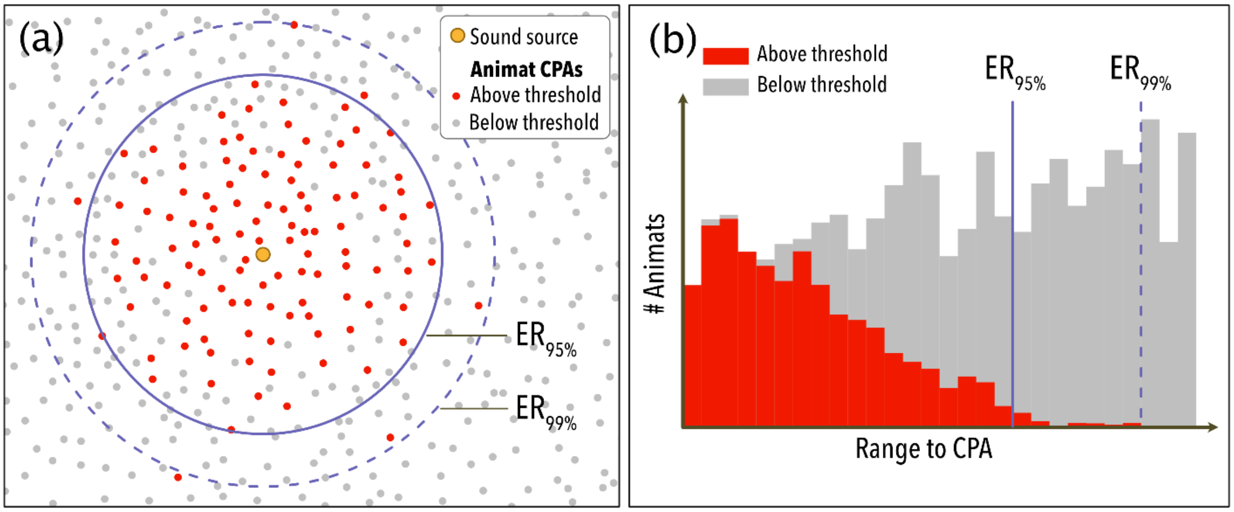

Figure 10. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animat CPAs near a sound source. Panel (b) shows the distribution of distances to animat CPAs. The 95 % and 99 % exposure ranges ($ER_{95\%}$ and $ER_{99\%}$) are indicated in both panels.

3. Marine Fauna Included in the Acoustic Assessment

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

All marine mammal species are protected under the MMPA. Some marine mammal stocks may be designated as Strategic under the MMPA (2015), which requires the jurisdictional agency (NMFS for the Atlantic offshore species considered in this application) to impose additional protection measures. A stock is considered Strategic if:

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

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

- The Secretary, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals established under MMPA Title II, determines that a species or population stock is below its optimum sustainable population;
- A State, to which authority for the conservation and management of a species or population stock is transferred under Section 109 of the MMPA, determines that such species or stock is below its optimum sustainable population; or
- A species or population stock is listed as an endangered or threatened species under the ESA. Some species are further protected under the ESA (2002).

Under the ESA, a species is considered endangered if it is "in danger of extinction throughout all or a significant portion of its range." A species is considered threatened if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (ESA 2002). Six marine mammal species know to occur in the Northwest Atlantic OCS region are ESA listed (Table 18). All four species of sea turtle (Table 20) as well as four fish species (see Section 3.3) occurring in the Northwest Atlantic OCS region are also ESA listed.

3.1. Marine Mammals that May Occur in the Area

Thirty-eight marine mammal species (whales, dolphins, porpoise, and seals) comprising 39 stocks have been documented as present (some year–round, some seasonally, and some as occasional visitors) in the Northwest Atlantic Outer Continental Shelf (OCS) region (CeTAP 1982, USFWS 2014, Roberts et al. 2016, Hayes et al. 2022). All 38 marine mammal species identified in Table 18 are protected by the MMPA and some are also listed under the ESA. The five ESA-listed marine mammal species known to be present year-round, seasonally, or occasionally in southern New England waters are sperm whale (*Physeter macrocephalus*), North Atlantic right whale (NARW) (*Eubalaena glacialis)*, fin whale (*Balaenoptera physalus*), blue whale (*B. musculus*), and sei whale (*B. borealis*). The humpback whale (*Megaptera novaeangliae*), which may occur year-round, has been delisted as an endangered species.

Southern New England waters (including the Project Area (see Figure 1)) are primarily used as opportunistic feeding areas or habitat during seasonal migratory movements that occur between the feeding areas located farther north and the breeding areas located farther south that are typically used by some of these large whale species. The modeling used in this assessment considered minke and sei whales to be migratory in the region.

The four species of phocids (true seals) that have ranges overlapping the Project Area are harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), harp seals (*Pagophilus groenlandicus*), and hooded seals (*Cystophora cristata*) (Hayes et al. 2022). None of these are ESA listed, but all are protected under the MMPA.

The expected occurrence of each marine mammal species in the Project Area is listed in Table 18. Many of these marine mammal species do not commonly occur in this region of the Atlantic Ocean. For this assessment, species presence was categorized as the following:

- Common – Occurring consistently in moderate to large numbers;
- Regular – Occurring in low to moderate numbers on a regular basis or seasonally;
- Uncommon – Occurring in low numbers or on an irregular basis; and
- Rare – There are limited species records for some years; range includes the Offshore Development Area but due to habitat preferences and distribution information, species are generally not expected to occur in the Lease Area, though rare sightings are a possibility. Records may exist for adjacent waters.

Marine mammal species considered c*ommon* and *uncommon* (Table 18) were selected for quantitative assessment by acoustic impact analysis and exposure modeling. Quantitative assessment of bottlenose dolphins (*Tursiops truncatus*) presumed all impacted individuals belong to the Western North Atlantic Offshore stock because the northern limit of the range of the coastal stock does not extend into the Project Area. Quantitative assessment of *rare* species was not conducted because impacts to those species approach zero due to their low densities. The modeled species are identified in Table 18. The likelihood of incidental exposure for each species based on its presence, density, and overlap of proposed activities is described in Section 4.3.1.

Table 18. Marine mammals that may occur in the Project Area.

Species	Scientific name	Stock	Regulatory status [a]	Relative occurrence in SouthCoast Wind	Abundance [b]
Baleen whales (Mysticeti)					
Blue whale	*Balaenoptera musculus*	Western North Atlantic	ESA-Endangered	Rare	402
Fin whale[c]	*Balaenoptera physalus*	Western North Atlantic	ESA-Endangered	Common	6,802
Humpback whale[c]	*Megaptera novaeangliae*	Gulf of Maine	MMPA	Common	1,396
Minke whale[c]	*Balaenoptera acutorostrata*	Canadian Eastern Coastal	MMPA	Common	21,968
North Atlantic right whale[c]	*Eubalaena glacialis*	Western North Atlantic	ESA-Endangered	Common	338[d]
Sei whale[c]	*Balaenoptera borealis*	Nova Scotia	ESA-Endangered	Common	6,292
Toothed whales (Odontoceti)					
Sperm whales (Physeteridae and Kogiidae)					
Sperm whale[c]	*Physeter macrocephalus*	North Atlantic	ESA-Endangered	Uncommon	4,349
Dwarf sperm whale	*Kogia sima*	Western North Atlantic	MMPA	Rare	7,750[e]
Pygmy sperm whale	*Kogia breviceps*	Western North Atlantic	MMPA	Rare	7,750[e]
Dolphins (Delphinidae)					
Atlantic spotted dolphin[c]	*Stenella frontalis*	Western North Atlantic	MMPA	Uncommon	39,921
Atlantic white-sided dolphin[c]	Lagenorhynchus acutus	Western North Atlantic	MMPA	Common	93,233
Bottlenose dolphin[c]	*Tursiops truncatus*	Western North Atlantic, offshore[f]	MMPA	Common	62,851
		Western North Atlantic, Northern Migratory Coastal	MMPA-Strategic	Rare	6,639
Clymene dolphin	*Stenella clymene*	Western North Atlantic	MMPA	Rare	4,237
False killer whale	*Pseudorca crassidens*	Western North Atlantic	MMPA	Rare	1,791
Fraser's dolphin	*Lagenodelphis hosei*	Western North Atlantic	MMPA	Rare	Unknown
Killer whale	*Orcinus orca*	Western North Atlantic	MMPA	Rare	Unknown
Melon-headed whale	*Peponocephala electra*	Western North Atlantic	MMPA	Rare	Unknown
Pan-tropical spotted dolphin	*Stenella attenuata*	Western North Atlantic	MMPA	Rare	6,593
Pilot whale, long-finned[c]	*Globicephala melas*	Western North Atlantic	MMPA	Uncommon	39,215
Pilot whale, short-finned[c]	*Globicephala macrorhynchus*	Western North Atlantic	MMPA	Uncommon	28,924
Pygmy killer whale	*Feresa attenuata*	Western North Atlantic	MMPA	Rare	Unknown
Risso's dolphin[c]	*Grampus griseus*	Western North Atlantic	MMPA	Uncommon	35,215
Rough-toothed dolphin	*Steno bredanensis*	Western North Atlantic	MMPA	Rare	136
Common dolphin[c]	*Delphinus delphis*	Western North Atlantic	MMPA	Common	172,974
Spinner dolphin	*Stenella longirostris*	Western North Atlantic	MMPA	Rare	4,102
Striped dolphin	*Stenella coeruleoalba*	Western North Atlantic	MMPA	Rare	67,036
White-beaked dolphin	*Lagenorhynchus albirostris*	Western North Atlantic	MMPA	Rare	536,016
Beaked whales (Ziphiidae)					
Cuvier's beaked whale	*Ziphius cavirostris*	Western North Atlantic	MMPA	Rare	5,744
Blainville's beaked whale	*Mesoplodon densirostris*	Western North Atlantic	MMPA	Rare	10,107[g]
Gervais' beaked whale	*Mesoplodon europaeus*	Western North Atlantic	MMPA		

Sowerby's beaked whale	*Mesoplodon bidens*	Western North Atlantic	MMPA		
True's beaked whale	*Mesoplodon mirus*	Western North Atlantic	MMPA		
Northern bottlenose whale	*Hyperoodon ampullatus*	Western North Atlantic	MMPA	Rare	Unknown
Porpoises (Phocoenidae)					
Harbor porpoise[c]	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	MMPA	Common	95,543
Earless seals (Phocidae)					
Gray seal[c]	*Halichoerus grypus*	Western North Atlantic	MMPA	Common	27,300[h]
Harbor seal[c]	*Phoca vitulina*	Western North Atlantic	MMPA	Regular	61,336
Harp seal[c]	*Pagophilus groenlandicus*	Western North Atlantic	MMPA	Uncommon	Unknown[i]
Hooded seal	*Cystophora cristata*	Western North Atlantic	MMPA	Rare	Unknown

[a] Denotes the highest federal regulatory classification. A strategic stock is defined as any marine mammal stock: 1) for which the level of direct human-caused mortality exceeds the potential biological removal level; 2) that is declining and likely to be listed as Threatened under the ESA; or 3) that is listed as Threatened or Endangered under the ESA or as depleted under the MMPA (Hayes et al. 2022).

[b] Best available abundance estimate is from NOAA Fisheries Stock Assessment Reports (Hayes et al. 2023).

[c] Modeled species.

[d] Best available abundance estimate is from NOAA Fisheries Stock Assessment (Hayes et al. 2023). NARW consortium has released the 2021 report card results predicting a NARW population of 336 for 2020 (Pettis et al. 2022). However, the consortium "alters" the methods of Pace et al. (2017, 2021) to subtract additional mortality. This method is used in order to estimate all mortality, not just the observed mortality, therefore the 2022 SAR (Hayes et al. 2023) will be used to report an unaltered output of the Pace et al. (2017, 2021) model (DoC and NOAA 2020).

[e] This estimate includes both dwarf and pygmy sperm whales. Source: NOAA Fisheries (2023).

[f] Bottlenose dolphins occurring in the Offshore Development Area likely belong to the Western North Atlantic Offshore stock (Hayes et al. 2022).

[g] This estimate includes all undifferentiated Mesoplodon spp. beaked whales in the Atlantic. Sources: Kenney and Vigness-Raposa (2009), Rhode Island Ocean Special Area Management Plan (2011), Waring et al. (2011, 2013, 2015), Hayes et al. (2022).

[h] Estimate of gray seal population in US waters. Data are derived from pup production estimates; Hayes et al. (2022) note that uncertainty about the relationship between whelping areas along with a lack of reproductive and mortality data make it difficult to reliably assess the population trend.

[i] Hayes et al. (2022) report insufficient data to estimate the population size of harp seals in US waters; the best estimate for the whole population is 7.6 million.

3.2. Mean Monthly Marine Mammal Density Estimates

Mean monthly marine mammal density estimates (animals per 100 square kilometers [animals/100 km^2]) were obtained using the 2022 Duke University Marine Geospatial Ecology Laboratory model results (Roberts et al. 2016, 2022), which were recently updated for all species. The 2022 updated NARW model (v12) provides model predictions for three eras, 2003–2019, 2003–2009, and 2010–2019, to reflect the apparent shift in NARW distribution around 2010. The modeling reported herein used the 2010–2019 density predictions as recommended by Roberts et al. (2022). Similarly, the 2022 updated humpback whale model (v11) provides model predictions for three eras, 2002–2019, 2002–2008, and 2009–2019. The modeling reported herein used the 2009-2019 density predictions as recommended by Roberts et al. (2022).

Densities were calculated within buffered polygons around the Lease Area perimeter. The following buffer ranges were pre-selected: 1, 5, 10, 15, 20, 30, 40, and 50 km. For each species, foundation type, and attenuation level, the most appropriate density buffer was selected from this list. The buffer range was selected using the 95th percentile exposure range ($ER_{95\%}$) for each case, using the next highest buffer range. For example, if the $ER_{95\%}$ was 8.5 km, the 10 km buffer would be used. In cases where the $ER_{95\%}$ was longer than 50 km, the 50-km buffer range was used. The 50 km limit is derived from studies of mysticetes that demonstrate received levels, distance from the source, and behavioral context are known to influence the probability of behavioral response (Dunlop et al. 2017).

The mean species density for each month was determined by calculating the unweighted mean of all 5 × 5 km grid cells partially or fully within the selected buffer polygon. Figure 11 shows the 5-km buffer polygon with the selected density grid cells highlighted. Table 19 includes the densities calculated for all species using the 5-km buffer. Densities were computed monthly, annually, and for the May–December period to coincide with proposed pile driving activities. Density tables for the remaining buffer distances are included in Appendix G.

For long- and short-finned pilot whales (*Globicephala melas* and *G. macrorhynchus*, respectively), monthly densities are unavailable from Roberts et al. (2016, 2022), so annual mean densities were used. Additionally, Roberts et al. (2016, 2022) provide density for pilot whales as a guild that includes both species. To obtain density estimates for long-finned and short-finned pilot whales, the guild density from Roberts et al. (2016, 2022) was scaled by the relative stock sizes based on the best available abundance estimate from NOAA Fisheries 2021 SARs (Hayes et al. 2022). Equation 1 shows an example of how abundance scaling is applied to compute density for short-finned pilot whales:

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

where a represents abundance and d represents density. Similarly, densities are provided for seals as a guild consisting primarily of harbor and gray seals (Roberts et al. 2016, 2022). Gray and harbor seal densities were scaled by relative NOAA Fisheries SAR (Hayes et al. 2022) abundance. Harp seal densities are expected to be much lower than those of the other two seal species, but since there are no available density or location-specific abundance data to inform scaling, the gray seal density was used as a conversative estimate of harp seal density.

Only the offshore stock of bottlenose dolphins is expected to occur near the Project Area, but the density model from Roberts et al. (2016, 2022) does not delineate this species into different stocks. Density for the offshore stock was calculated by splitting the buffer area at the 20-m isobath and estimating densities for the buffered area deeper than 20 m.

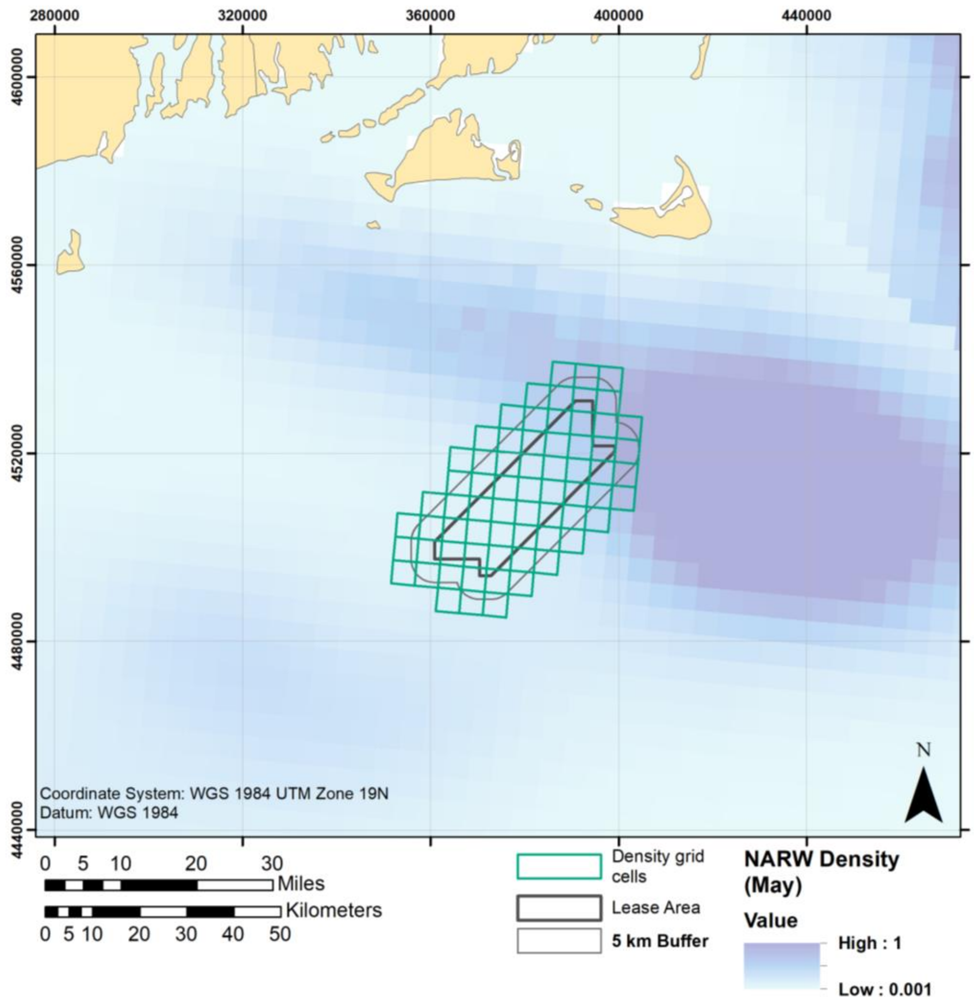

Figure 11. Marine mammal (e.g., NARW) density map showing highlighted grid cells used to calculate mean monthly species estimates (animals per 100 km^2) within a 5 km buffer around SouthCoast Wind Lease Area (Roberts et al. 2016, 2022).

Table 19. Mean monthly marine mammal density estimates for all species in a 5 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.218	0.175	0.144	0.149	0.302	0.292	0.474	0.360	0.269	0.081	0.052	0.142	0.222	0.247
Minke whale	0.104	0.132	0.140	0.756	1.534	1.822	0.832	0.494	0.567	0.506	0.052	0.070	0.584	0.735
Humpback whale	0.026	0.024	0.050	0.182	0.315	0.357	0.218	0.130	0.173	0.263	0.207	0.026	0.164	0.211
North Atlantic right whale[b]	0.422	0.478	0.430	0.424	0.323	0.059	0.032	0.020	0.031	0.050	0.081	0.246	0.216	0.105
Sei whale[b]	0.038	0.025	0.050	0.119	0.193	0.064	0.016	0.012	0.019	0.040	0.089	0.067	0.061	0.063
Atlantic white-sided dolphin	2.572	1.508	1.077	1.663	3.705	3.814	2.064	0.922	2.023	3.079	2.292	3.238	2.330	2.642
Atlantic spotted dolphin	0.001	0.000	0.001	0.006	0.033	0.051	0.049	0.081	0.429	0.610	0.160	0.015	0.120	0.179
Common dolphin	9.086	3.373	3.041	4.563	7.740	16.823	15.489	20.570	34.253	31.550	16.454	14.252	14.766	19.641
Bottlenose dolphin, offshore	0.505	0.118	0.074	0.209	0.934	1.562	1.708	1.965	1.926	1.757	1.530	1.283	1.131	1.583
Risso's dolphin	0.049	0.006	0.004	0.023	0.135	0.090	0.117	0.257	0.318	0.155	0.145	0.193	0.124	0.176
Long-finned pilot whale[c]	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
Short-finned pilot whale[c]	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Sperm whale[b]	0.045	0.016	0.016	0.004	0.017	0.031	0.056	0.170	0.100	0.072	0.043	0.029	0.050	0.065
Harbor porpoise	11.140	11.968	11.374	9.740	7.603	1.637	1.591	1.458	1.690	2.134	2.234	7.171	5.812	3.190
Gray seal	5.918	5.894	4.210	3.497	4.742	0.556	0.104	0.099	0.206	0.543	2.394	5.062	2.769	1.713
Harbor seal	13.296	13.242	9.458	7.856	10.654	1.250	0.234	0.223	0.463	1.220	5.378	11.372	6.221	3.849
Harp seal	5.918	5.894	4.210	3.497	4.742	0.556	0.104	0.099	0.206	0.543	2.394	5.062	2.769	1.713

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).

[b] Listed as Endangered under the ESA.

[c] Density adjusted by relative abundance.

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

Four species of sea turtles may occur in the Project Area (Table 20), : loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*). All are listed as threatened or endangered. Many species of sea turtle prefer coastal waters; however, leatherback and loggerhead sea turtles are known to occupy deep-water habitats and are considered common during summer and fall in Southern New England waters. Kemp's ridley sea turtles are thought to be regular visitors and green sea turtles, although uncommon, may be present during those seasons when water temperatures are highest.

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

Atlantic sturgeon distribution varies by season, but they are primarily found in shallow coastal waters (bottom depth less than 20 m) during the summer months (May to September) and move to deeper waters (20–50 m) in winter and early spring (December to March) (Dunton et al. 2010). Shortnose sturgeon occur primarily in fresh and estuarine waters, and they occasionally enter the coastal ocean. Adults ascend rivers to spawn from February to April, and eggs are deposited over hard bottom, in shallow fast-moving water (Dadswell et al. 1984). Because of their preference for mainland rivers and fresh and estuarine waters, shortnose sturgeon are unlikely to be found in the vicinity of the Project Area. Atlantic salmon is an anadromous species that historically ranged from northern Quebec southeast to Newfoundland and southwest to Long Island Sound. The Gulf of Maine Distinct Population Segment (DPS) of the Atlantic salmon that spawns within eight coastal watersheds within Maine is federally listed as Endangered. In 2009, the DPS was expanded to include all areas of the Gulf of Maine between the Androscoggin River and the Dennys River (NOAA Fisheries 2022). It is possible that adult Atlantic salmon may occur off the Massachusetts coast while migrating to rivers to spawn. However, only certain Gulf of Maine populations are listed as Endangered, and Gulf of Maine salmon are unlikely to be encountered south of Cape Cod (BOEM 2014). The giant manta ray is found worldwide in tropical, subtropical, and temperate bodies of water. It is commonly found offshore, in oceanic waters, and near productive coastlines. As such, giant manta rays can be found in cool water, as low as 19°C, although temperature preference appears to vary by region. For example, off the US East Coast, giant manta rays are commonly found in waters from 19 to 22°C, whereas those off the Yucatan peninsula and Indonesia are commonly found in waters between 25 to 30°C. Individuals have been observed as far north as New Jersey in the Western Atlantic basin indicating that the Offshore Development Area is located at the northern boundary of the species' range (NOAA Fisheries 2021).

Table 20. Sea turtle species potentially occurring within the regional waters of the Western North Atlantic Outer Continental Shelf (OCS) and Project Area.

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

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

3.4. Sea Turtle Density Estimates

There are limited density estimates for sea turtles in the Lease Area. For this analysis, sea turtle densities were obtained from the US Navy Operating Area Density Estimate (NODE) database on the Strategic Environmental Research and Development Program Spatial Decision Support System (SERDP-SDSS) portal (DoN, 2012, 2017) and from the Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles (Kraus et al. 2016). These data are summarized seasonally (winter, spring, summer, and fall). Since the results from Kraus et al. (2016) use data that were collected more recently, those were used preferentially where possible.

Sea turtles were most commonly observed in summer and fall, absent in winter, and nearly absent in spring during the Kraus et al. (2016) surveys of the MA WEA and RI/MA WEAs. Because of this, the more conservative winter and spring densities from SERDP-SDSS are used for all species. It should be noted that SERDP-SDSS densities are provided as a range, where the maximum density will always exceed zero, even though turtles are unlikely to be present in winter. As a result, winter and spring sea turtle densities in the Lease Area, while low, are likely still overestimated.

For summer and fall, the more recent leatherback and loggerhead densities extracted from Kraus et al. (2016) were used. These species were the most commonly observed sea turtle species during aerial surveys by Kraus et al. (2016) in the MA/RI and MA WEAs. However, Kraus et al. (2016) reported seasonal densities for leatherback sea turtles only, so the loggerhead densities were calculated for summer and fall by scaling the averaged leatherback densities from Kraus et al. (2016) by the ratio of the seasonal sighting rates of the two species during the surveys. The Kraus et al. (2016) estimates of loggerhead sea turtle density for summer and fall are slightly higher than the SERDP-SDSS densities, and thus more conservative.

Kraus et al. (2016) reported only six total Kemp's ridley sea turtle sightings, so the estimates from SERDP-SDSS were used for all seasons. Green sea turtles are rare in this area, and there are no density data available for this species. The Kemp's ridley sea turtle density is used as a surrogate to provide a conservative estimate.

Sea turtle densities used in exposure estimates are provided in Table 21.

Table 21. Sea turtle density estimates for all modeled species in a 5 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.006	0.006	0.006	0.006
Leatherback sea turtle	0.027	0.630[c]	0.873[c]	0.027
Loggerhead sea turtle	0.076	0.206[d]	0.633[d]	0.076
Kemp's ridley sea turtle	0.006	0.006	0.006	0.006

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 5 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

4. Results

Sound fields were modeled from both locations for monopiles and pin piles, representing the range of water depths within the Project (Figure 2, Table 5). This section summarizes the source modeling results (Section 4.1), the acoustic propagation modeling results (Section 4.2), exposure and exposure ranges estimates from animal movement modeling for marine mammals and sea turtles (Sections 4.3–4.4), and the acoustic radial distance to fish and sea turtle impulsive sound thresholds (Section 4.5). The report tables indicate the relevant Wood step function for each species (migrating, sensitive (harbor porpoise only), or general (all others)), and the reader should refer to Table 16 for more details.

4.1. Modeled Source Characteristics

4.1.1. Impact Pile Driving

Figures 12–13 show forcing functions computed for the 16 m monopile and the 4.5 m pin pile using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010). The forcing functions serve as the inputs to JASCO's pile driving source model used to estimate equivalent acoustic source characteristics detailed in Appendix E. Figures 14–17 show decidecade band levels at 10 m for the modeled piles. Broadband SEL at 10 m from the modeled monopile and pin pile locations are shown in Tables 22 and 23, respectively.

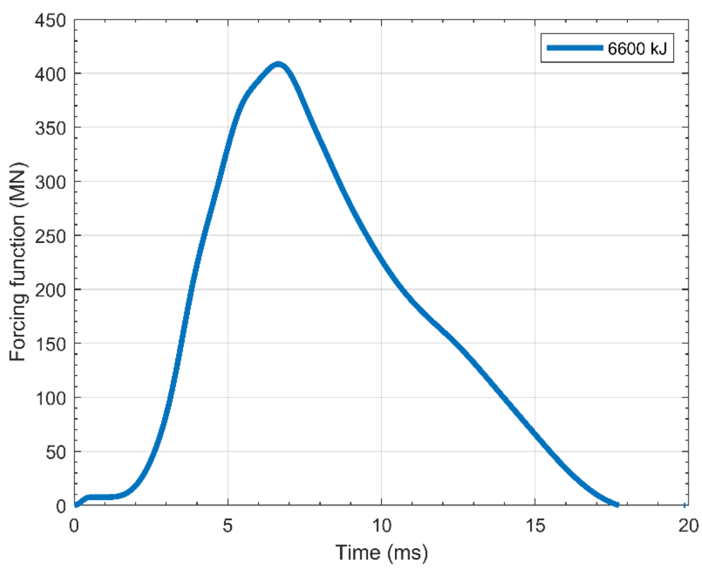

Figure 12. Modeled forcing functions versus time for a 16 m diameter monopile for a 6600 kJ hammer energy.

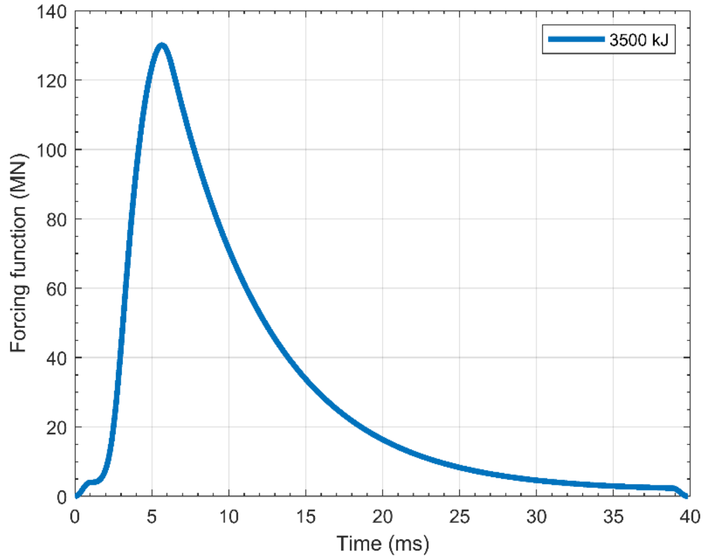

Figure 13. Modeled forcing functions versus time for a 4.5 m diameter pin pile for a 3500 kJ hammer energy.

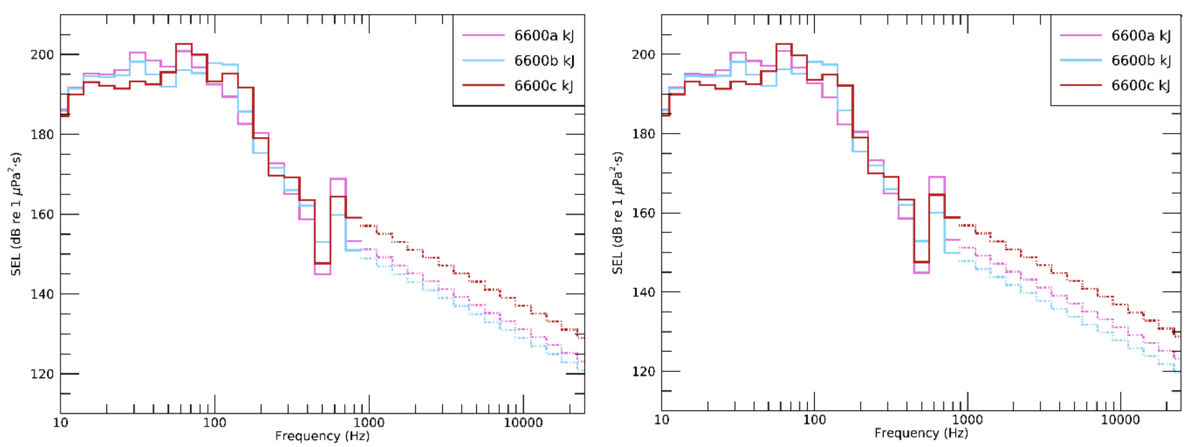

Figure 14. Location L01: Decidecade band levels for a 16 m diameter monopile assuming an expected installation scenario using an NNN 6600 hammer with an average (left) summer and (right) winter sound speed profiles.

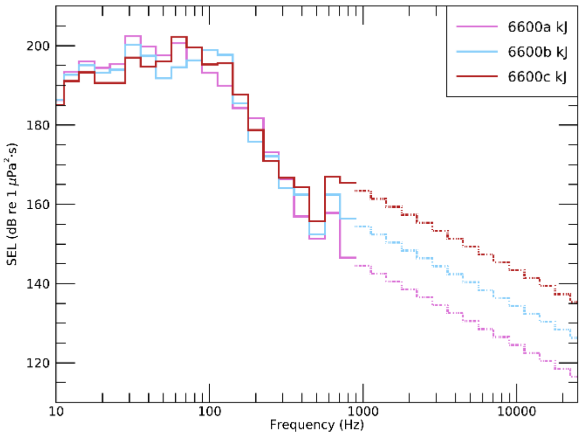

Figure 15. Location L02: Decidecade band levels for a 16 m diameter monopile assuming an expected installation scenario using an NNN 6600 hammer with an average (left) summer and (right) winter sound speed profiles.

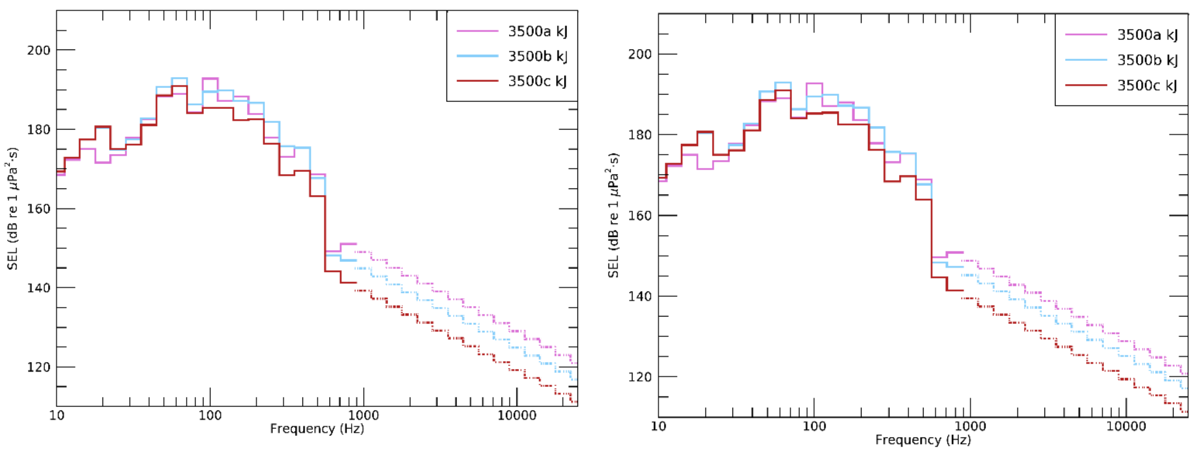

Figure 16. Location L01: Decidecade band levels for a 4.5 m diameter pin pile assuming an expected installation scenario using an MHU 3500S hammer with an average (left) summer and (right) winter sound speed profiles.

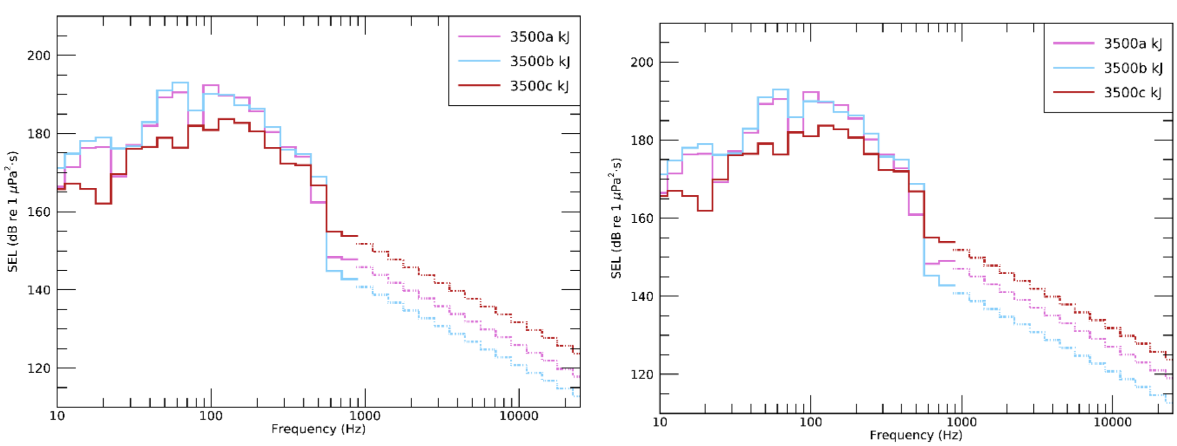

Figure 17. Location L02: Decidecade band levels for a 4.5 m diameter pin pile assuming an expected installation scenario using an MHU 3500S hammer with an average (left) summer and (right) winter sound speed profiles.

Table 22. Broadband SEL (dB re 1 µPa^2·s) per modeled energy level at 10 m from a 16 m diameter monopile installed using an NNN 6600 kJ hammer at both locations. Summer and winter levels are the same.

Energy level (kJ)	L_E @ 10 m from L01	L_E @ 10 m from L02
6600a	207.5	208.1
6600b	206.2	206.9
6600c	206.9	207.1

Table 23. Broadband SEL (dB re 1 µPa^2·s) per modeled energy level at 10 m from a 4.5 m diameter jacket pin pile installed using an MHU 3500S kJ hammer at both locations. Summer and winter levels are the same.

Energy level (kJ)	L_E @ 10 m from L01	L_E @ 10 m from L02
3500a	197.4	198.1
3500b	198.5	198.7
3500c	195.7	190.5

4.1.2. Vibratory Pile Driving

Figures 18 and 19 show 1-second long forcing functions for the jacket and monopile under vibratory hammers calculated using GRLWEAP 2010 (GRLWEAP, Pile Dynamics 2010) with the addition of non-linearities (see Section 2.2.2). Figures 20–23 show decidecade band levels at 10 m for the modeled piles. Observed peaks correspond to the frequency of vibration of the hammer and subsequent harmonics.

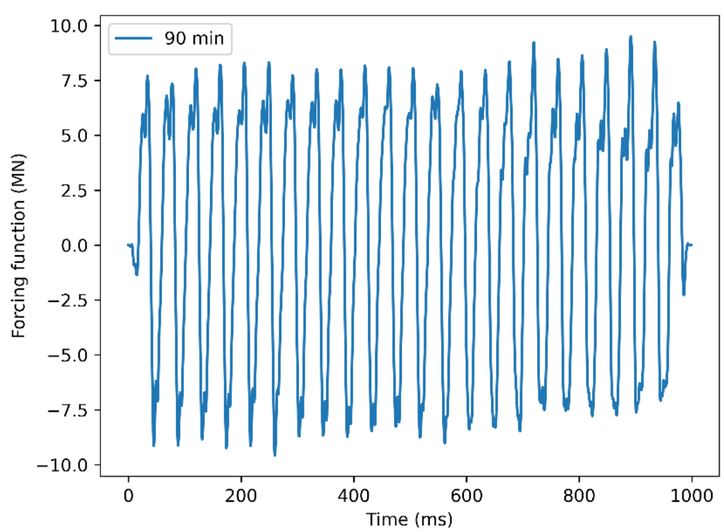

Figure 18. Modeled one second vibratory forcing function for a 4.5 m diameter pin pile.

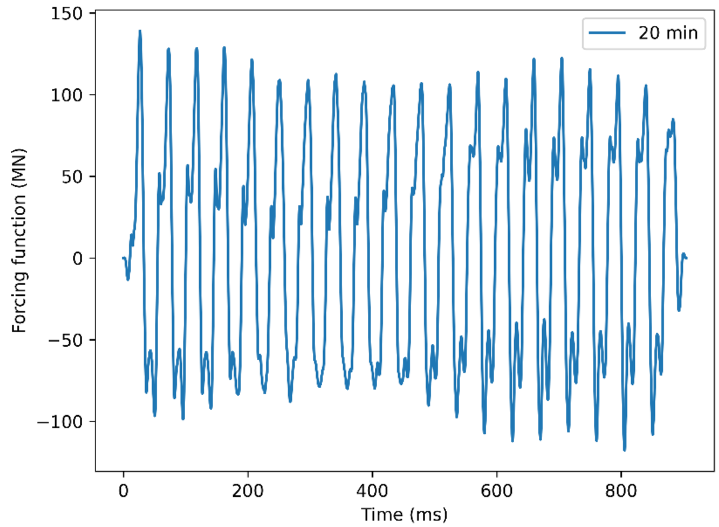

Figure 19. Modeled one second vibratory forcing function for a 16 m diameter monopile.

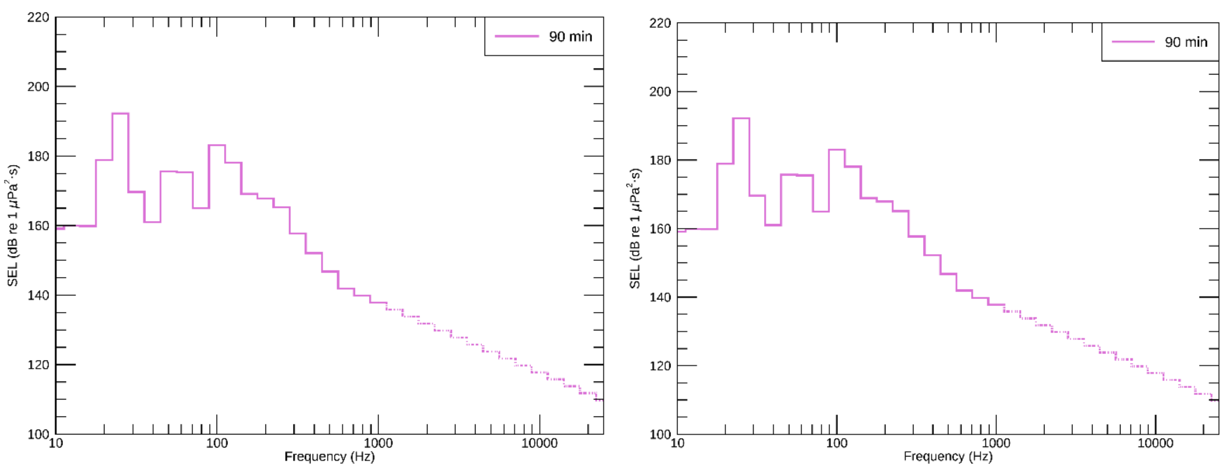

Figure 20. Jacket foundation (4.5 m diameter pile, S-CV640 hammer) at location L01: Decidecade band levels for the receiver with highest SEL at 10 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

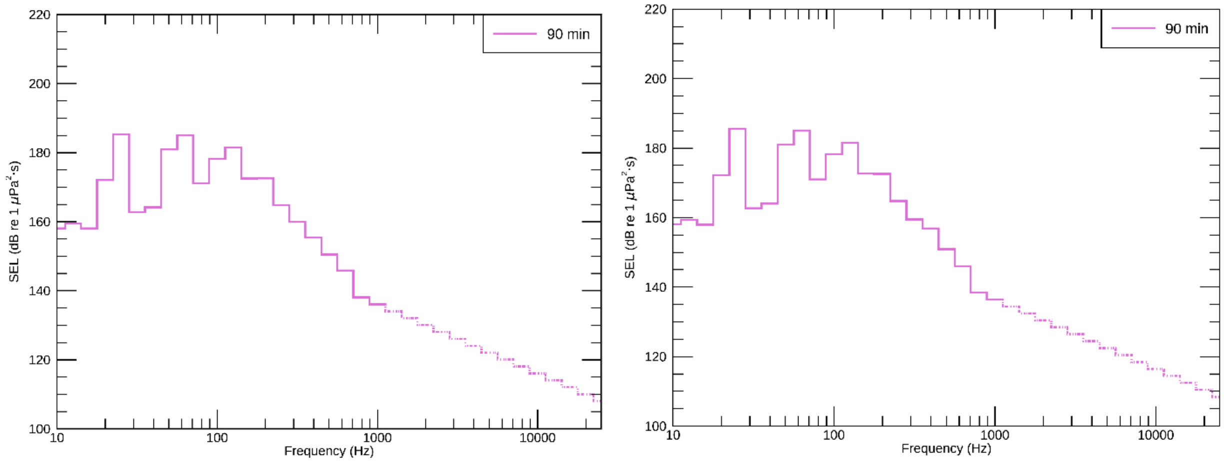

Figure 21. Jacket foundation (4.5 m diameter pile, S-CV640 hammer) at location L02: Decidecade band levels for the receiver with highest SEL at 10 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

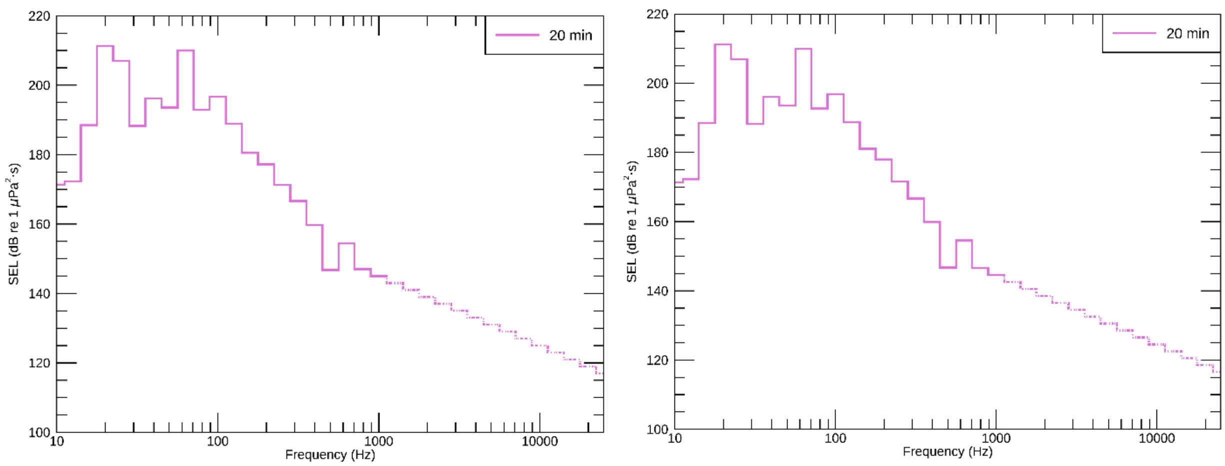

Figure 22. Monopile foundation (16 m diameter pile, HX-CV640 hammer) at location L01: Decidecade band levels for the receiver with highest SEL at 10 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

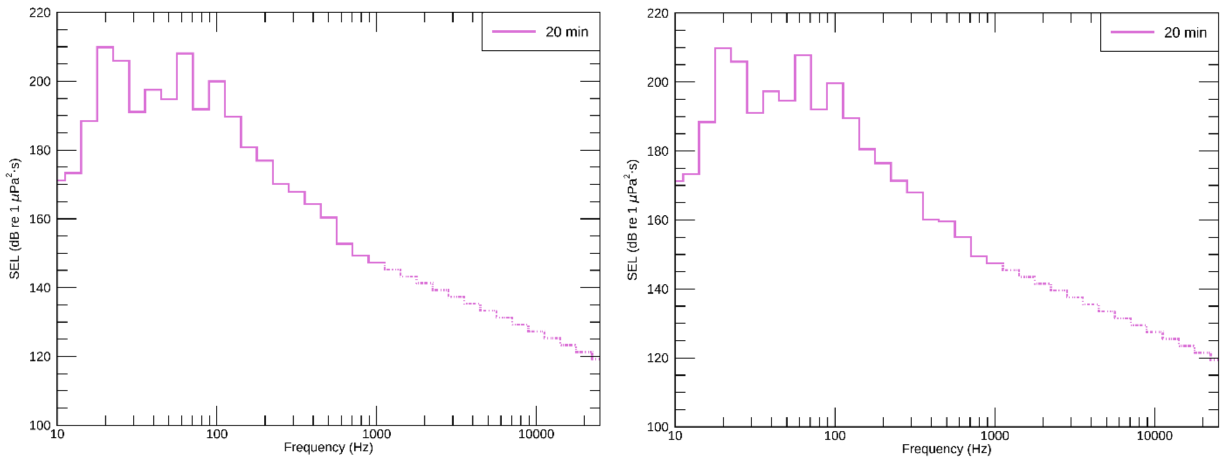

Figure 23. Monopile foundation (16 m diameter pile, HX-CV640 hammer) at location L02: Decidecade band levels for the receiver with highest SEL at 10 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

Table 24. Broadband L_E (dB re 1 µPa^2·s) per duration of vibratory piling at 10 m from a 4.5 m diameter pin pile and a 16 m diameter monopile with installations using a TA-CV320 and a HX-CV640 hammers, respectively, at both locations. Summer and winter levels are the same.

Pile Type	Duration of Vibro-hammering (min)	L_E @ 10 m from L01	L_E @ 10 m from L02
4.5 m Jacket pin pile	90	193.3	190.3
16 m monopile	20	214.8	213.5

4.2. Modeled Sound Fields

Three dimensional (3-D) sound fields for 16 m monopiles and 4.5 m pin piles were calculated using the source characteristics (Section 4.1 and Appendix B) at two representative locations (Table 5). Environmental parameters (bathymetry, geoacoustic information, and sound speed profiles) chosen for the propagation modeling and the modeling procedures are found in Appendix F. Ranges to PK thresholds, ranges to various SPL and SEL isopleths for single hammer strikes at the different hammer energy levels, ranges to cumulative thresholds (per pile), and ranges to vibratory and combined vibratory and impact pile driving sound fields are shown in Appendix G.

The hammering schedule for each foundation type was determined from pile driving parameters provided in Section 1.2.1. For a single pile, the installation time was calculated using the blow rate and blow count at each hammer energy level, if only impact pile driving is considered. For the cases where vibratory and impact pile driving is considered, the time of vibratory piling was added as well. For the cumulative SEL, 20 min (monopile) and 90 min (pin piles) for vibratory piling followed by impact pile driving were considered. For impact pile driving of monopiles, the strike rate is 30 strikes per minute and the total strike count is 5000. Considering both vibratory (20 min) and impact piling (167 min), the total hours for monopile installation is ~3.1 h. For impact pile driving of pin piles, the strike rate was 30 strikes per minute and the total strike count is 2667. Considering both vibratory (90 min) and impact piling (89 min), the total hours for pin pile installation is ~3 h.

4.3. Exposure Estimates

Exposure estimates were calculated for marine mammals and sea turtles using each of the proposed construction schedules (see Section 1.2.2). Sections 4.3.1 and 4.3.2 include results for each species and metric, assuming 10 dB attenuation and a summer sound speed profile. See Appendix H.2.2 for full results, including all modeled attenuation levels and winter results.

For scenarios with vibratory pile driving, SEL injury exposures are calculated by summing the contributions from both impulsive and non-impulsive sources and using the lower impulsive threshold. Marine mammal behavioral exposures include any animats exposed above either the vibratory or impact pile driving thresholds. The behavioral exposures are estimated using both the NOAA (2005) and Wood et al. (2012) criteria (see Section 2.4.1.4 for further details). For construction schedules that include vibratory pile setting (Schedules 2 and 3), the behavioral threshold for NOAA (2005) for all species is 120 dB, which is lower than the Wood et al. (2012) behavioral thresholds. The Wood et al. (2012) behavioral thresholds at 120dB includes only a 50% response by sensitive odontocetes, a 10% response by migrating mysticete, and 0% response by all other species.

4.3.1. Marine Mammals

Table 25. Construction schedule 1 (monopile): Mean number of marine mammals predicted to receive sound levels above exposure criteria with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.2.

Species		Year 1 – Project 1				Year 2 – Project 2			
		Injury		Behavior		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]	L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	13.15	0.01	38.76	40.55	10.95	0.01	31.90	32.97
	Minke whale (migrating)	45.73	<0.01	168.58	567.39	45.01	<0.01	163.90	536.65
	Humpback whale	9.33	<0.01	28.37	28.67	9.70	<0.01	28.78	28.69
	North Atlantic right whale[c]	2.07	<0.01	8.80	8.74	2.19	<0.01	9.07	8.92
	Sei whale[c] (migrating)	1.30	<0.01	4.69	27.14	1.47	<0.01	5.18	29.01
MF	Atlantic white sided dolphin	0	0	520.75	164.08	0	0	550.05	173.57
	Atlantic spotted dolphin	0	0	22.71	7.16	0	0	26.05	8.01
	Common dolphin	0	0	6975.27	2207.95	0	0	6912.30	2165.84
	Bottlenose dolphin, offshore	0	0	267.39	93.69	0	0	249.70	87.15
	Risso's dolphin	0	0	36.45	10.70	0	0	31.93	9.39
	Long-finned pilot whale	0	0	34.61	10.95	0	0	32.86	10.42
	Short-finned pilot whale	0	0	26.09	8.14	0	0	24.65	7.69
	Sperm whale[c]	0	0	12.42	4.05	0	0	10.37	3.44
HF	Harbor porpoise (sensitive)	0	5.25	312.22	1618.93	0	5.41	304.34	1533.99
PW	Gray seal	0.03	<0.01	68.74	36.70	0.04	0.01	76.79	41.27
	Harbor seal	0.39	0.18	171.44	89.25	0.43	0.20	191.51	100.62
	Harp seal	0.10	<0.01	83.17	44.80	0.12	0.01	92.84	50.40

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

Table 26. Construction schedule 2 (monopile): Mean number of marine mammals predicted to receive sound levels above exposure criteria with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.2.

Species		Year 1 – Project 1				Year 2 – Project 2			
		Injury		Behavior		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]	L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	12.71	0.01	458.20	33.16	14.30	0.02	480.18	36.19
	Minke whale (migrating)	48.19	<0.01	892.16	502.02	49.58	<0.01	868.22	494.57
	Humpback whale	10.28	0.01	288.90	26.37	10.70	0.01	281.97	26.64
	North Atlantic right whale[c]	2.05	<0.01	99.91	7.19	2.27	<0.01	99.95	8.31
	Sei whale[c] (migrating)	1.41	<0.01	45.42	24.20	1.44	<0.01	41.91	24.53
MF	Atlantic white sided dolphin	0	0	3121.74	156.20	0	0	3044.96	163.98
	Atlantic spotted dolphin	0	0	314.61	7.66	0	0	319.59	8.17
	Common dolphin	0	0	39749.14	2045.32	0	0	41092.18	2244.35
	Bottlenose dolphin, offshore	0	0	2239.22	84.56	0	0	2341.10	92.16
	Risso's dolphin	0	0	1637.79	9.19	0	0	1759.84	10.40
	Long-finned pilot whale	0	0	345.90	10.00	0	0	353.79	10.92
	Short-finned pilot whale	0	0	270.46	7.29	0	0	280.24	7.91
	Sperm whale[c]	0	0	114.23	3.55	0	0	121.35	3.94
HF	Harbor porpoise (sensitive)	0	5.43	2325.99	1260.77	0	6.14	2381.32	1488.80
PW	Gray seal	0.05	0.01	2852.04	28.19	0.06	0.01	2732.53	35.92
	Harbor seal	0.28	0.13	5077.60	70.10	0.35	0.16	4902.30	87.41
	Harp seal	0.09	0.01	3444.19	34.94	0.11	0.01	3281.75	43.80

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

Table 27. Construction schedule 3 (jacket): Mean number of marine mammals predicted to receive sound levels above exposure criteria with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.2.

Species		Year 1 – Project 1				Year 2 – Project 2			
		Injury		Behavior		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]	L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	10.31	0	22.44	32.14	8.10	0.03	113.00	24.34
	Minke whale (migrating)	45.61	0	196.07	856.56	34.86	0	491.14	649.79
	Humpback whale	11.69	0	28.36	34.15	8.67	0	97.70	25.05
	North Atlantic right whale[c]	3.88	0	11.96	13.35	3.07	0	39.95	11.22
	Sei whale[c] (migrating)	2.29	0.01	6.11	57.29	1.69	<0.01	18.01	44.74
MF	Atlantic white sided dolphin	0	0	727.05	289.65	0	0	1647.54	226.65
	Atlantic spotted dolphin	0	0	24.35	10.91	0	0	74.62	8.80
	Common dolphin	0	0	8552.10	3422.27	0	0	20176.85	2507.74
	Bottlenose dolphin, offshore	0	0	303.48	137.32	0	0	829.54	102.19
	Risso's dolphin	0	0	29.05	14.08	0	0	135.72	10.62
	Long-finned pilot whale	0	0	39.75	17.18	0	0	112.19	13.01
	Short-finned pilot whale	0	0	29.91	12.58	0	0	82.78	9.50
	Sperm whale[c]	0	0	10.01	4.89	0	0	35.11	3.51
HF	Harbor porpoise (sensitive)	0	0.74	377.27	4223.20	0	0.84	1001.11	4087.78
PW	Gray seal	0.06	0	73.77	84.30	0.09	0	325.63	76.29
	Harbor seal	0	0.61	293.12	242.85	0	0.49	796.36	214.89
	Harp seal	0	0	140.93	126.41	0	0	460.30	112.02

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

4.3.1.1. Effect of Aversion

The mean exposure estimates reported in Section 4.3 do not consider animals avoiding loud sounds (aversion) or implementation of mitigation measures other than sound attenuation using NAS. Some marine mammals are well known for their aversive responses to anthropogenic sound (e.g., harbor porpoise), although it is assumed that most species will avert from noise. The Wood et al. (2012) step function includes a probability of response that is based primarily on observed aversive behavior in field studies. Additional exposure estimates with aversion based on the Wood et al. (2012) response probabilities were calculated for NARW and harbor porpoise in this study. For comparative purposes only, the results are shown with and without aversion (Table 28). Aversion was not applied to exposure estimates and only presented here for comparison.

Table 28. Construction schedule 1 (monopile), year 1: Mean number of marine mammals predicted to receive sound levels above exposure criteria with 10 dB attenuation and with and without aversion for aversive species. Construction schedule assumptions are summarized in Section 1.2.2.

Species	10 dB attenuation – no aversion				10 dB attenuation – with aversion			
	Injury		Behavior		Injury		Behavior	
	L_E	L_{pk}	L_p [a]	L_p [b]	L_E	L_{pk}	L_p [a]	L_p [b]
North Atlantic right whale[c]	2.07	<0.01	8.80	8.74	0.46	0	4.80	6.53
Harbor porpoise	0	5.25	312.22	1618.93	0	0	71.51	1256.60

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

4.3.2. Sea Turtles

As was done for marine mammals (see Section 4.3.1), the numbers of individual sea turtles predicted to receive sound levels above threshold criteria were determined using animal movement modeling. The construction schedules described in Section 1.2.2 were used to calculate the total number of real-world individual turtles predicted to receive sound levels above injury and behavior thresholds (Finneran et al. 2017) in the Lease Area. Tables 29–30 include results assuming broadband attenuation of 10 dB, calculated in the same way as the marine mammal exposures. See Appendix H.2.2 for more details on aversion.

Table 29. Construction schedule 1 (monopile): Mean number of sea turtles predicted to receive sound levels above exposure criteria (Finneran et al. 2017) with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Year 1 – Project 1			Year 2 – Project 2		
	Injury		Behavior	Injury		Behavior
	L_E	L_{pk}	L_p	L_{pk}	L_E	L_p
Kemp's ridley turtle[a]	<0.01	0	0.12	<0.01	0	0.11
Leatherback turtle[a]	2.03	0	5.69	1.97	0	5.71
Loggerhead turtle	0.10	0	3.83	0.12	0	4.03
Green turtle	<0.01	0	0.10	<0.01	0	0.10

[a] Listed as Endangered under the ESA.

Table 30. Construction schedule 2 (monopile): Mean number of sea turtles predicted to receive sound levels above exposure criteria (Finneran et al. 2017) with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Year 1 – Project 1			Year 2 – Project 2		
	Injury		Behavior	Injury		Behavior
	L_E	L_{pk}	L_p	L_{pk}	L_E	L_p
Kemp's ridley turtle[a]	<0.01	0	0.11	<0.01	0	0.12
Leatherback turtle[a]	2.15	0	5.61	2.31	0	6.25
Loggerhead turtle	0.16	0	3.94	0.19	0	4.29
Green turtle	<0.01	0	0.10	<0.01	0	0.11

[a] Listed as Endangered under the ESA.

Table 31. Construction schedule 3 (jacket): Mean number of sea turtles predicted to receive sound levels above exposure criteria (Finneran et al. 2017) with 10 dB attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Year 1 – Project 1			Year 2 – Project 2		
	Injury		Behavior	Injury		Behavior
	L_E	L_{PK}	L_p	L_{PK}	L_E	L_p
Kemp's ridley turtle[a]	<0.01	0	<0.01	<0.01	0	<0.01
Leatherback turtle[a]	0.59	0	1.77	0.40	0	1.25
Loggerhead turtle	0	0	3.45	0	0	2.60
Green turtle	<0.01	0	<0.01	<0.01	0	<0.01

[a] Listed as Endangered under the ESA.

4.4. Exposure Range Estimates

Exposure ranges, or ER95%, are the horizontal distances that include 95 % of the closest point of approach of animats exceeding a given impact threshold. These were calculated for marine mammals and sea turtles, and these results are summarized in Figure 24 for each of the foundation types and installation scenarios, assuming 10 dB attenuation and a summer sound speed profile. Sections 4.4.1 and 4.4.2 provide additional detail for each species and metric. For full results, including all modeled attenuation levels and both summer and winter sound speed profiles (see Appendix H.2.3).

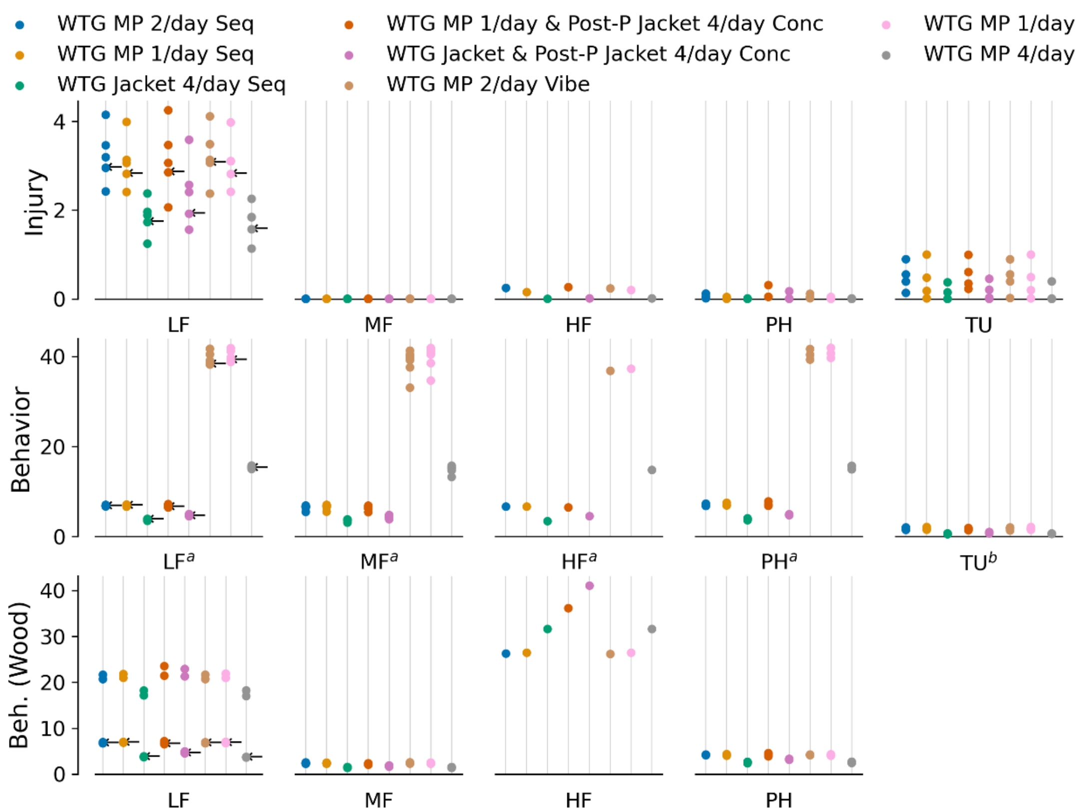

Figure 24. Maximum exposure ranges (ER95%) for injury and behavior thresholds, shown for each hearing group, assuming an attenuation of 10 dB and summer sound speed profile. Each dot represents a species within the indicated hearing group (LF = low frequency cetacean, MF = mid-frequency cetacean, HF = high frequency cetacean, PW = phocid pinniped in water, and TU = turtle), and dot color represents a combination of foundation type (Jacket or Monopile [MP]) and installation schedule (number of piles installed per day). Note the difference in y-axis scaling between the injury and behavior plots. Arrows indicate NARWs. Superscript a indicates that the NOAA (2005) behavioral thresholds for marine mammals were used, and superscript b indicates that the Finneran et al. (2017) behavioral threshold for turtles was used. “Pre-P” prefers to pre-piled jackets and “Post-P” refers to post-piled jackets.

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

4.4.1. Marine Mammals

The exposure ranges, $ER_{95\%}$, to injury and behavior thresholds are summarized for sequential impact pile driving (Section 4.4.1.1), concurrent impact pile driving (Section 4.4.1.2), and vibratory and impact pile driving (Section 4.4.1.3), assuming 10 dB broadband attenuation and a summer acoustic propagation environment. Additional configurations are provided in Appendix H.2.3. Single strike ranges to various isopleths from acoustic modeling can be found in Appendix G along with per pile SEL acoustic ranges to isopleths for the hearing groups assuming no movement of animals during pile driving.

4.4.1.1. Sequential Impact Pile Driving

Table 32. WTG monopile foundation (16 m diameter, summer, two piles per day[d]) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	4.15	<0.01	7.03	6.97
	Minke whale (migrating)	2.42	0	6.68	20.70
	Humpback whale	3.46	<0.01	6.79	6.75
	North Atlantic right whale[c]	2.95	<0.01	6.71	6.70
	Sei whale[c] (migrating)	3.19	<0.01	6.86	21.65
MF	Atlantic white sided dolphin	0	0	6.54	2.33
	Atlantic spotted dolphin	0	0	6.64	2.44
	Common dolphin	0	0	6.44	2.37
	Bottlenose dolphin, offshore	0	0	5.46	2.25
	Risso's dolphin	0	0	6.87	2.31
	Long-finned pilot whale	0	0	6.60	2.38
	Short-finned pilot whale	0	0	6.66	2.36
	Sperm whale[c]	0	0	6.75	2.56
HF	Harbor porpoise (sensitive)	0	0.25	6.67	26.28
PW	Gray seal	0.01	0.01	7.29	4.26
	Harbor seal	0.12	0	6.84	4.12
	Harp seal	0.05	0.01	6.79	4.19

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

Table 33. WTG monopile foundation (16 m diameter, summer, one pile per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	3.99	0	7.08	7.01
	Minke whale (migrating)	2.41	0	6.61	20.97
	Humpback whale	3.13	0	6.97	6.95
	North Atlantic right whale[c]	2.82	0	6.82	6.84
	Sei whale[c] (migrating)	3.06	<0.01	7.04	21.80
MF	Atlantic white sided dolphin	0	0	6.57	2.45
	Atlantic spotted dolphin	0	0	6.94	2.37
	Common dolphin	0	0	6.67	2.30
	Bottlenose dolphin, offshore	0	0	5.51	2.30
	Risso's dolphin	0	0	7.02	2.50
	Long-finned pilot whale	0	0	6.58	2.43
	Short-finned pilot whale	0	0	6.80	2.40
	Sperm whale[c]	0	0	6.93	2.27
HF	Harbor porpoise (sensitive)	0	0.15	6.67	26.44
PW	Gray seal	0	0	7.48	4.35
	Harbor seal	<0.01	0.01	6.91	4.02
	Harp seal	0.04	0	6.93	4.19

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

Table 34. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	2.37	0	3.92	3.88
	Minke whale (migrating)	1.24	0	3.47	17.14
	Humpback whale	1.88	0	3.77	3.73
	North Atlantic right whale[c]	1.73	0	3.73	3.70
	Sei whale[c] (migrating)	1.96	<0.01	3.85	18.21
MF	Atlantic white sided dolphin	0	0	3.55	1.44
	Atlantic spotted dolphin	0	0	3.80	1.37
	Common dolphin	0	0	3.63	1.52
	Bottlenose dolphin, offshore	0	0	3.08	1.38
	Risso's dolphin	0	0	3.68	1.53
	Long-finned pilot whale	0	0	3.66	1.53
	Short-finned pilot whale	0	0	3.68	1.50
	Sperm whale[c]	0	0	3.73	1.40
HF	Harbor porpoise (sensitive)	0	<0.01	3.47	31.63
PW	Gray seal	0	0	4.04	2.69
	Harbor seal	0	0.01	3.61	2.36
	Harp seal	0	0	3.88	2.62

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

Table 35. Post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
LF	Fin whale[c]	3.18	0	4.55	4.55
	Minke whale (migrating)	1.58	0	4.34	19.32
	Humpback whale	2.36	0	4.45	4.43
	North Atlantic right whale[c]	2.01	0	4.28	4.38
	Sei whale[c] (migrating)	2.59	<0.01	4.42	20.56
MF	Atlantic white sided dolphin	0	0	4.14	1.75
	Atlantic spotted dolphin	0	0	4.40	1.80
	Common dolphin	0	0	4.38	1.88
	Bottlenose dolphin, offshore	0	0	3.72	1.74
	Risso's dolphin	0	0	4.42	1.78
	Long-finned pilot whale	0	0	4.31	1.82
	Short-finned pilot whale	0	0	4.30	1.91
	Sperm whale[c]	0	0	4.34	1.81
HF	Harbor porpoise (sensitive)	0	0.06	4.31	35.96
PW	Gray seal	0.41	0	4.68	3.33
	Harbor seal	0	0.01	4.40	3.19
	Harp seal	0	0	4.47	3.20

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

There is not a significant difference in the exposure ranges for WTG monopile foundation (16 m diameter, summer) between 1 and 2 piles per day. Differences in exposure ranges to behavior effects criteria are likely associated with model run variations from animat randomness. The exposure ranges for injury for 2 piles per day are slightly larger than for one, but the difference is small. This small difference is attributed to the low occurrence of animats receiving important SEL from both activities.

4.4.1.2. Concurrent Impact Pile Driving

Table 36. WTG monopile foundation (16 m diameter, summer, one pile per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
	Fin whale[c]	4.25	0	7.19	7.18
	Minke whale (migrating)	2.06	<0.01	6.44	21.43
LF	Humpback whale	3.47	0	6.75	6.80
	North Atlantic right whale[c]	2.85	0	6.52	6.51
	Sei whale[c] (migrating)	3.06	<0.01	6.97	23.52
	Atlantic white sided dolphin	0	0	6.29	2.07
	Atlantic spotted dolphin	0	0	6.29	2.18
	Common dolphin	0	0	6.26	2.20
MF	Bottlenose dolphin, offshore	0	0	5.41	2.05
	Risso's dolphin	0	0	6.85	2.27
	Long-finned pilot whale	0	0	6.46	2.24
	Short-finned pilot whale	0	0	6.55	2.25
	Sperm whale[c]	0	0	6.60	2.37
HF	Harbor porpoise (sensitive)	0	0.27	6.50	36.18
	Gray seal	0.31	0	7.79	4.57
PW	Harbor seal	0.05	<0.01	6.81	3.88
	Harp seal	0.04	0	7.10	4.30

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

Table 37. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury		Behavior	
		L_E	L_{pk}	L_p [a]	L_p [b]
	Fin whale[c]	3.58	0	4.98	4.95
	Minke whale (migrating)	1.56	0	4.59	21.20
LF	Humpback whale	2.57	0	4.80	4.79
	North Atlantic right whale[c]	1.92	0	4.50	4.51
	Sei whale[c] (migrating)	2.41	<0.01	4.75	22.90
	Atlantic white sided dolphin	0	0	4.34	1.73
	Atlantic spotted dolphin	0	0	4.31	1.86
	Common dolphin	0	0	4.58	1.82
MF	Bottlenose dolphin, offshore	0	0	3.84	1.63
	Risso's dolphin	0	0	4.74	1.73
	Long-finned pilot whale	0	0	4.51	1.87
	Short-finned pilot whale	0	0	4.67	1.74
	Sperm whale[c]	0	0	4.75	1.85
HF	Harbor porpoise (sensitive)	0	0.01	4.57	41.07
	Gray seal	0.17	0	4.94	3.33
PW	Harbor seal	0	<0.01	4.73	3.13
	Harp seal	0	0	4.82	3.22

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

4.4.1.3. Vibratory and Impact

Table 38. WTG monopile foundation (16 m diameter, summer, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury			Behavior		
		Vibratory and Impact		Vibratory	Impact		Vibratory
		L_E	L_{pk}	L_E	L_p [a]	L_p [b]	L_p [a]
LF	Fin whale[c]	4.11	<0.01	0.08	7.00	6.95	41.69
	Minke whale (migrating)	2.37	0	0	6.69	20.70	38.49
	Humpback whale	3.49	<0.01	0.18	6.84	6.81	39.06
	North Atlantic right whale[c]	3.07	<0.01	0.13	6.72	6.71	38.20
	Sei whale[c] (migrating)	3.13	<0.01	0	6.87	21.65	40.46
MF	Atlantic white-sided dolphin	0	0	0	6.58	2.31	37.57
	Atlantic spotted dolphin	0	0	0	6.65	2.45	39.53
	Common dolphin	0	0	0	6.43	2.37	39.94
	Bottlenose dolphin	0	0	0	5.42	2.30	33.05
	Risso's dolphin	0	0	0	6.86	2.36	41.27
	Long-finned pilot whale	0	0	0	6.56	2.36	39.17
	Short-finned pilot whale	0	0	0	6.66	2.36	40.43
	Sperm whale[c]	0	0	0	6.81	2.57	40.27
HF	Harbor porpoise (sensitive)	0	0.24	0	6.59	26.23	36.86
PW	Gray seal	0.01	0.01	0	7.30	4.26	40.38
	Harbor seal	0.11	0	0	6.84	4.13	39.28
	Harp seal	0.05	0.01	0	6.81	4.18	41.64

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

Table 39. WTG monopile foundation (16 m diameter, summer, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury			Behavior		
		Vibratory and Impact		Vibratory	Impact		Vibratory
		L_E	L_{pk}	L_E	L_p [a]	L_p [b]	L_p [a]
LF	Fin whale[c]	3.98	0	0	7.06	7.02	41.83
	Minke whale (migrating)	2.41	0	0	6.65	20.96	38.77
	Humpback whale	3.10	0	0	6.96	6.90	39.71
	North Atlantic right whale[c]	2.81	0	0	6.77	6.76	39.14
	Sei whale[c] (migrating)	3.11	<0.01	0	7.01	21.88	41.15
MF	Atlantic white-sided dolphin	0	0	0	6.64	2.47	38.50
	Atlantic spotted dolphin	0	0	0	6.90	2.44	40.92
	Common dolphin	0	0	0	6.74	2.31	40.99
	Bottlenose dolphin	0	0	0	5.46	2.26	34.63
	Risso's dolphin	0	0	0	6.97	2.50	41.86
	Long-finned pilot whale	0	0	0	6.70	2.47	40.42
	Short-finned pilot whale	0	0	0	6.82	2.35	41.45
	Sperm whale[c]	0	0	0	6.83	2.29	40.64
HF	Harbor porpoise (sensitive)	0	0.20	0	6.68	26.46	37.31
PW	Gray seal	0	0	0	7.49	4.31	40.66
	Harbor seal	0.01	0.01	0	6.81	4.01	39.66
	Harp seal	0.04	0	0	7.02	4.15	41.89

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

Table 40. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with 10 dB attenuation.

Species		Injury			Behavior		
		Vibratory and Impact		Vibratory	Impact		Vibratory
		L_E	L_{pk}	L_E	L_p [a]	L_p [b]	L_p [a]
LF	Fin whale[c]	2.25	<0.01	0	3.90	3.75	15.75
	Minke whale (migrating)	1.13	0	0	3.53	17.00	14.99
	Humpback whale	1.84	0	0	3.74	3.71	15.47
	North Atlantic right whale[c]	1.57	0	0	3.67	3.62	15.21
	Sei whale[c] (migrating)	1.84	<0.01	0	3.85	18.23	15.43
MF	Atlantic white-sided dolphin	0	0	0	3.54	1.38	14.67
	Atlantic spotted dolphin	0	0	0	3.83	1.47	15.72
	Common dolphin	0	0	0	3.63	1.52	15.11
	Bottlenose dolphin	0	0	0	3.24	1.37	13.22
	Risso's dolphin	0	0	0	3.69	1.52	15.45
	Long-finned pilot whale	0	0	0	3.61	1.52	15.22
	Short-finned pilot whale	0	0	0	3.62	1.46	15.18
	Sperm whale[c]	0	0	0	3.72	1.47	15.27
HF	Harbor porpoise (sensitive)	0	0.02	0	3.62	31.62	14.85
PW	Gray seal	0	0	0	4.02	2.70	15.68
	Harbor seal	0	0.01	0	3.68	2.42	14.91
	Harp seal	0	0	0	3.89	2.50	15.67

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

The exposure ranges using injury criteria for sequential (impact only piling) and the corresponding pile types using vibratory and impact piling are not significantly different, as is expected. Although the injury exposure ranges for vibratory and impact piling include the energy from vibratory piling that occurred immediately before, the amount of energy added by vibratory setting is small, as demonstrated by the "vibratory" only exposure range values. When comparing the exposure ranges using behavior criteria between sequential (impact only) and corresponding pile types using vibratory and impact piling, the values are similar and differences are likely due to differences in the hammering schedule (Section 1.2.1) of the impact hammer following vibratory piling versus the impact only hammer. There are large differences in the exposure ranges for behavior criteria between impact piling and vibratory piling activities.

4.4.2. Sea Turtles

Similar to the results presented for marine mammals (Section 4.3), the exposure ranges ($ER_{95\%}$) for sea turtles are summarized in Sections 4.4.2.1 through 4.4.2.3 for monopile and jacket foundations, assuming 10 dB broadband attenuation and a summer acoustic propagation environment. Additional configurations are provided in Appendix H.2.3. Single strike ranges to various isopleths from acoustic modeling can be found in Appendix G, along with per pile SEL distances to isopleths for the hearing groups assuming no movement of animals during pile driving.

4.4.2.1. Sequential Impact Pile Driving

Table 41. WTG monopile foundation (16 m diameter, summer, two piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0.39	0	1.70
Leatherback turtle[a]	0.89	0	2.01
Loggerhead turtle	0.13	0	1.46
Green turtle	0.55	0	1.95

[a] Listed as Endangered under the ESA.

Table 42. WTG monopile foundation (16 m diameter, summer, one pile per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0.18	0	1.78
Leatherback turtle[a]	1.00	0	2.11
Loggerhead turtle	0.01	0	1.50
Green turtle	0.48	0	1.70

[a] Listed as Endangered under the ESA.

Table 43. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0	0	0.61
Leatherback turtle[a]	0.37	0	0.65
Loggerhead turtle	0	0	0.50
Green turtle	0.15	0	0.68

[a] Listed as Endangered under the ESA.

Table 44. Post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0.13	0	0.86
Leatherback turtle[a]	0.57	0	0.99
Loggerhead turtle	0	0	0.86
Green turtle	0.15	0	0.87

[a] Listed as Endangered under the ESA.

4.4.2.2. Concurrent Impact Pile Driving

Table 45. WTG monopile foundation (16 m diameter, summer, one pile per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0.35	0	1.68
Leatherback turtle[a]	0.99	0	1.66
Loggerhead turtle	0.22	0	1.39
Green turtle	0.60	0	1.89

[a] Listed as Endangered under the ESA.

Table 46. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury		Behavior
	L_E	L_{pk}	L_p
Kemp's ridley turtle[a]	0.03	0	0.78
Leatherback turtle[a]	0.45	0	0.99
Loggerhead turtle	0	0	0.70
Green turtle	0.20	0	0.78

[a] Listed as Endangered under the ESA.

4.4.2.3. Vibratory and Impact

Table 47. WTG monopile foundation (16 m diameter, summer, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury			Behavior
	Vibratory and Impact		Vibratory	Vibratory and Impact
	L_E	L_{pk}	L_E	L_p
Kemp's ridley turtle[a]	0.39	0	0	1.72
Leatherback turtle[a]	0.89	0	0	2.01
Loggerhead turtle	0.02	0	0	1.33
Green turtle	0.55	0	0	1.93

[a] Listed as Endangered under the ESA.

Table 48. WTG monopile foundation (16 m diameter, summer, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury			Behavior
	Vibratory and Impact		Vibratory	Vibratory and Impact
	L_E	L_{pk}	L_E	L_p
Kemp's ridley turtle[a]	0.20	0	0	1.75
Leatherback turtle[a]	1.00	0	0	2.11
Loggerhead turtle	0.01	0	0	1.48
Green turtle	0.49	0	0	1.70

[a] Listed as Endangered under the ESA.

Table 49. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with 10 dB attenuation.

Species	Injury			Behavior
	Vibratory and Impact		Vibratory	Vibratory and Impact
	L_E	L_{pk}	L_E	L_p
Kemp's ridley turtle[a]	0	0	0	0.63
Leatherback turtle[a]	0.39	0	0	0.65
Loggerhead turtle	0	0	0	0.56
Green turtle	<0.01	0	0	0.64

[a] Listed as Endangered under the ESA.

4.5. Fish Acoustic Range Estimates

Although some fish may move during pile driving, they were considered static receivers and acoustic distances where sound levels could exceed fish regulatory thresholds were determined using a maximum-over-depth approach and finding the distance that encompasses at least 95 % of the horizontal area that would be exposed to sound at or above the specified level (see Appendix F.3). The calculated acoustic distances for fish to the GARFO (2020) and Popper et al. (2014) thresholds (Andersson et al. 2007, Wysocki et al. 2007, FHWG 2008, Stadler and Woodbury 2009, Mueller-Blenkle et al. 2010, Purser and Radford 2011, Popper et al. 2014) with 10 dB of broadband attenuation are shown in Tables 50–53 (tables with 0, 6, and 15 dB attenuation can be found in Appendix G).

Table 50. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L01 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			6600 (a)	6600 (b)	6600 (c)	6600 (a)	6600 (b)	6600 (c)
Fish ≥ 2 g	L_E[a]	187	8.50			9.68		
	L_{pk}[a]	206	0.14	0.14	0.15	0.14	0.15	0.16
	L_p[b]	150	12.41	13.86	12.87	16.17	17.22	14.72
Fish < 2 g	L_p[b]	183	10.99			13.19		
	L_{pk}[a]	206	0.14	0.14	0.15	0.14	0.15	0.16
	L_p[b]	150	12.41	13.86	12.87	16.17	17.22	14.72
Fish without swim bladder	L_E[c]	216	0.42			0.42		
	L_E[c]	213	0.03	0.02	0.06	0.03	0.02	0.03
Fish with swim bladder not involved in hearing	L_E[c]	203	2.45			2.54		
	L_{pk}[c]	207	0.13	0.13	0.14	0.13	0.13	0.14
Fish with swim bladder involved in hearing	L_E[c]	203	2.45			2.54		
	L_{pk}[c]	207	0.13	0.13	0.14	0.13	0.13	0.14
Sea turtles	L_E[d]	204	2.19			2.27		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	1.93	1.92	2.08	1.99	2.00	2.13

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).

A dash indicates that distances could not be calculated because thresholds were not reached.

[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).

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

[c] Popper et al. (2014).

[d] Finneran et al. (2017).

[e] McCauley et al. (2000b).

Table 51. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L02 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			6600 (a)	6600 (b)	6600 (c)	6600 (a)	6600 (b)	6600 (c)
Fish ≥ 2 g	L_E[a]	187	6.51			7.69		
	L_{pk}[a]	206	0.11	0.11	0.11	0.11	0.11	0.11
	L_p[b]	150	8.38	9.69	10.37	11.11	12.35	12.99
Fish < 2 g	L_p[b]	183	8.26			10.10		
	L_{pk}[a]	206	0.11	0.11	0.11	0.11	0.11	0.11
	L_p[b]	150	8.38	9.69	10.37	11.11	12.35	12.99
Fish without swim bladder	L_E[c]	216	0.34			0.35		
	L_E[c]	213	0.04	0.04	0.05	0.04	0.04	0.05
Fish with swim bladder not involved in hearing	L_E[c]	203	1.90			2.00		
	L_{pk}[c]	207	0.10	0.09	0.10	0.10	0.09	0.10
Fish with swim bladder involved in hearing	L_E[c]	203	1.90			2.00		
	L_{pk}[c]	207	0.10	0.09	0.10	0.10	0.09	0.10
Sea turtles	L_E[d]	204	1.75			1.82		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	1.44	1.61	1.78	1.50	1.68	1.83

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).
A dash indicates that distances could not be calculated because thresholds were not reached.
[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
[b] Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007).
[c] Popper et al. (2014).
[d] Finneran et al. (2017).
[e] McCauley et al. (2000b).

Table 52: Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L01 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			3500 (a)	3500 (b)	3500 (c)	3500 (a)	3500 (b)	3500 (c)
Fish ≥ 2 g	L_E[a]	187	7.34			8.21		
	L_{pk}[a]	206	0.10	0.06	0.03	0.10	0.06	0.03
	L_p[b]	150	9.23	10.99	8.05	11.40	13.02	8.94
Fish < 2 g	L_p[b]	183	9.63			11.78		
	L_{pk}[a]	206	0.10	0.06	0.03	0.10	0.06	0.03
	L_p[b]	150	9.23	10.99	8.05	11.40	13.02	8.94
Fish without swim bladder	L_E[c]	216	0.16			0.17		
	L_E[c]	213	-	-	-	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.48			1.48		
	L_{pk}[c]	207	0.09	0.06	0.03	0.09	0.06	0.03
Fish with swim bladder involved in hearing	L_E[c]	203	1.48			1.48		
	L_{pk}[c]	207	0.09	0.06	0.03	0.09	0.06	0.03
Sea turtles	L_E[d]	204	1.30			1.30		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	0.95	0.72	0.44	0.97	0.73	0.44

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).

A dash indicates that distances could not be calculated because thresholds were not reached.

[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).

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

[c] Popper et al. (2014).

[d] Finneran et al. (2017).

[e] McCauley et al. (2000b).

Table 53. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L02 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			3500 (a)	3500 (b)	3500 (c)	3500 (a)	3500 (b)	3500 (c)
Fish ≥ 2 g	L_E[a]	187	5.48			6.30		
	L_{pk}[a]	206	0.09	0.06	-	0.10	0.06	-
	L_p[b]	150	7.27	8.34	3.37	8.54	11.07	3.26
Fish < 2 g	L_p[b]	183	7.17			8.74		
	L_{pk}[a]	206	0.09	0.06	-	0.10	0.06	-
	L_p[b]	150	7.27	8.34	3.37	8.54	11.07	3.26
Fish without swim bladder	L_E[c]	216	0.18			0.18		
	L_E[c]	213	-	-	-	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.32			1.38		
	L_{pk}[c]	207	0.09	0.06	-	0.09	0.06	-
Fish with swim bladder involved in hearing	L_E[c]	203	1.32			1.38		
	L_{pk}[c]	207	0.09	0.06	-	0.09	0.06	-
Sea turtles	L_E[d]	204	1.18			1.22		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	0.96	0.72	0.20	1.01	0.73	0.21

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).

A dash indicates that distances could not be calculated because thresholds were not reached.

[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).

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

[c] Popper et al. (2014).

[d] Finneran et al. (2017).

[e] McCauley et al. (2000b).

Table 54. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L01 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			3500 (a)	3500 (b)	3500 (c)	3500 (a)	3500 (b)	3500 (c)
Fish ≥ 2 g	L_E[a]	187	6.31			6.83		
	L_{pk}[a]	206	0.08	0.05	0.02	0.08	0.05	0.02
	L_p[b]	150	8.25	9.28	6.81	9.59	10.79	7.41
Fish < 2 g	L_p[b]	183	8.50			9.63		
	L_{pk}[a]	206	0.08	0.05	0.02	0.08	0.05	0.02
	L_p[b]	150	8.25	9.28	6.81	9.59	10.79	7.41
Fish without swim bladder	L_E[c]	216	0.13			0.13		
	L_E[c]	213	-	-	-	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.11			1.12		
	L_{pk}[c]	207	0.06	0.04	-	0.06	0.04	-
Fish with swim bladder involved in hearing	L_E[c]	203	1.11			1.12		
	L_{pk}[c]	207	0.06	0.04	-	0.06	0.04	-
Sea turtles	L_E[d]	204	0.92			0.93		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	0.73	0.48	0.26	0.74	0.48	0.26

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).
A dash indicates that distances could not be calculated because thresholds were not reached.
[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
[b] Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007).
[c] Popper et al. (2014).
[d] Finneran et al. (2017).
[e] McCauley et al. (2000b).

Table 55. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer and winter at location L02 for different energy levels with 10 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)					
			Summer			Winter		
			3500 (a)	3500 (b)	3500 (c)	3500 (a)	3500 (b)	3500 (c)
Fish ≥ 2 g	L_E[a]	187	4.77			5.36		
	L_{pk}[a]	206	0.08	0.05	-	0.09	0.05	-
	L_p[b]	150	6.38	7.34	2.78	7.44	9.11	2.71
Fish < 2 g	L_p[b]	183	6.26			7.48		
	L_{pk}[a]	206	0.08	0.05	-	0.09	0.05	-
	L_p[b]	150	6.38	7.34	2.78	7.44	9.11	2.71
Fish without swim bladder	L_E[c]	216	0.13			0.13		
	L_E[c]	213	-	-	-	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.06			1.09		
	L_{pk}[c]	207	0.07	0.04	-	0.07	0.04	-
Fish with swim bladder involved in hearing	L_E[c]	203	1.06			1.09		
	L_{pk}[c]	207	0.07	0.04	-	0.07	0.04	-
Sea turtles	L_E[d]	204	0.91			0.93		
	L_{pk}[d]	232	-	-	-	-	-	-
	L_p[e]	175	0.72	0.53	0.14	0.76	0.52	0.13

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); L_E = sound exposure level (dB re 1 µPa^2·s); L_p = unweighted sound pressure (dB re 1 µPa).

A dash indicates that distances could not be calculated because thresholds were not reached.

[a] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).

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

[c] Popper et al. (2014).

[d] Finneran et al. (2017).

[e] McCauley et al. (2000b).

5. Summary

Sounds fields produced during impact pile driving for installation of 16 m monopile foundations and 4.5 m jacket foundations were found by modeling the vibration of the pile when struck with a hammer, determining a far-field representation of the pile as a sound source, and then propagating the sound from the apparent source into the environment.

Sound fields were sampled by simulating animal movement within the sound fields and determining if the levels experienced by simulated marine mammal and sea turtle animats (simulated animals) exceed regulatory thresholds. The number of animals predicted to experience levels exceeding injury or behavioral thresholds are provided in Section 4.3 and Appendix H.2.2. For those animats, the closest point of approach to the source was found and the distance accounting for 95 % of exceedances was reported as the exposure range, $ER_{95\%}$. The species-specific $ER_{95\%}$ (see tables in Section 4.4 and Appendix H.2.3) were determined with different broadband attenuation levels (0, 6, 10, and 15 dB) to account for the use of noise reduction systems, such as bubble curtains. $ER_{95\%}$ can be used for mitigation purposes, such as establishing monitoring or exclusion areas. Fish were considered as static receivers, so exposure ranges were not calculated. Instead, the acoustic distance to their regulatory thresholds were determined and reported, with the different broadband attenuation levels (see tables in Section 4.5).

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Appendix A. Glossary

1/3-octave

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

1/3-octave-band

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

absorption

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

attenuation

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

auditory frequency weighting (auditory weighting function, frequency-weighting function)

The process of band-pass filtering sounds to reduce the importance of inaudible or less-audible frequencies for individual species or groups of species of aquatic mammals (ISO 2017). One example is M-weighting introduced by Southall et al. (2007) to describe "Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds".

azimuth

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

bandwidth

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

bathymetry

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

broadband sound level

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

continuous sound

A sound whose sound pressure level remains above ambient sound during the observation period (ANSI and ASA S1.13-2005 (R2010)). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

compressional wave

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

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 2006).

decidecade

One tenth of a decade (ISO 2017). Note: An alternative name for decidecade (symbol ddec) is “one-tenth decade”. A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a “one-third octave”.

decidecade band

Frequency band whose bandwidth is one decidecade. Note: The bandwidth of a decidecade band increases with increasing center frequency.

decibel (dB)

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

frequency

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

geoacoustic

Relating to the acoustic properties of the seabed.

hertz (Hz)

A unit of frequency defined as one cycle per second.

impulsive sound

Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA and US Dept of Commerce 2013, ANSI S12.7-1986 (R2006)). For example, seismic airguns and impact pile driving.

octave

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

peak sound pressure level (L_{pk})

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

permanent threshold shift (PTS)

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

point source

A source that radiates sound as if from a single point (ANSI S1.1-1994 (R2004)).

pressure, acoustic

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

pressure, hydrostatic

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

propagation loss

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

received level

The sound level measured at a receiver.

rms

root-mean-square.

rms sound pressure level (L_p)

The root-mean-square average of the instantaneous sound pressure as measured over some specified time interval. For continuous sound, the time interval is one second. See also sound pressure level (L_p) and 90% rms SPL.

shear wave

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

signature

Pressure signal generated by a source.

sound

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

sound exposure

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

sound exposure level (SEL)

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

sound field

Region containing sound waves (ANSI S1.1-1994 (R2004)).

sound pressure level (SPL)

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

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa^2:

$$L_p = 10\log_{10}(p^2/p_0^2) = 20\log_{10}(p/p_0)$$

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

sound speed profile

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

source level (SL)

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

temporary threshold shift (TTS)

Temporary loss of hearing sensitivity caused by excessive noise exposure.

Appendix B. Summary of Acoustic Assessment Assumption

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

SouthCoast Wind is expected to construct WTG monopile foundations consisting of single tapered piles. For monopile foundation models, piles are assumed to be vertical and driven to a maximum penetration depth of 35 m, while jacket piles are assumed to be driven to a penetration depth of 60 m. While pile penetrations across the Project will vary, these values were chosen as the maximum penetration depth. The estimated numbers of strikes required to install piles to completion were obtained from SouthCoast Wind in consultation with potential hammer suppliers. All acoustic evaluation was performed assuming that only one pile is driven at a time. Modeling input, assumptions, and methods are listed in Table B-1.

Table B-1. Details of model inputs, assumptions, and methods for the expected installation scenarios.

Parameter	Description
Monopile pile driving source model	
16 m monopile foundation	
Modeling method	Finite-difference structural model of pile vibration based on thin-shell theory; Hammer forcing functions computed using GRLWEAP
Vibratory hammer frequency	23.3 Hz
Number of clamps	32
Weight of individual clamps	65.7 kN
Time of vibratory installation	20 min
Impact hammer energy	6600 kJ
Ram weight	3257.6 kN
Helmet weight	4400 kN
Strike rate (min^{-1})	30
Estimated number of strikes to drive pile	7000
Expected maximum penetration	5 m
Modeled seabed penetration per energy level	10, 10, and 15 m
Pile length	105 m
Pile diameter	Tapered 9 to 16 m
Pile wall thickness	110 mm (top) and 166 mm (bottom)
Shaft resistance	44, 61, and 74% (for each penetration step – a, b, c)
4.5 m jacket foundation	
Modeling method	Finite-difference structural model of pile vibration based on thin-shell theory; Hammer forcing functions computed using GRLWEAP
Vibratory hammer frequency	23.3 Hz
Number of clamps	4
Weight of individual clamps	53.39 kN
Time of vibratory installation	90 minutes

Impact hammer energy	3500 kJ
Ram weight	1718.947 kN
Helmet weight	1830 kN
Strike rate (min^{-1})	30
Estimated number of strikes to drive pile	4000
Expected maximum penetration	60 m
Modeled seabed penetration per energy level	20, 20, and 20 m
Pile length	63 m
Pile diameter	4.5 m
Pile wall thickness	50 mm
Shaft resistance	66, 80, and 86% (for each penetration depth)
Environmental parameters for all pile types	
Sound speed profile	GDEM data averaged over region
Bathymetry	SRTM 15 data
Geoacoustics	Elastic seabed properties based on client-supplied description of seabed layering
Quake (shaft and toe)	2.54 mm
Shaft damping	0.164 s/m
Toe damping	0.49 s/m
Propagation model for all pile types	
Modeling method	FWRAM full-waveform parabolic equation propagation model with 22.5° azimuthal resolution
Source representation	Vertical line array
Frequency range	10–32,000 Hz
Synthetic trace length	Monopiles: 1000 ms (12.5 m pile), 1500 ms (16 m pile) Jacket: 1500 ms
Maximum modeled range	90 km

Appendix C. Underwater Acoustics

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

C.1. Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa in water and p_0 = 20 μPa in air. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow ISO standard definitions and symbols for sound metrics (e.g., ISO 2017).

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

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

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

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

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

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

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

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying L_p function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted L_p ($L_{p,\text{fast}}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,\text{boxcar 125ms}}$. Another approach, historically used to evaluate L_p of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5 % and 95 % of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90 % SPL ($L_{p,90\%}$).

The sound exposure level (SEL or L_E; dB re 1 µPa^2·s) is the time-integral of the squared acoustic pressure over a duration (T):

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

where T_0 is a reference time interval of 1 s. L_E continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered in terms of relevance for impact to the exposed recipients.

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

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

C.2. Decidecade Band Analysis

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

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

$$f_c(i) = 10^{\frac{i}{10}}\ \text{kHz} \tag{C-6}$$

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

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_{\mathrm{c}}(i) \quad \text{and} \quad f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_{\mathrm{c}}(i) \tag{C-7}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure C-1). The acoustic modeling spans from band –24 ($f_{\mathrm{c}}(-24)$ = –4 kHz) to band 14 ($f_{\mathrm{c}}(14)$ = 25 kHz).

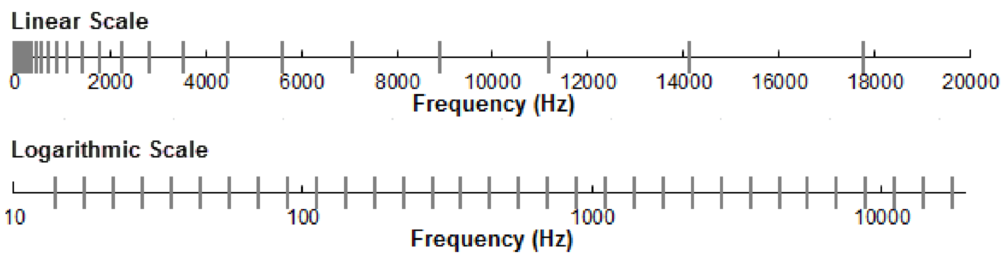

Figure C-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

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

$$L_{p,i} = 10 \log_{10} \int_{f_{\mathrm{lo},i}}^{f_{\mathrm{hi},i}} S(f)\, df \tag{C-8}$$

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

$$\text{Broadband SPL} = 10 \log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}} \tag{C-9}$$

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

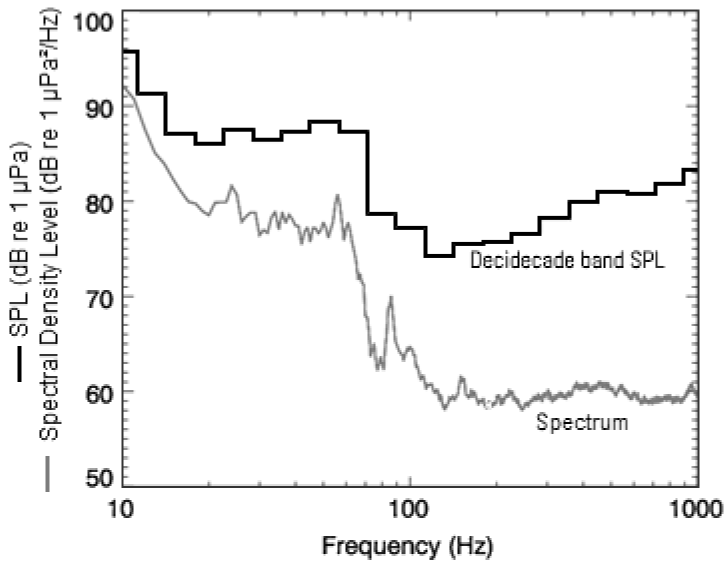

Figure C-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum.

Appendix D. Auditory (Frequency) Weighting Functions

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

D.1. Frequency Weighting Functions-Technical Guidance (NMFS 2018)

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. This frequency-weighting function is expressed as:

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

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2018). Table D-1 lists the frequency-weighting parameters for each hearing group; Figure D-1 shows the resulting frequency-weighting curves.

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

Table D-1. Parameters for the auditory weighting functions recommended by NMFS (2018).

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

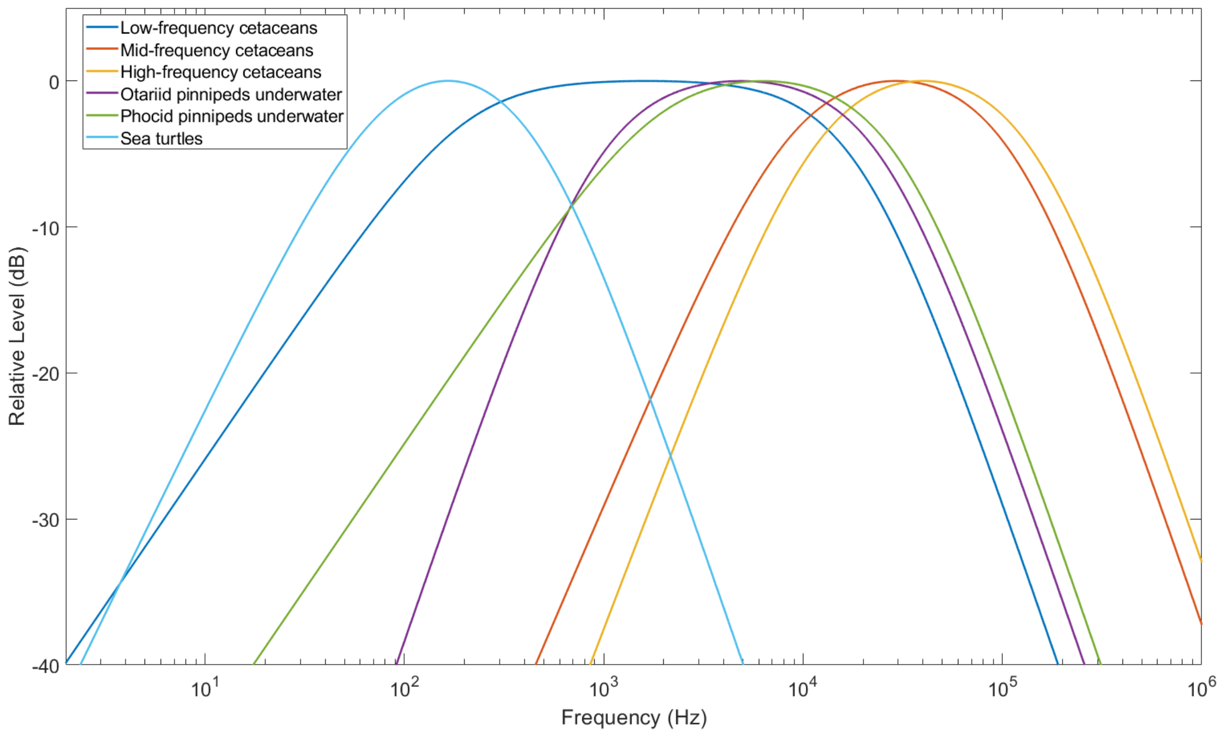

Figure D-1. Auditory weighting functions for the functional marine mammal hearing groups as recommended by NMFS (2018).

D.2. Southall et al. (2007) Frequency Weighting Functions

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

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

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

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

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

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

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

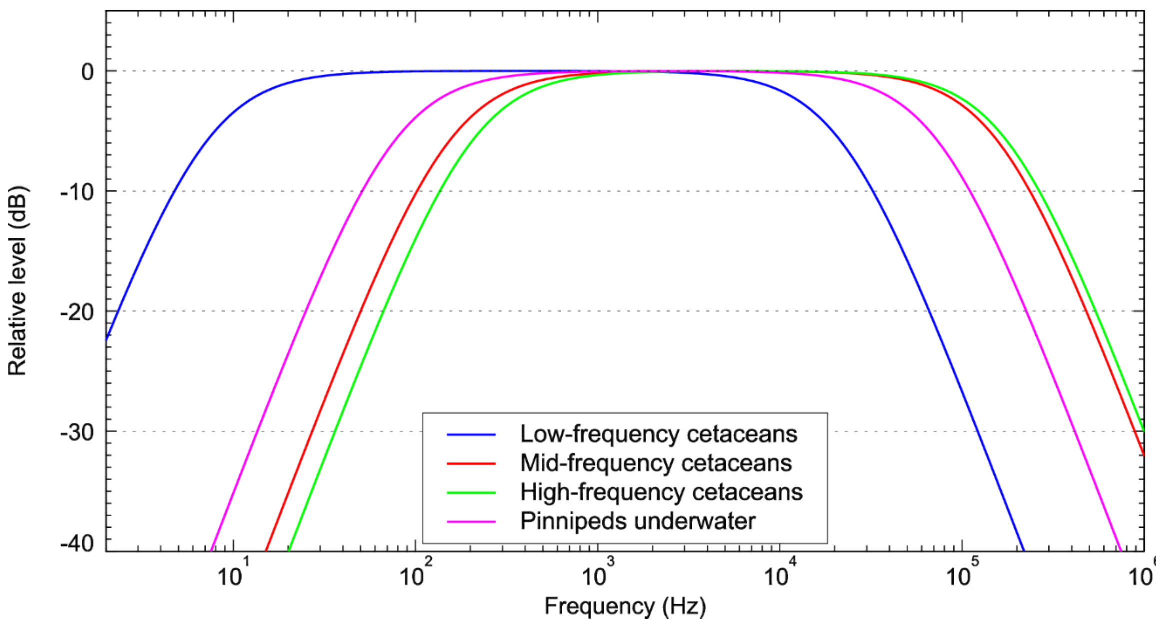

Figure D-2. Auditory weighting functions for the functional marine mammal hearing groups as recommended by Southall et al. (2007).These frequency-weighting functions are used in the application of the SPL metrics proposed by Wood et al. (2012).

Appendix E. Pile Driving Source Model (PDSM)

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

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

The sound radiating from the pile itself is simulated using a vertical array of discrete point sources. The point sources are centered on the pile axis. Their amplitudes and phases are derived using an inverse technique, such that their collective particle velocity, calculated using a near-field wave-number integration model, matches the particle velocity in the water at the pile wall. The sound field propagating away from the vertical source array is then calculated using a full-wave acoustic propagation model from which time-domain waveforms may be calculated (see Appendix F.2). MacGillivray (2014) describes the theory behind the physical model in more detail.

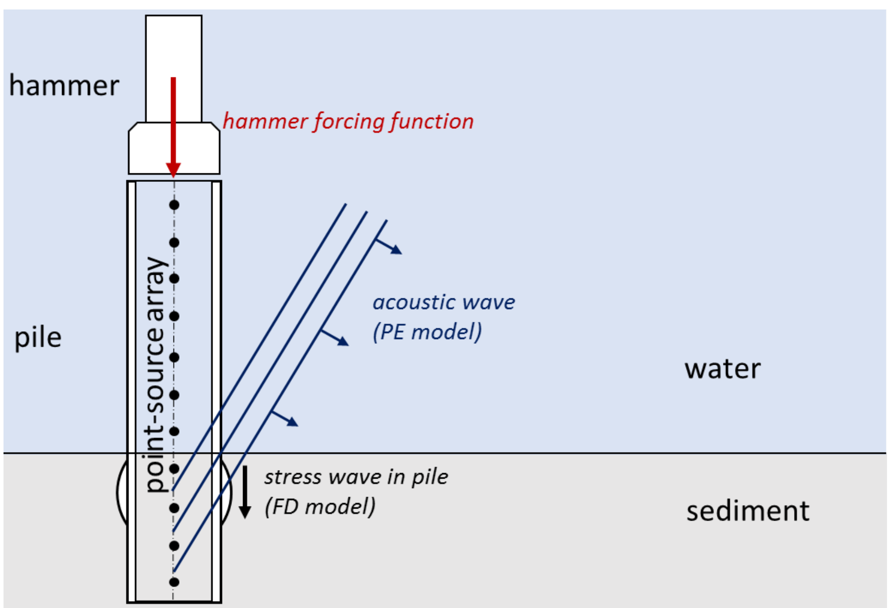

Figure E-1. Physical model geometry for impact driving of a cylindrical pile (vertical cross-section). The hammer forcing function is used with the finite difference (FD) model to compute the stress wave vibration in the pile. A vertical array of point sources is used with the parabolic equation (PE)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

Appendix F. Sound Propagation Modeling

F.1. Environmental Parameters

F.1.1. Bathymetry

A bathymetry grid for the acoustic propagation model was compiled based on the Shuttle Radar Topography Mission (SRTM) data referred to as SRTM-TOPO15+ (Becker et al. 2009).

F.1.2. Geoacoustics

In shallow water environments where there is increased interaction with the seafloor, the properties of the substrate have a large influence over the sound propagation. A simplified geoacoustic profile was developed from site-specific seabed layering information provided by SouthCoast Wind. The dominant soil type in the area is expected to be sand. Tables F-1 shows the sediment layer geoacoustic property profile based on the sediment type and generic porosity-depth profile using a sediment grain-shearing model (NGI 2021, Buckingham 2005).

Table F-1. Location AY40: Estimated geoacoustic properties used for modeling, as a function of depth. Within an indicated depth range, the parameters vary linearly.

Depth below seafloor (m)	Material	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–21	Medium sand	2.09	1770.1–1774.4	0.88–0.879	300.0	3.65
21–23		2.09–2.095	1774.4–1778.8	0.879–0.878		
23–38.5		2.095–2.099	1778.8–1783.1	0.878–0.877		
38.5–42		2.099–2.152	1783.1–1833.5	0.877–0.865		
42–72		2.152–2.216	1833.5–1893.3	0.865–0.848		
72–200		2.216–2.337	1893.3–2003.3	0.848–0.807		
200–350		2.337–2.634	2003.3–2268.9	0.807–0.664		

F.1.3. Sound Speed Profile

The speed of sound in sea water is a function of temperature, salinity, and pressure (depth) (Coppens 1981). Sound speed profiles were obtained from the US Navy's Generalized Digital Environmental Model (GDEM; NAVO 2003). Two representative seasons were modeled for this Project, summer and winter, since these represent two distinct acoustic propagation regimes. Considering the average sound speed in the area around the proposed construction site and the deep waters beyond the Lease Area, the shape of the sound speed profiles is consistent within seasons. The summer average was based on the profiles for June, July, and August. The winter average was based on the January, February, and March profiles.

Project-level exposure estimates used sound fields based on the summer average sound speed profile from April through November, and sound fields based on the winter average sound speed profile from December through March.

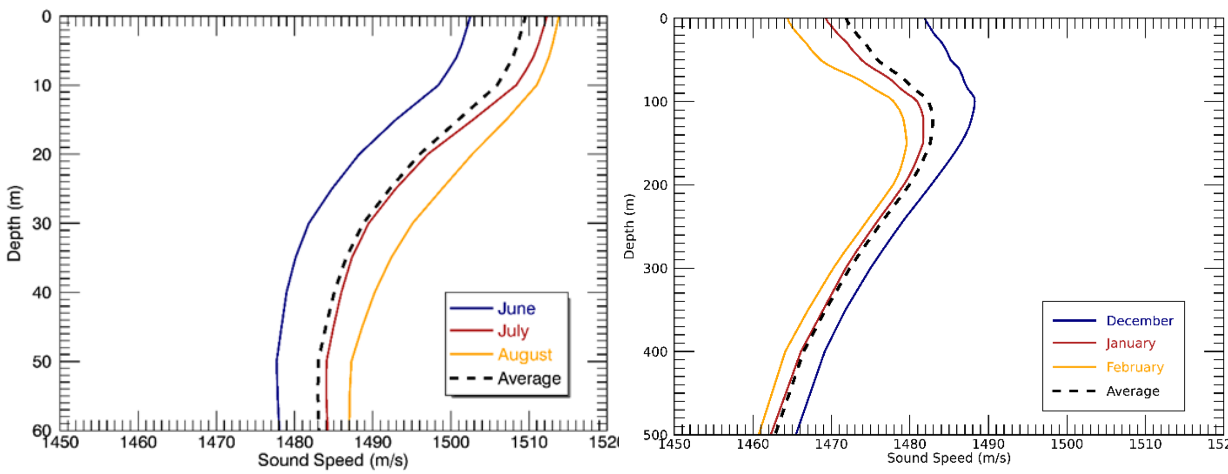

Figure F-1. Sound speed profiles up to 100 m for (left) summer and (right) winter. Seasonal averages and monthly profiles used in each of the seasonal averages are displayed.

F.2. Sound Propagation with FWRAM

For impulsive sounds from impact pile driving as well as non-impulsive sounds from vibratory piling, time-domain representations of the pressure waves generated in the water are required for calculating SPL and peak pressure level. Furthermore, the pile must be represented as a distributed source to accurately characterize vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using JASCO's FWRAM, a full-wave acoustic propagation model based on the wide-angle parabolic equation (PE) algorithm (Collins 1993). FWRAM computes pressure waveforms as a function of range and depth via Fourier synthesis of transfer functions in closely spaced frequency bands in range-varying marine acoustic environments. FWRAM employs an array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Synthetic pressure waveforms were modeled over the frequency range of 10–1024 Hz , inside a 1 s window (e.g., Figure F-2). The synthetic pressure waveforms were post-processed, after applying a travel time correction, to calculate standard SPL and SEL metrics versus range and depth from the source. The acoustic field is extended to higher frequencies (up to 32,000 Hz) by applying a 20 dB/decade decay rate to match acoustic measurements of impact pile driving (Illingworth & Rodkin 2007, Matuschek and Betke

2009). The same decay rate is used for vibratory pile driving due to the lack of publicly available data from acoustic measurements made from vibratory piling of large piles.

Acoustic fields in three dimensions are generated by modeling propagation loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as *N*×2-D (Figure F-3). These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ planes.

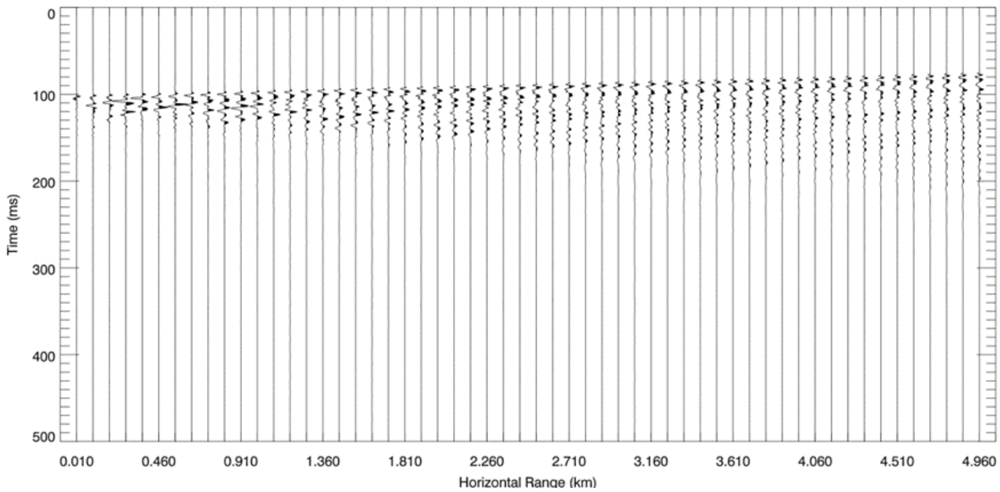

Figure F-2. Example of synthetic pressure waveforms computed by FWRAM at multiple range offsets. Receiver depth is 35 m and the amplitudes of the pressure traces have been normalised for display purposes.

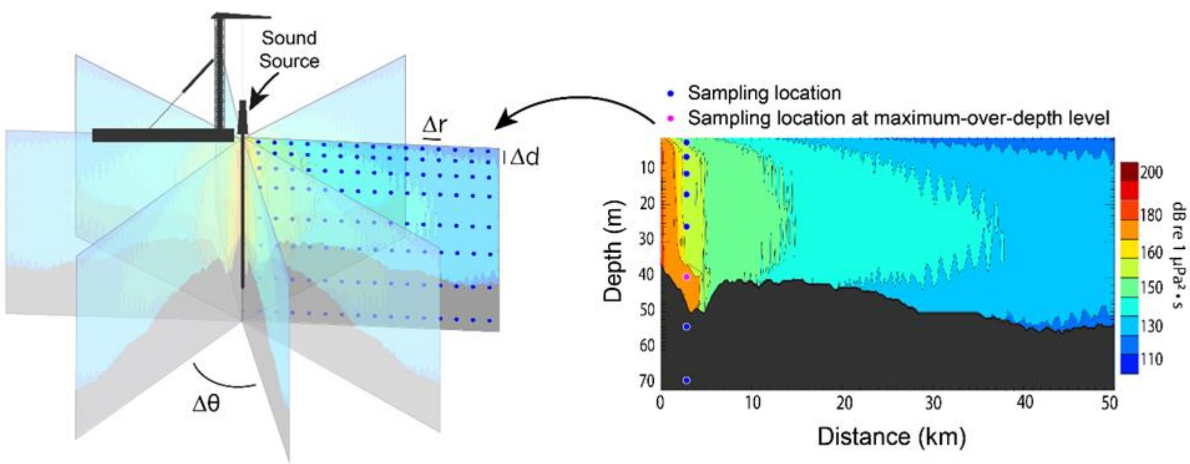

Figure F-3. Modeled three-dimensional sound field (*N*×2-D method) and maximum-over-depth modeling approach. Sampling locations are shown as blue dots on both figures. On the right panel, the pink dot represents the sampling location where the sound level is maximum over the water column. This maximum-over-depth level is used in calculating distances to sound level thresholds for some marine animals.

F.3. Estimating Acoustic Distance to Threshold Levels

A maximum-over depth approach is used to determine acoustic distances to the defined thresholds (distances to isopleths). That is, at each horizontal sampling distance, the maximum received level that occurs within the water column is used as the value at that distance. The distances to a threshold typically differ along different radii and may not be continuous because sound levels may drop below threshold at some distances and then exceed threshold at farther distances. Figure F-4 shows an example of an area with sound levels above threshold and two methods of reporting the injury or behavioral disruption distance: (1) R_{max}, the maximum distance at which the sound level was encountered in the modeled maximum-over-depth sound field, and (2) $R_{95\%}$, the maximum distance at which the sound level was encountered after the 5 % farthest such points were excluded. $R_{95\%}$ is used because, regardless of the shape of the maximum-over-depth footprint, the predicted distance encompasses at least 95 % of the horizontal area that would be exposed to sound at or above the specified level. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the heterogeneity of the acoustic environment. $R_{95\%}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonification zone.

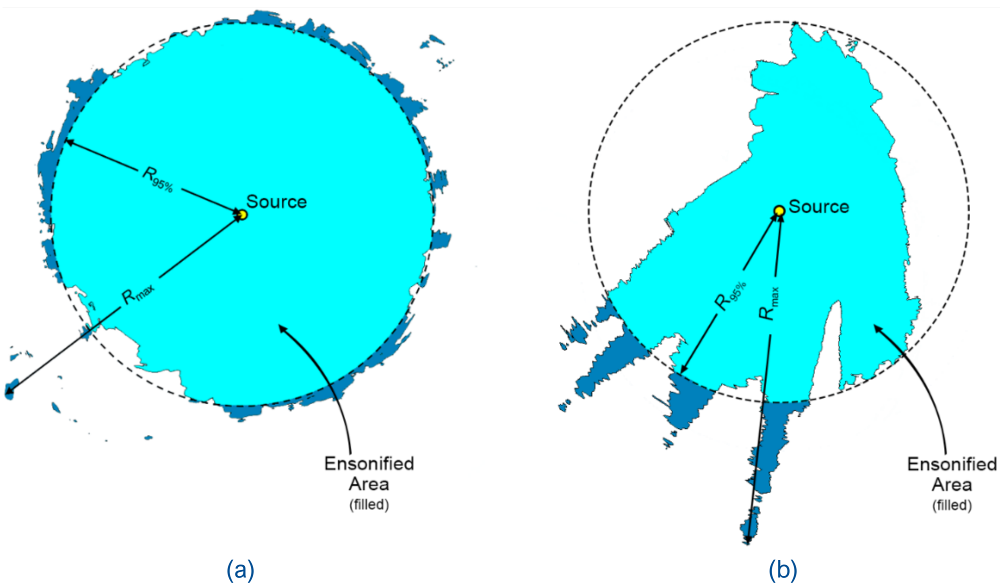

Figure F-4. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ distances shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

F.4. Model Validation

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

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

Appendix G. Acoustic Range Results

The following subsections contain decidecade band and broadband levels at 750 m from the source, tables of acoustic ranges (R_{max} and $R_{95\%}$ in km) to marine mammal (NMFS 2018), sea turtle (Finneran et al. 2017), and fish (FHWG 2008, Stadler and Woodbury 2009, Popper et al. 2014) injury thresholds. The acoustic ranges to behavioral thresholds for marine mammals (NOAA 2005, Wood et al. 2012), sea turtles (McCauley et al. 2000b), and fish (Andersson et al. 2007, Wysocki et al. 2007, Mueller-Blenkle et al. 2010, Purser and Radford 2011) are also included. The acoustic ranges are shown for the following categories: Flat is unweighted, LF is low-frequency cetaceans, MF is mid-frequency cetaceans, HF is high-frequency cetaceans, PPW is phocid pinnipeds in water, and TUW is turtles in water. TUW weighting functions are from the US Navy (Finneran et al. 2017). The rest are from the Technical Guidance (NMFS 2018). R_{max} is the maximum distance at which the sound level was encountered in the modeled maximum-over-depth sound field. $R_{95\%}$ is the maximum distance at which the sound level was encountered after the 5% farthest such points were excluded (Appendix F). The results for the OSP jacket foundation assume a 2 dB post-piling shift.

G.1. Received Levels at 750 m

G.1.1. Impact Pile Driving

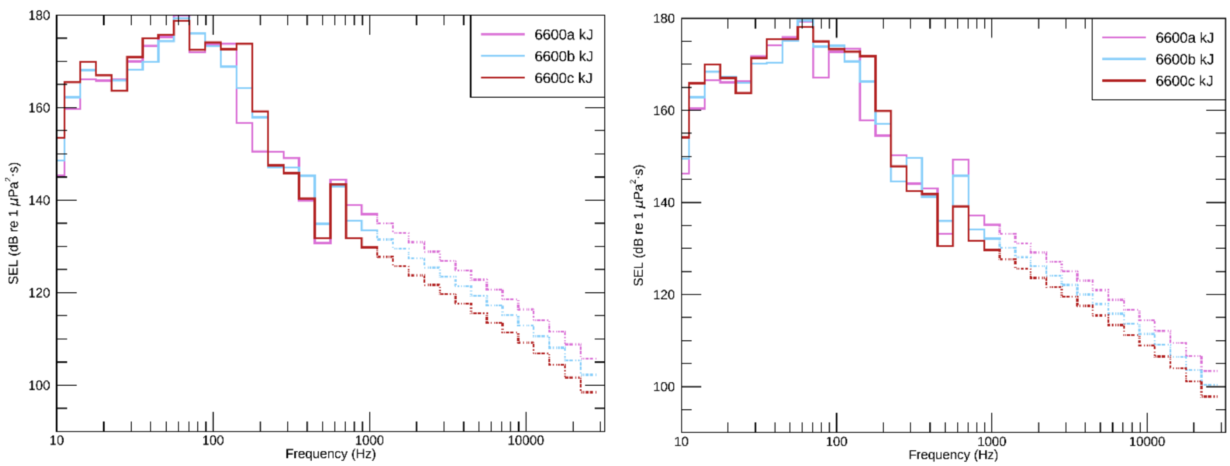

Figure G-1. Location L01: Decidecade band levels at 750 m from a 16 m diameter monopile assuming an expected installation scenario using an NNN 6600 hammer with an average (left) summer and (right) winter sound speed profiles.

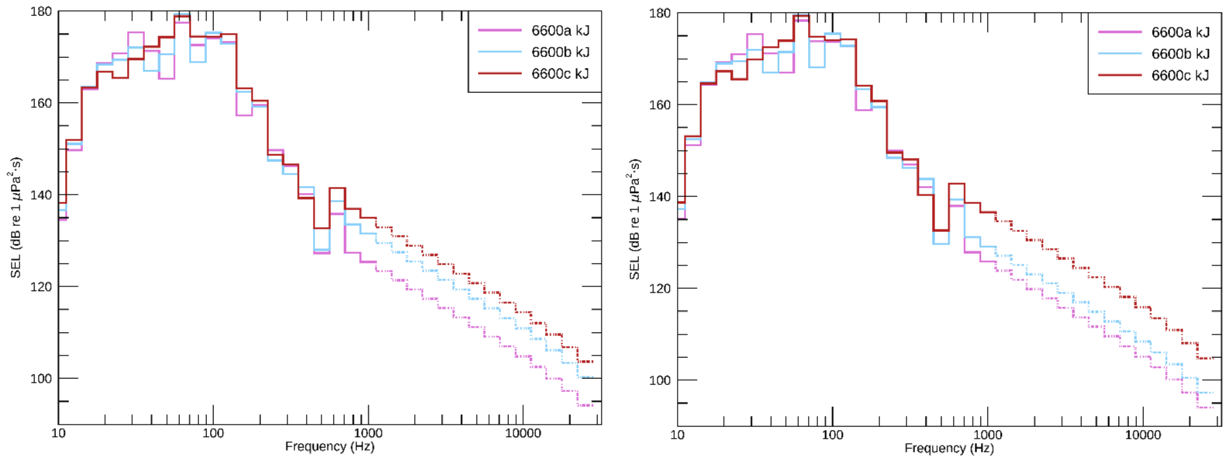

Figure G-2. Location L02: Decidecade band levels at 750 m from a 16 m diameter monopile assuming an expected installation scenario using an NNN 6600 hammer with an average (left) summer and (right) winter sound speed profiles.

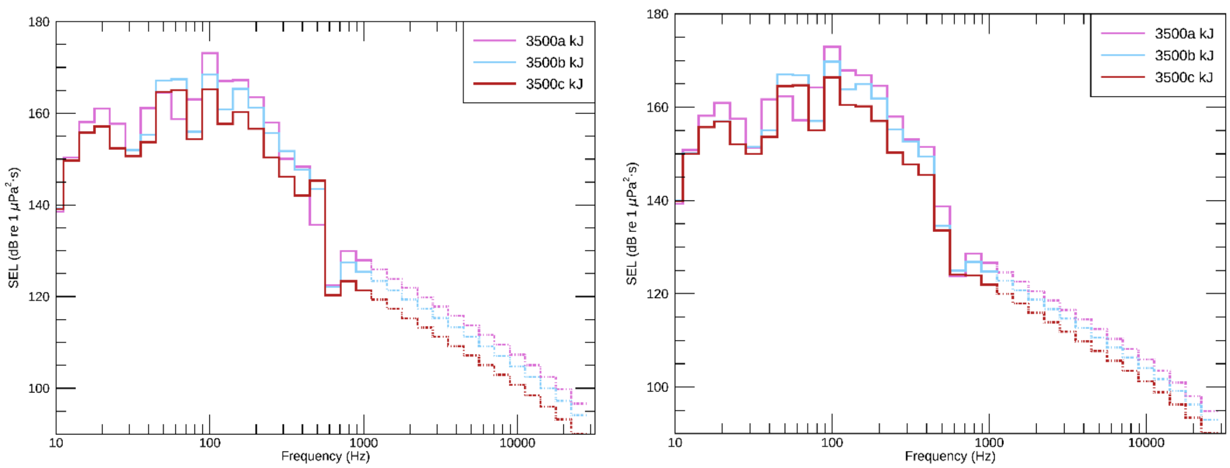

Figure G-3. Location L01: Decidecade band levels at 750 m from a 4.5 m diameter pin pile assuming an expected installation scenario using an MHU 3500S hammer with an average (left) summer and (right) winter sound speed profiles.

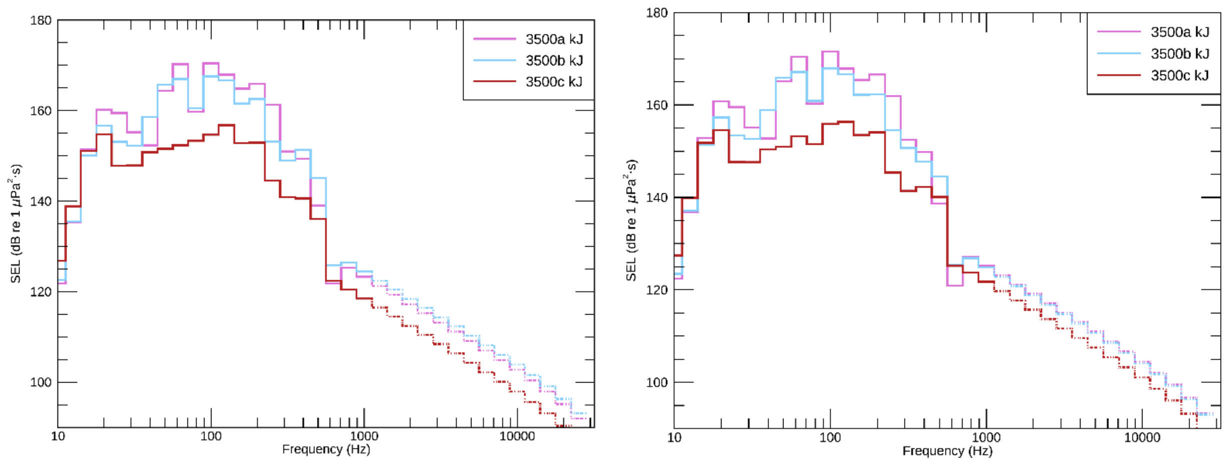

Figure G-4. Location L02: Decidecade band levels at 750 m from a 4.5 m diameter pin pile assuming an expected installation scenario using an MHU 3500S hammer with an average (left) summer and (right) winter sound speed profiles.

Table G-1. Broadband SEL (dB re 1 µPa²·s) per modeled energy level at 750 m from a 16 m diameter monopile installed using an NNN 6600 kJ hammer at both locations, for summer and winter conditions.

Energy level (kJ)	L_E @ 750 m from L01, Summer	L_E @ 750 m from L01, Winter	L_E @ 750 m from L02, Summer	L_E @ 750 m from L02, Winter
6600a	183.8	183.5	182.7	183.2
6600b	183.4	183.6	183.0	183.2
6600c	184.2	184.1	183.5	183.5

Table G-2. Broadband SEL (dB re 1 µPa²·s) per modeled energy level at 750 m from a 4.5 m diameter jacket pin pile installed using an MHU 3500S kJ hammer at both locations, for summer and winter conditions.

Energy level (kJ)	L_E @ 750 m from L01, Summer	L_E @ 750 m from L01, Winter	L_E @ 750 m from L02, Summer	L_E @ 750 m from L02, Winter
3500a	176.4	176.4	176.1	176.7
3500b	174.2	174.6	174.4	174.6
3500c	171.3	171.7	163.6	163.8

G.1.2. Vibratory Pile Driving

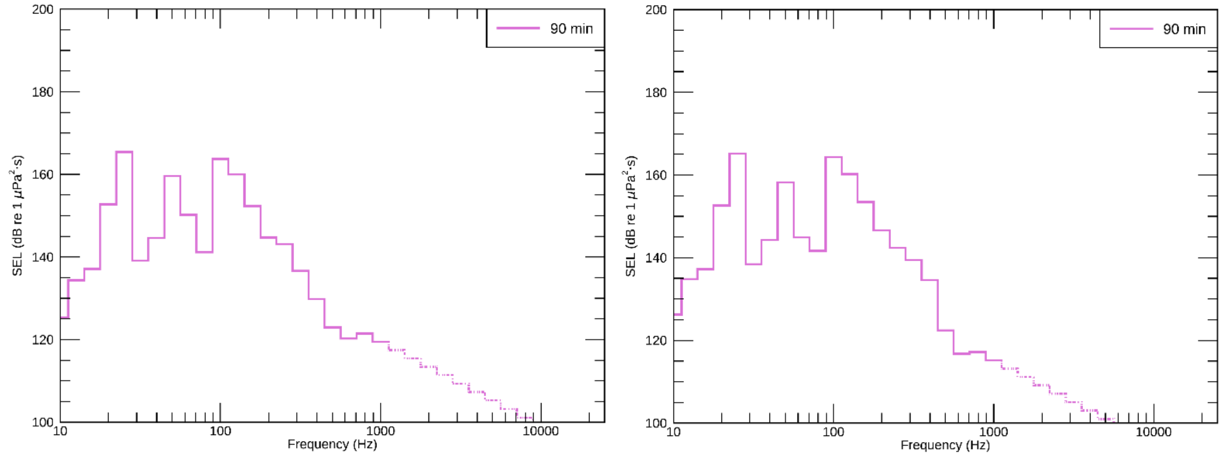

Figure G-5. Jacket foundation (4.5 m diameter pile, S-CV640 hammer) at location L01: Decidecade band levels for the receiver with highest SEL at 750 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

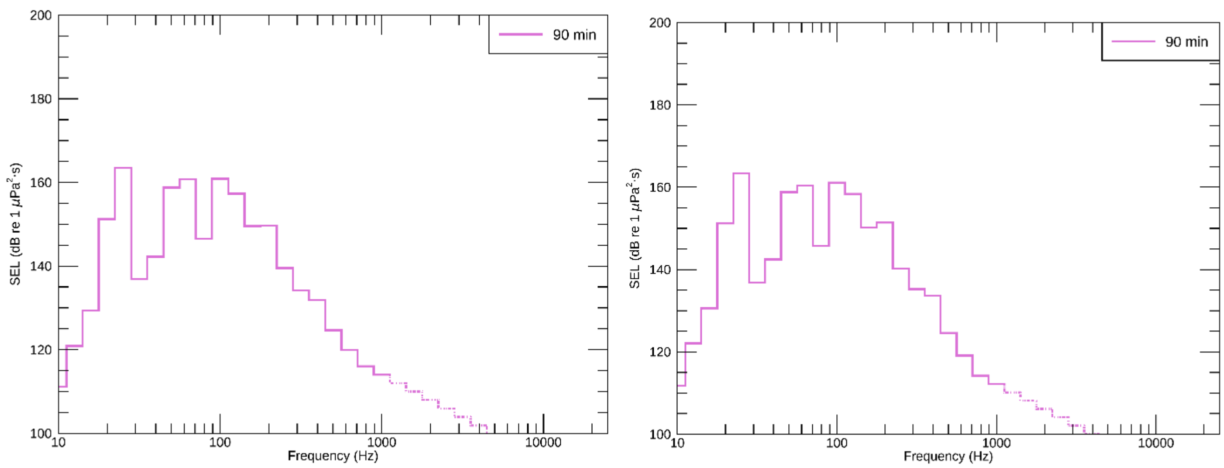

Figure G-6. Jacket foundation (4.5 m diameter pile, S-CV640 hammer) at location L02: Decidecade band levels for the receiver with highest SEL at 750 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

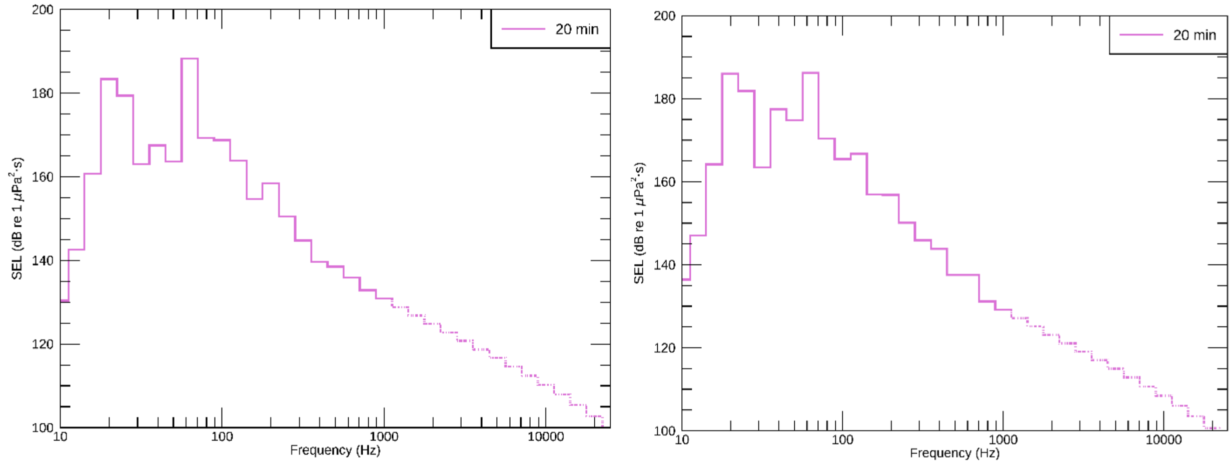

Figure G-7. Monopile foundation (16 m diameter pile, HX-CV640 hammer) at location L01: Decidecade band levels for the receiver with highest SEL at 750 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

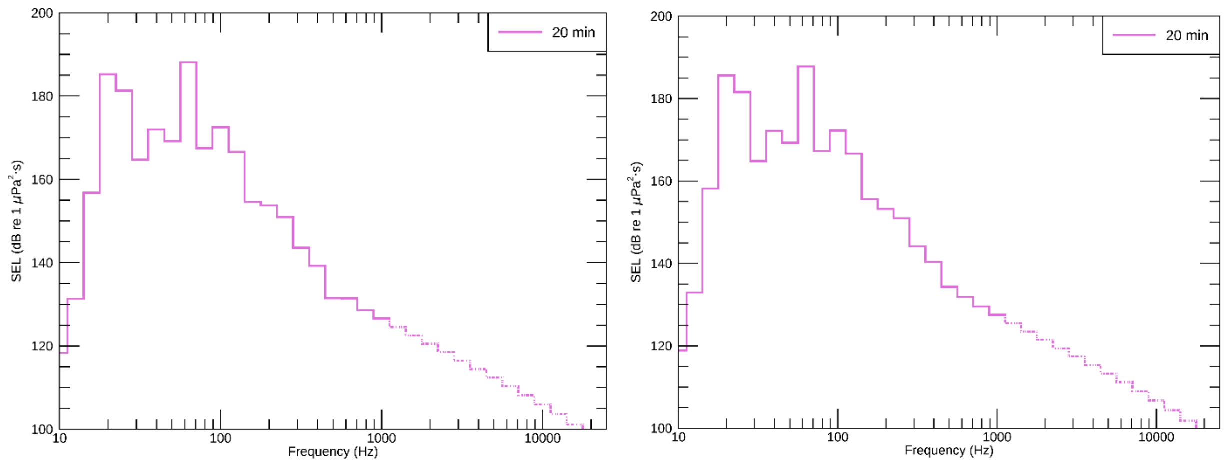

Figure G-8. Monopile foundation (16 m diameter pile, HX-CV640 hammer) at location L02: Decidecade band levels for the receiver with highest SEL at 750 m horizontal range from the pile for (left) summer and (right) winter conditions. The values at higher frequencies (1–25 kHz, dashed lines) have been extrapolated assuming constant decay rates.

Table G-3. Broadband SEL (dB re 1 μPa²·s) per duration of vibratory piling at 750 m from a 4.5 m diameter pin pile and a 16 m diameter monopile with installations using a TA-CV320 and a HX-CV640 hammers, respectively, at both locations, for summer and winter conditions.

Pile Type	Duration of Vibro-hammering (min)	L_E @ 750 m from L01, summer	L_E @ 750 m from L01, winter	L_E @ 750 m from L02, summer	L_E @ 750 m from L02, winter
4.5 m Jacket pin pile	90	169.2	169.2	167.6	167.7
16 m monopile	20	190.0	190.3	190.8	190.9

G.2. Impact Pile Driving Single-Strike PK Acoustic Ranges

G.2.1. 16 m Monopile Foundation

Table G-4. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.10	0.11	0.12
PPW	218	0.11	0.12	0.13
HF	202	0.81	0.93	0.90

Table G-5. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	0.02	0.02	0.02
HF	202	0.38	0.47	0.50

Table G-6. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.25	0.20	0.27

Table G-7. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.13	0.14

Table G-8. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.10	0.11	0.12
PPW	218	0.11	0.12	0.13
HF	202	0.92	0.92	0.99

Table G-9. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	0.02	0.02	0.02
HF	202	0.37	0.43	0.48

Table G-10. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.23	0.20	0.26

Table G-11. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.13	0.14

Table G-12. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.06	0.07	0.08
PPW	218	0.07	0.09	0.09
HF	202	0.63	0.73	0.82

Table G-13. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.02	-	0.03
PPW	218	0.03	0.03	0.04
HF	202	0.34	0.35	0.38

Table G-14. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.20	0.17	0.18

Table G-15. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.10	0.09	0.10

Table G-16. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.06	0.07	0.08
PPW	218	0.07	0.09	0.09
HF	202	0.68	0.73	0.83

Table G-17. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.02	-	0.03
PPW	218	0.03	0.02	0.03
HF	202	0.35	0.34	0.37

Table G-18. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.20	0.17	0.17

Table G-19. Monopile foundation (16 m diameter, NNN 6600 hammer) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		6600 (a)	6600 (b)	6600c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.10	0.09	0.10

G.2.2. 4.5 m Diameter Pin Pile (post-piled, 2 dB shift)

Table G-20. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.06	0.04	-
PPW	218	0.08	0.05	0.02
HF	202	0.58	0.45	0.31

Table G-21. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.26	0.15	0.09

Table G-22. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.14	0.09	0.06

Table G-23. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.09	0.06	0.03

Table G-24. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.07	0.04	-
PPW	218	0.09	0.05	-
HF	202	0.61	0.40	0.12

Table G-25. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.31	0.16	0.03

Table G-26. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.10	0.02

Table G-27. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.09	0.06	-

Table G-28. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.07	0.04	-
PPW	218	0.08	0.05	-
HF	202	0.54	0.43	0.12

Table G-29. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.32	0.16	0.03

Table G-30. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.10	0.02

Table G-31. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.09	0.06	-

Table G-32. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.07	0.04	-
PPW	218	0.09	0.05	-
HF	202	0.61	0.40	0.12

Table G-33. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.31	0.16	0.03

Table G-34. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 10 dB.

1Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.10	0.02

Table G-35. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.09	0.06	-

G.2.3. 4.5 m Diameter Pin Pile (pre-piled)

Table G-36. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	0.03	-
PPW	218	0.02	0.03	-
HF	202	0.51	0.38	0.16

Table G-37. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.17	0.12	0.07

Table G-38. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.12	0.08	0.05

Table G-39. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.06	0.04	-

Table G-40. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	0.03	-
PPW	218	0.02	0.03	-
HF	202	0.49	0.38	0.16

Table G-41. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.17	0.12	0.07

Table G-42. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.13	0.08	0.05

Table G-43. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.06	0.04	-

Table G-44. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.05	0.03	-
PPW	218	0.06	0.03	-
HF	202	0.44	0.37	0.09

Table G-45. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.19	0.13	0.02

Table G-46. J Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.12	0.08	-

Table G-47. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during summer at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.07	0.04	-

Table G-48. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.04	0.03	-
PPW	218	0.06	0.03	-
HF	202	0.41	0.35	0.09

Table G-49. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.19	0.13	0.02

Table G-50. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.12	0.08	-

Table G-51. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L02 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500c
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.07	0.04	-

G.3. Impact Pile Driving Single-Strike SPL Ranges

G.3.1. 16 m Monopile Foundation

Table G-52. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.24	0.23	0.23	0.22	-	-	-	-	0.09	0.09
190	1.18	1.14	1.15	1.10	0.15	0.15	0.09	0.09	0.41	0.40
180	3.12	2.97	3.02	2.89	0.67	0.65	0.40	0.38	1.66	1.59
175	4.75	4.54	4.67	4.45	1.36	1.31	0.83	0.80	2.70	2.59
170	6.76	6.42	6.69	6.35	2.40	2.29	1.64	1.57	4.16	3.97
160	13.34	12.41	13.24	12.33	5.46	5.20	4.16	3.97	8.73	8.23
150	23.91	21.63	23.78	21.51	11.04	10.21	8.68	8.16	17.14	15.61
140	38.56	33.99	38.38	33.85	20.14	18.29	16.76	15.19	29.99	26.92
130	71.05	59.36	70.27	58.73	35.46	31.40	29.77	26.70	50.40	43.44
120	>90	83.60	>90	83.40	67.39	56.26	53.34	45.60	>90	74.40

Table G-53. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.09	0.09	0.09	0.09	-	-	-	-	-	-
190	0.44	0.42	0.43	0.42	0.03	0.03	-	-	0.16	0.16
180	1.84	1.77	1.78	1.71	0.30	0.29	0.16	0.16	0.76	0.73
175	2.86	2.75	2.82	2.70	0.62	0.60	0.37	0.35	1.51	1.45
170	4.38	4.19	4.31	4.12	1.22	1.18	0.75	0.73	2.50	2.40
160	8.90	8.39	8.80	8.31	3.34	3.18	2.48	2.38	5.71	5.40
150	16.94	15.47	16.86	15.39	7.26	6.83	5.68	5.41	11.66	10.86
140	29.10	26.17	28.96	26.06	14.36	13.24	11.46	10.61	21.48	19.45
130	47.09	41.01	46.85	40.80	26.15	23.59	21.07	18.85	36.50	32.30
120	83.40	71.68	83.18	71.37	44.08	38.40	36.83	32.43	67.39	56.31

Table G-54. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.24	0.23	0.23	0.22	-	-	-	-	0.09	0.09
180	1.18	1.14	1.15	1.10	0.15	0.15	0.09	0.09	0.41	0.40
175	2.01	1.93	1.97	1.89	0.35	0.34	0.17	0.17	0.84	0.81
170	3.12	2.97	3.02	2.89	0.67	0.65	0.40	0.38	1.66	1.59
160	6.76	6.42	6.69	6.35	2.40	2.29	1.64	1.57	4.16	3.97
150	13.34	12.41	13.24	12.33	5.46	5.20	4.16	3.97	8.73	8.23
140	23.91	21.63	23.78	21.51	11.04	10.21	8.68	8.16	17.14	15.61
130	38.56	33.99	38.38	33.85	20.14	18.29	16.76	15.19	29.99	26.92
120	71.05	59.36	70.27	58.73	35.46	31.40	29.77	26.70	50.40	43.44

Table G-55. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	-	-	-	-	-	-
180	0.61	0.58	0.58	0.57	0.03	0.03	-	-	0.17	0.17
175	1.18	1.14	1.15	1.10	0.15	0.15	0.09	0.09	0.41	0.40
170	2.01	1.93	1.97	1.89	0.35	0.34	0.17	0.17	0.84	0.81
160	4.75	4.54	4.67	4.45	1.36	1.31	0.83	0.80	2.70	2.59
150	9.44	8.92	9.36	8.84	3.64	3.47	2.70	2.58	6.14	5.80
140	17.92	16.32	17.83	16.24	7.80	7.36	6.11	5.80	12.50	11.65
130	30.47	27.33	30.34	27.22	15.23	14.01	12.26	11.39	23.08	20.88
120	49.90	43.11	49.60	42.87	27.53	24.77	22.56	20.30	38.42	33.85

Table G-56. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.24	0.24	0.23	0.23	-	-	-	-	0.07	0.07
190	1.21	1.16	1.17	1.13	0.15	0.15	0.06	0.06	0.41	0.39
180	3.30	3.16	3.20	3.06	0.67	0.65	0.39	0.38	1.72	1.65
175	5.32	5.02	5.22	4.93	1.42	1.36	0.83	0.80	2.82	2.70
170	7.92	7.48	7.82	7.39	2.49	2.38	1.72	1.65	4.57	4.37
160	17.80	16.17	17.68	16.06	6.27	5.92	4.62	4.42	10.92	10.16
150	35.93	32.04	35.68	31.83	14.58	13.41	10.76	9.88	24.88	22.71
140	>90	82.31	>90	81.96	33.39	30.25	25.46	23.17	57.26	48.85
130	>90	85.34	>90	85.33	>90	83.43	75.86	63.13	>90	85.09
120	>90	85.97	>90	85.93	>90	85.81	>90	85.68	>90	85.91

Table G-57. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.09	0.09	0.09	0.09	-	-	-	-	-	-
190	0.44	0.43	0.44	0.42	0.03	0.03	-	-	0.16	0.16
180	1.87	1.80	1.82	1.74	0.23	0.22	0.16	0.16	0.74	0.71
175	2.94	2.82	2.89	2.77	0.61	0.59	0.35	0.34	1.55	1.48
170	4.85	4.60	4.75	4.52	1.26	1.22	0.74	0.72	2.58	2.48
160	11.04	10.28	10.92	10.16	3.65	3.47	2.59	2.49	6.53	6.18
150	23.52	21.44	23.36	21.29	8.73	8.16	6.55	6.19	15.68	14.33
140	48.38	42.01	47.91	41.65	19.96	18.18	15.28	13.99	33.81	30.39
130	>90	84.62	>90	84.55	48.04	42.02	36.12	32.54	>90	82.51
120	>90	85.68	>90	85.54	>90	85.01	>90	84.26	>90	85.36

Table G-58. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.24	0.24	0.23	0.23	-	-	-	-	0.07	0.07
180	1.21	1.16	1.17	1.13	0.15	0.15	0.06	0.06	0.41	0.40
175	2.08	1.99	2.02	1.93	0.33	0.32	0.18	0.17	0.90	0.80
170	3.30	3.16	3.20	3.06	0.67	0.65	0.39	0.38	1.72	1.65
160	7.92	7.48	7.82	7.39	2.49	2.38	1.72	1.65	4.57	4.37
150	17.80	16.17	17.68	16.06	6.27	5.92	4.62	4.42	10.92	10.16
140	35.93	32.04	35.68	31.83	14.58	13.41	10.76	9.88	24.88	22.71
130	>90	82.31	>90	81.96	33.39	30.25	25.46	23.17	57.26	48.85
120	>90	85.34	>90	85.33	>90	83.43	75.86	63.13	>90	85.09

Table G-59. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	-	-	-	-	-	-
180	0.61	0.59	0.58	0.57	0.03	0.03	-	-	0.18	0.18
175	1.21	1.16	1.17	1.13	0.15	0.15	0.06	0.06	0.41	0.40
170	2.08	1.99	2.02	1.93	0.33	0.32	0.18	0.17	0.90	0.80
160	5.32	5.02	5.22	4.93	1.42	1.36	0.83	0.80	2.82	2.70
150	12.08	11.26	11.96	11.15	3.99	3.82	2.84	2.72	7.07	6.69
140	25.29	23.05	25.12	22.91	9.40	8.82	7.07	6.66	17.00	15.46
130	52.71	45.41	52.08	44.94	22.04	19.87	16.68	15.19	36.65	32.73
120	>90	84.79	>90	84.73	53.49	46.25	39.66	35.45	>90	83.51

Table G-60. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.19	0.19	0.18	0.18	-	-	-	-	0.10	0.09
190	1.12	1.08	1.09	1.04	0.15	0.14	0.10	0.10	0.41	0.36
180	3.44	3.29	3.36	3.22	0.70	0.67	0.42	0.41	1.76	1.69
175	5.42	5.14	5.35	5.07	1.47	1.42	0.93	0.89	2.94	2.82
170	7.95	7.44	7.86	7.36	2.60	2.50	1.78	1.70	4.73	4.50
160	15.06	13.86	14.96	13.79	6.00	5.68	4.64	4.40	9.68	9.11
150	25.22	22.90	25.11	22.79	11.86	11.01	9.20	8.63	18.14	16.58
140	38.73	34.17	38.54	34.01	20.98	19.08	17.34	15.81	30.11	27.07
130	69.34	58.46	68.61	57.87	35.44	31.50	29.81	26.81	50.13	43.51
120	>90	83.22	>90	83.12	68.01	57.76	52.93	46.08	>90	74.69

Table G-61. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.10	0.09	0.09	-	-	-	-	-	-
190	0.44	0.43	0.38	0.37	0.04	0.04	-	-	0.15	0.15
180	1.83	1.76	1.78	1.71	0.29	0.28	0.16	0.15	0.71	0.69
175	3.08	2.94	2.99	2.87	0.61	0.59	0.34	0.33	1.55	1.49
170	4.98	4.74	4.90	4.67	1.28	1.23	0.75	0.73	2.70	2.60
160	10.24	9.53	10.12	9.46	3.80	3.63	2.71	2.60	6.38	6.05
150	18.46	16.89	18.37	16.80	7.95	7.44	6.16	5.82	12.88	11.98
140	29.80	26.81	29.68	26.70	15.12	13.94	12.08	11.22	22.58	20.48
130	47.02	41.06	46.79	40.84	26.52	24.01	21.53	19.55	36.26	32.18
120	82.83	71.22	82.59	70.89	44.47	38.90	36.64	32.46	66.53	56.33

Table G-62. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.19	0.18	0.18	-	-	-	-	0.10	0.09
180	1.12	1.08	1.09	1.04	0.15	0.14	0.10	0.10	0.41	0.36
175	2.00	1.92	1.95	1.88	0.32	0.31	0.17	0.17	0.91	0.84
170	3.44	3.29	3.36	3.22	0.70	0.67	0.42	0.41	1.76	1.69
160	7.95	7.44	7.86	7.36	2.60	2.50	1.78	1.70	4.73	4.50
150	15.06	13.86	14.96	13.79	6.00	5.68	4.64	4.40	9.68	9.11
140	25.22	22.90	25.11	22.79	11.86	11.01	9.20	8.63	18.14	16.58
130	38.73	34.17	38.54	34.01	20.98	19.08	17.34	15.81	30.11	27.07
120	69.34	58.46	68.61	57.87	35.44	31.50	29.81	26.81	50.13	43.51

Table G-63. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	-	-	-	-	-	-
180	0.53	0.51	0.51	0.50	0.05	0.05	0.02	0.02	0.16	0.16
175	1.12	1.08	1.09	1.04	0.15	0.14	0.10	0.10	0.41	0.36
170	2.00	1.92	1.95	1.88	0.32	0.31	0.17	0.17	0.91	0.84
160	5.42	5.14	5.35	5.07	1.47	1.42	0.93	0.89	2.94	2.82
150	11.10	10.30	11.00	10.20	4.15	3.95	2.93	2.81	6.85	6.48
140	19.25	17.64	19.16	17.56	8.48	7.95	6.60	6.21	13.70	12.68
130	31.02	27.86	30.89	27.75	16.02	14.72	12.86	11.94	23.93	21.70
120	49.74	43.10	49.43	42.86	27.81	25.09	23.07	20.91	38.17	33.71

Table G-64. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.20	0.19	0.19	0.19	-	-	-	-	0.09	0.09
190	1.15	1.10	1.10	1.07	0.15	0.15	0.09	0.09	0.36	0.35
180	3.66	3.51	3.58	3.43	0.71	0.69	0.41	0.39	1.81	1.74
175	6.03	5.68	5.94	5.61	1.52	1.44	0.94	0.91	3.06	2.93
170	9.23	8.63	9.16	8.55	2.69	2.58	1.84	1.76	5.07	4.81
160	18.86	17.22	18.76	17.13	6.58	6.24	4.90	4.66	12.40	11.57
150	37.74	33.62	37.43	33.36	15.96	14.69	11.64	10.87	26.00	23.76
140	>90	84.36	>90	84.27	37.28	33.40	26.82	24.49	88.23	72.90
130	>90	85.56	>90	85.55	>90	84.85	>90	83.22	>90	85.40
120	>90	85.96	>90	85.91	>90	85.73	>90	85.48	>90	85.88

Table G-65. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.09	0.09	0.09	-	-	-	-	-	-
190	0.42	0.41	0.39	0.38	0.04	0.04	-	-	0.15	0.15
180	1.87	1.80	1.82	1.75	0.26	0.26	0.16	0.16	0.73	0.70
175	3.26	3.12	3.18	3.04	0.63	0.61	0.32	0.31	1.60	1.53
170	5.49	5.19	5.42	5.11	1.34	1.28	0.76	0.74	2.81	2.69
160	12.76	11.86	12.66	11.76	4.01	3.82	2.81	2.69	7.27	6.86
150	24.63	22.47	24.46	22.31	9.40	8.80	6.76	6.40	16.92	15.48
140	55.03	47.34	54.10	46.66	21.44	19.51	16.48	15.16	36.50	32.70
130	>90	85.20	>90	85.16	63.84	53.84	40.23	35.83	>90	84.57
120	>90	85.70	>90	85.68	>90	85.35	>90	85.07	>90	85.56

Table G-66. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.20	0.19	0.19	0.19	-	-	-	-	0.09	0.09
180	1.15	1.10	1.10	1.07	0.15	0.15	0.09	0.09	0.36	0.35
175	2.09	2.00	2.02	1.94	0.30	0.29	0.17	0.17	0.90	0.80
170	3.66	3.51	3.58	3.43	0.71	0.69	0.41	0.39	1.81	1.74
160	9.23	8.63	9.16	8.55	2.69	2.58	1.84	1.76	5.07	4.81
150	18.86	17.22	18.76	17.13	6.58	6.24	4.90	4.66	12.40	11.57
140	37.74	33.62	37.43	33.36	15.96	14.69	11.64	10.87	26.00	23.76
130	>90	84.36	>90	84.27	37.28	33.40	26.82	24.49	88.23	72.90
120	>90	85.56	>90	85.55	>90	84.85	>90	83.22	>90	85.40

Table G-67. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	-	-	-	-	-	-
180	0.53	0.51	0.50	0.48	0.05	0.05	0.02	0.02	0.17	0.17
175	1.15	1.10	1.10	1.07	0.15	0.15	0.09	0.09	0.36	0.35
170	2.09	2.00	2.02	1.94	0.30	0.29	0.17	0.17	0.90	0.80
160	6.03	5.68	5.94	5.61	1.52	1.44	0.94	0.91	3.06	2.93
150	13.76	12.70	13.66	12.61	4.37	4.16	3.06	2.92	8.03	7.52
140	26.24	23.91	26.05	23.77	10.08	9.47	7.40	6.97	18.10	16.53
130	64.92	54.51	63.19	53.28	23.48	21.45	17.80	16.33	40.05	35.61
120	>90	85.29	>90	85.27	80.59	67.04	45.05	39.72	>90	84.83

Table G-68. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.24	0.24	0.24	0.23	0.02	0.02	-	-	0.11	0.11
190	1.19	1.14	1.15	1.11	0.16	0.16	0.12	0.12	0.48	0.47
180	3.54	3.33	3.47	3.27	0.89	0.86	0.53	0.51	1.91	1.83
175	5.25	4.93	5.17	4.86	1.67	1.60	1.10	1.06	3.08	2.90
170	7.53	6.97	7.44	6.89	2.81	2.67	1.98	1.90	4.68	4.42
160	14.12	12.87	14.00	12.78	6.06	5.68	4.79	4.53	9.26	8.62
150	23.47	21.32	23.32	21.20	11.82	10.83	9.32	8.69	17.38	15.78
140	38.47	33.93	38.23	33.74	21.36	19.39	17.76	16.19	30.16	27.08
130	77.46	64.83	76.63	64.03	39.94	35.16	32.79	29.26	56.40	48.76
120	>90	84.46	>90	84.40	82.53	71.72	72.39	61.22	>90	82.13

Table G-69. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.11	0.11	0.10	0.10	-	-	-	-	-	-
190	0.49	0.48	0.48	0.47	0.08	0.08	0.02	0.02	0.16	0.16
180	1.94	1.86	1.91	1.83	0.34	0.33	0.17	0.17	0.91	0.88
175	3.18	3.00	3.11	2.93	0.73	0.71	0.45	0.43	1.71	1.64
170	4.85	4.58	4.78	4.52	1.52	1.45	0.94	0.90	2.85	2.71
160	9.66	8.96	9.60	8.89	3.98	3.76	2.92	2.78	6.20	5.80
150	17.38	15.73	17.28	15.64	7.96	7.39	6.32	5.90	12.22	11.20
140	28.45	25.68	28.32	25.57	15.18	13.86	12.30	11.32	21.41	19.45
130	48.34	42.01	47.94	41.71	27.54	24.84	22.74	20.58	37.97	33.51
120	>90	75.31	>90	74.75	52.59	45.89	43.25	37.94	79.36	67.20

Table G-70. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.03	0.03	-	-	-	-	-	-
190	0.24	0.24	0.24	0.23	0.02	0.02	-	-	0.11	0.11
180	1.19	1.14	1.15	1.11	0.16	0.16	0.12	0.12	0.48	0.47
175	2.17	2.08	2.11	2.02	0.37	0.36	0.18	0.17	1.00	0.97
170	3.54	3.33	3.47	3.27	0.89	0.86	0.53	0.51	1.91	1.83
160	7.53	6.97	7.44	6.89	2.81	2.67	1.98	1.90	4.68	4.42
150	14.12	12.87	14.00	12.78	6.06	5.68	4.79	4.53	9.26	8.62
140	23.47	21.32	23.32	21.20	11.82	10.83	9.32	8.69	17.38	15.78
130	38.47	33.93	38.23	33.74	21.36	19.39	17.76	16.19	30.16	27.08
120	77.46	64.83	76.63	64.03	39.94	35.16	32.79	29.26	56.40	48.76

Table G-71. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.12	0.12	0.12	0.12	-	-	-	-	0.02	0.02
180	0.56	0.54	0.54	0.53	0.10	0.10	0.02	0.02	0.17	0.17
175	1.19	1.14	1.15	1.11	0.16	0.16	0.12	0.12	0.48	0.47
170	2.17	2.08	2.11	2.02	0.37	0.36	0.18	0.17	1.00	0.97
160	5.25	4.93	5.17	4.86	1.67	1.60	1.10	1.06	3.08	2.90
150	10.28	9.42	10.14	9.35	4.29	4.05	3.22	3.04	6.64	6.20
140	18.20	16.50	18.10	16.41	8.47	7.88	6.74	6.28	12.98	11.92
130	29.81	26.82	29.66	26.70	16.12	14.69	13.10	12.03	22.97	20.85
120	51.63	44.61	51.19	44.26	29.14	26.20	24.37	22.03	40.48	35.56

Table G-72. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.23	0.23	0.23	0.22	-	-	-	-	0.11	0.11
190	1.24	1.19	1.20	1.16	0.17	0.17	0.12	0.12	0.50	0.49
180	3.66	3.46	3.60	3.40	0.93	0.90	0.56	0.54	1.96	1.89
175	5.51	5.18	5.43	5.11	1.78	1.71	1.16	1.12	3.20	3.03
170	8.20	7.57	8.10	7.48	2.91	2.77	2.08	1.99	4.90	4.63
160	16.26	14.72	16.14	14.62	6.50	6.11	5.08	4.78	10.26	9.41
150	30.84	27.62	30.59	27.42	13.50	12.34	10.44	9.55	20.56	18.69
140	>90	78.11	>90	76.09	28.54	25.46	21.19	19.14	50.96	43.39
130	>90	85.34	>90	85.32	>90	83.14	70.46	56.19	>90	85.08
120	>90	85.89	>90	85.86	>90	85.62	>90	85.40	>90	85.82

Table G-73. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.11	0.11	0.10	0.10	-	-	-	-	-	-
190	0.50	0.49	0.49	0.48	0.06	0.06	0.02	0.02	0.17	0.17
180	1.99	1.91	1.96	1.88	0.34	0.33	0.18	0.18	0.94	0.91
175	3.28	3.11	3.21	3.04	0.74	0.71	0.46	0.44	1.81	1.73
170	5.07	4.78	5.00	4.72	1.56	1.50	1.00	0.97	2.92	2.79
160	10.76	9.79	10.64	9.67	4.16	3.93	3.06	2.89	6.66	6.24
150	20.20	18.36	20.00	18.26	8.79	8.15	6.80	6.37	13.96	12.74
140	42.74	37.15	42.31	36.82	17.68	16.09	14.08	12.86	28.62	25.68
130	>90	84.54	>90	84.45	43.95	37.75	30.88	27.32	>90	80.29
120	>90	85.56	>90	85.53	>90	85.04	>90	84.37	>90	85.38

Table G-74. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.23	0.23	0.23	0.22	-	-	-	-	0.11	0.11
180	1.24	1.19	1.20	1.16	0.17	0.17	0.12	0.12	0.50	0.49
175	2.23	2.13	2.18	2.08	0.38	0.37	0.19	0.19	1.08	1.04
170	3.66	3.46	3.60	3.40	0.93	0.90	0.56	0.54	1.96	1.89
160	8.20	7.57	8.10	7.48	2.91	2.77	2.08	1.99	4.90	4.63
150	16.26	14.72	16.14	14.62	6.50	6.11	5.08	4.78	10.26	9.41
140	30.84	27.62	30.59	27.42	13.50	12.34	10.44	9.55	20.56	18.69
130	>90	78.12	>90	76.09	28.54	25.46	21.19	19.14	50.96	43.39
120	>90	85.34	>90	85.32	>90	83.14	70.46	56.19	>90	85.08

Table G-75. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.12	0.12	0.12	0.12	-	-	-	-	0.02	0.02
180	0.58	0.56	0.57	0.55	0.10	0.09	0.02	0.02	0.18	0.17
175	1.24	1.19	1.20	1.16	0.17	0.17	0.12	0.12	0.50	0.49
170	2.23	2.13	2.18	2.08	0.38	0.37	0.19	0.19	1.08	1.04
160	5.51	5.18	5.43	5.11	1.78	1.71	1.16	1.12	3.20	3.03
150	11.66	10.65	11.54	10.53	4.48	4.25	3.43	3.24	7.18	6.69
140	21.78	19.80	21.60	19.63	9.36	8.68	7.35	6.83	14.96	13.62
130	46.57	40.17	46.05	39.77	18.80	17.14	15.06	13.75	31.19	27.77
120	>90	84.78	>90	84.71	49.38	41.91	34.72	30.34	>90	82.92

Table G-76. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.18	0.18	0.18	0.18	-	-	-	-	0.06	0.06
190	0.89	0.85	0.86	0.83	0.11	0.11	0.06	0.06	0.33	0.32
180	2.38	2.23	2.32	2.18	0.51	0.49	0.31	0.28	1.20	1.14
175	3.54	3.29	3.45	3.22	0.98	0.94	0.61	0.58	1.92	1.82
170	4.98	4.62	4.91	4.57	1.70	1.61	1.17	1.11	2.92	2.75
160	9.12	8.38	9.07	8.33	4.00	3.76	2.92	2.75	6.37	5.92
150	16.04	14.45	15.98	14.40	8.27	7.65	6.32	5.89	12.71	11.65
140	25.31	22.64	25.24	22.57	15.63	14.15	12.79	11.75	20.73	18.45
130	35.68	31.95	35.59	31.87	25.36	22.69	21.21	18.81	31.72	28.28
120	48.65	43.72	48.52	43.59	36.23	32.45	32.42	28.88	43.54	39.11

Table G-77. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.07	0.07	0.07	0.07	-	-	-	-	-	-
190	0.39	0.38	0.38	0.37	0.03	0.03	-	-	0.12	0.12
180	1.41	1.33	1.36	1.29	0.22	0.21	0.12	0.12	0.56	0.54
175	2.18	2.03	2.12	1.98	0.46	0.44	0.26	0.24	1.08	1.02
170	3.21	2.99	3.14	2.92	0.89	0.84	0.54	0.52	1.79	1.68
160	6.30	5.82	6.25	5.77	2.44	2.29	1.77	1.67	4.17	3.91
150	11.72	10.68	11.66	10.62	5.37	5.02	4.14	3.89	8.51	7.86
140	19.05	17.12	18.99	17.07	10.85	9.95	8.47	7.85	15.80	14.27
130	29.36	26.22	29.27	26.15	18.87	16.99	15.97	14.45	25.36	22.69
120	40.37	36.26	40.26	36.17	29.64	26.43	25.82	23.16	35.99	32.26

Table G-78. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.18	0.18	0.18	-	-	-	-	0.06	0.06
180	0.89	0.85	0.86	0.83	0.11	0.11	0.06	0.06	0.33	0.32
175	1.53	1.44	1.50	1.41	0.24	0.24	0.13	0.13	0.65	0.63
170	2.38	2.23	2.32	2.18	0.51	0.49	0.31	0.28	1.20	1.14
160	4.98	4.62	4.91	4.57	1.70	1.61	1.17	1.11	2.92	2.75
150	9.12	8.38	9.07	8.33	4.00	3.76	2.92	2.75	6.37	5.92
140	16.04	14.45	15.98	14.40	8.27	7.65	6.32	5.89	12.71	11.65
130	25.32	22.64	25.24	22.57	15.63	14.15	12.79	11.75	20.73	18.45
120	35.68	31.95	35.59	31.87	25.36	22.69	21.21	18.81	31.72	28.28

Table G-79. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.02	0.02
180	0.46	0.44	0.44	0.43	0.05	0.05	0.02	0.02	0.14	0.13
175	0.89	0.85	0.86	0.83	0.11	0.11	0.06	0.06	0.33	0.32
170	1.53	1.44	1.50	1.41	0.24	0.24	0.13	0.13	0.65	0.63
160	3.54	3.29	3.45	3.22	0.98	0.94	0.61	0.58	1.92	1.82
150	6.68	6.16	6.63	6.11	2.64	2.47	1.90	1.81	4.50	4.20
140	12.45	11.35	12.39	11.30	5.76	5.37	4.46	4.18	9.09	8.40
130	19.77	17.77	19.71	17.72	11.70	10.74	9.07	8.41	16.60	14.97
120	30.42	27.14	30.33	27.07	19.62	17.67	16.82	15.16	26.33	23.63

Table G-80. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.19	0.19	0.18	0.18	-	-	-	-	0.06	0.06
190	0.92	0.89	0.91	0.86	0.12	0.12	0.06	0.06	0.34	0.34
180	2.49	2.34	2.43	2.29	0.54	0.52	0.32	0.31	1.26	1.20
175	3.86	3.60	3.79	3.54	1.05	1.00	0.64	0.61	1.99	1.89
170	5.57	5.17	5.52	5.12	1.77	1.68	1.23	1.17	3.22	3.02
160	12.33	11.11	12.26	11.05	4.56	4.28	3.19	2.99	8.29	7.62
150	24.20	21.26	24.07	21.15	11.58	10.47	8.29	7.60	18.39	16.30
140	40.81	36.36	40.59	36.16	24.82	21.80	19.01	16.84	34.32	30.47
130	78.53	68.84	77.19	67.77	44.31	39.32	36.71	32.60	62.17	55.06
120	>90	85.29	>90	85.28	>90	82.69	74.76	65.68	>90	85.11

Table G-81. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.07	0.07	0.07	0.07	-	-	-	-	-	-
190	0.41	0.39	0.40	0.38	0.03	0.03	-	-	0.13	0.13
180	1.45	1.38	1.42	1.34	0.22	0.21	0.12	0.12	0.59	0.57
175	2.28	2.13	2.24	2.08	0.48	0.46	0.26	0.25	1.14	1.08
170	3.52	3.28	3.45	3.21	0.92	0.88	0.57	0.55	1.85	1.75
160	7.61	6.96	7.54	6.90	2.57	2.43	1.84	1.75	4.78	4.48
150	16.25	14.46	16.18	14.39	6.52	6.05	4.71	4.42	11.88	10.72
140	30.32	26.88	30.18	26.76	16.00	14.23	12.06	10.89	24.51	21.53
130	51.56	45.83	51.17	45.49	31.62	27.99	25.80	22.74	42.33	37.64
120	>90	84.27	>90	84.07	58.22	51.55	47.07	41.73	86.44	75.67

Table G-82. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.19	0.19	0.18	-	-	-	-	0.06	0.06
180	0.92	0.89	0.91	0.86	0.12	0.12	0.06	0.06	0.34	0.34
175	1.58	1.50	1.54	1.47	0.25	0.24	0.13	0.13	0.71	0.67
170	2.49	2.34	2.43	2.29	0.54	0.52	0.32	0.31	1.26	1.20
160	5.57	5.17	5.52	5.12	1.77	1.68	1.23	1.17	3.23	3.02
150	12.33	11.11	12.26	11.05	4.56	4.28	3.19	2.99	8.29	7.62
140	24.20	21.26	24.07	21.15	11.58	10.47	8.29	7.60	18.39	16.30
130	40.81	36.36	40.59	36.16	24.82	21.80	19.01	16.84	34.32	30.47
120	78.53	68.84	77.19	67.77	44.31	39.32	36.71	32.60	62.17	55.06

Table G-83. Monopile foundation (16 m diameter, NNN 6600, 6600(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.02	0.02
180	0.48	0.46	0.46	0.44	0.05	0.05	0.02	0.02	0.14	0.14
175	0.92	0.89	0.91	0.86	0.12	0.12	0.06	0.06	0.34	0.34
170	1.58	1.50	1.54	1.47	0.25	0.24	0.13	0.13	0.71	0.67
160	3.86	3.60	3.79	3.54	1.05	1.00	0.64	0.61	1.99	1.89
150	8.25	7.56	8.19	7.50	2.78	2.63	1.99	1.89	5.22	4.88
140	17.31	15.37	17.24	15.30	7.19	6.62	5.14	4.81	12.91	11.64
130	31.92	28.31	31.79	28.19	17.18	15.24	13.15	11.84	26.04	23.03
120	54.83	48.72	54.36	48.31	33.37	29.59	27.49	24.30	44.94	39.95

Table G-84. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.19	0.19	0.18	0.18	-	-	-	-	0.08	0.08
190	0.91	0.88	0.90	0.86	0.12	0.12	0.08	0.08	0.36	0.34
180	2.76	2.60	2.72	2.57	0.65	0.62	0.38	0.37	1.49	1.42
175	4.27	3.96	4.22	3.92	1.26	1.21	0.79	0.75	2.50	2.36
170	5.98	5.49	5.95	5.45	2.14	2.00	1.50	1.43	3.91	3.63
160	10.76	9.69	10.69	9.63	4.92	4.55	3.84	3.54	7.66	6.99
150	17.24	15.38	17.18	15.33	9.15	8.36	7.33	6.67	13.70	12.34
140	25.85	23.12	25.80	23.05	15.91	14.21	13.38	12.05	20.90	18.42
130	35.00	31.35	34.93	31.28	25.05	22.24	21.10	18.52	30.98	27.63
120	46.70	41.78	46.54	41.65	35.27	31.48	31.85	28.39	41.72	37.29

Table G-85. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.08	0.08	0.08	0.08	-	-	-	-	-	-
190	0.37	0.36	0.37	0.35	0.06	0.06	-	-	0.12	0.12
180	1.51	1.44	1.49	1.41	0.26	0.26	0.12	0.12	0.69	0.66
175	2.54	2.40	2.50	2.36	0.57	0.54	0.31	0.30	1.32	1.27
170	3.96	3.68	3.92	3.64	1.13	1.08	0.71	0.68	2.24	2.12
160	7.69	7.00	7.63	6.96	3.04	2.84	2.23	2.11	5.19	4.80
150	13.41	12.09	13.35	12.05	6.33	5.82	5.03	4.65	9.62	8.82
140	19.84	17.73	19.80	17.68	11.77	10.59	9.28	8.48	16.38	14.63
130	29.48	26.33	29.40	26.26	18.82	16.78	16.21	14.45	25.23	22.46
120	39.09	35.06	38.98	34.96	28.98	25.87	25.64	22.81	34.88	31.21

Table G-86. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.19	0.19	0.18	-	-	-	-	0.08	0.08
180	0.91	0.88	0.90	0.86	0.12	0.12	0.08	0.08	0.36	0.34
175	1.70	1.61	1.67	1.58	0.31	0.30	0.17	0.17	0.78	0.75
170	2.76	2.60	2.72	2.57	0.65	0.62	0.38	0.37	1.49	1.42
160	5.98	5.49	5.95	5.45	2.14	2.00	1.50	1.43	3.91	3.63
150	10.76	9.69	10.69	9.63	4.92	4.55	3.84	3.54	7.66	6.99
140	17.24	15.38	17.18	15.33	9.15	8.36	7.33	6.67	13.70	12.34
130	25.85	23.12	25.80	23.05	15.91	14.21	13.38	12.05	20.90	18.42
120	35.00	31.35	34.93	31.28	25.05	22.24	21.10	18.52	30.98	27.63

Table G-87. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.02	0.02
180	0.42	0.39	0.39	0.38	0.06	0.06	0.02	0.02	0.16	0.15
175	0.91	0.88	0.90	0.86	0.12	0.12	0.08	0.08	0.36	0.34
170	1.70	1.61	1.67	1.58	0.31	0.30	0.17	0.17	0.78	0.75
160	4.27	3.96	4.22	3.92	1.26	1.21	0.79	0.75	2.50	2.36
150	8.16	7.45	8.12	7.40	3.37	3.11	2.48	2.33	5.56	5.12
140	14.03	12.61	13.97	12.57	6.73	6.17	5.36	4.95	10.14	9.25
130	20.86	18.39	20.76	18.33	12.47	11.25	9.76	8.93	17.07	15.24
120	30.42	27.14	30.33	27.07	19.53	17.42	16.93	15.09	26.14	23.35

Table G-88. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.19	0.19	0.18	0.18	-	-	-	-	0.08	0.08
190	0.96	0.92	0.93	0.90	0.12	0.12	0.08	0.08	0.36	0.34
180	2.92	2.76	2.89	2.73	0.67	0.64	0.39	0.37	1.56	1.49
175	4.69	4.34	4.64	4.30	1.31	1.26	0.83	0.78	2.64	2.50
170	6.85	6.27	6.80	6.23	2.28	2.12	1.56	1.49	4.25	3.96
160	13.80	12.35	13.73	12.29	5.48	5.05	4.14	3.84	9.48	8.65
150	24.83	21.96	24.72	21.85	12.63	11.31	9.32	8.50	18.92	16.76
140	41.83	37.29	41.51	37.01	25.82	22.86	19.97	17.73	34.94	31.06
130	>90	82.04	>90	81.17	49.88	44.43	40.06	35.70	71.83	63.58
120	>90	85.85	>90	85.50	>90	84.43	>90	82.93	>90	85.21

Table G-89. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.08	0.08	0.08	0.08	-	-	-	-	-	-
190	0.37	0.36	0.37	0.36	0.05	0.05	-	-	0.13	0.13
180	1.58	1.51	1.54	1.48	0.27	0.26	0.13	0.13	0.70	0.68
175	2.70	2.54	2.66	2.51	0.59	0.57	0.31	0.30	1.39	1.33
170	4.32	4.01	4.28	3.97	1.17	1.12	0.72	0.69	2.39	2.26
160	9.18	8.37	9.14	8.32	3.32	3.07	2.37	2.23	5.88	5.42
150	17.31	15.34	17.23	15.27	7.67	6.97	5.64	5.19	12.95	11.62
140	30.46	27.05	30.32	26.92	16.74	14.82	13.12	11.75	24.98	22.06
130	54.97	49.00	54.29	48.41	32.95	29.24	27.25	24.19	44.87	39.98
120	>90	84.99	>90	84.94	69.98	62.06	55.38	49.34	>90	83.98

Table G-90. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.19	0.19	0.18	0.18	-	-	-	-	0.08	0.08
180	0.96	0.92	0.93	0.90	0.12	0.12	0.08	0.08	0.36	0.34
175	1.77	1.68	1.74	1.65	0.31	0.30	0.14	0.14	0.81	0.77
170	2.92	2.76	2.89	2.73	0.67	0.64	0.39	0.37	1.56	1.49
160	6.85	6.27	6.80	6.23	2.28	2.12	1.56	1.49	4.25	3.96
150	13.80	12.35	13.73	12.29	5.48	5.05	4.14	3.84	9.48	8.65
140	24.83	21.96	24.72	21.85	12.63	11.31	9.32	8.50	18.92	16.76
130	41.83	37.29	41.51	37.01	25.82	22.86	19.97	17.73	34.94	31.06
120	>90	82.04	>90	81.17	49.88	44.43	40.06	35.70	71.83	63.58

Table G-91. Monopile foundation (16 m diameter, NNN 6600, 6600(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.02	0.02
180	0.44	0.42	0.43	0.41	0.06	0.06	0.02	0.02	0.13	0.13
175	0.96	0.92	0.93	0.90	0.12	0.12	0.08	0.08	0.36	0.34
170	1.77	1.68	1.74	1.65	0.31	0.30	0.14	0.14	0.81	0.77
160	4.69	4.34	4.64	4.30	1.31	1.26	0.83	0.78	2.64	2.50
150	9.73	8.88	9.67	8.83	3.66	3.39	2.61	2.46	6.39	5.87
140	18.29	16.19	18.20	16.12	8.36	7.60	6.11	5.60	13.85	12.38
130	32.01	28.44	31.87	28.31	17.93	15.85	14.14	12.60	26.45	23.47
120	59.26	52.77	58.44	52.04	34.99	31.10	29.03	25.79	48.27	42.99

Table G-92. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.18	0.18	0.18	0.17	-	-	-	-	0.08	0.08
190	1.03	0.98	1.00	0.96	0.12	0.12	0.09	0.09	0.46	0.44
180	2.98	2.80	2.95	2.78	0.67	0.63	0.45	0.38	1.58	1.51
175	4.61	4.29	4.57	4.25	1.33	1.28	0.85	0.82	2.65	2.49
170	6.44	5.93	6.39	5.89	2.26	2.12	1.56	1.49	4.12	3.84
160	11.50	10.37	11.44	10.32	5.29	4.90	4.05	3.76	8.29	7.61
150	17.89	15.99	17.83	15.95	10.10	9.28	8.26	7.59	14.58	13.16
140	27.73	24.79	27.66	24.72	17.64	15.81	14.98	13.54	23.58	20.88
130	38.94	34.87	38.84	34.76	28.77	25.60	25.09	22.35	34.94	31.15
120	55.59	49.51	55.31	49.25	41.20	36.91	37.11	33.16	49.47	44.18

Table G-93. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.07	0.07	0.07	0.07	-	-	-	-	-	-
190	0.47	0.45	0.46	0.44	0.06	0.06	0.02	0.02	0.12	0.12
180	1.69	1.61	1.67	1.58	0.24	0.23	0.13	0.13	0.76	0.74
175	2.76	2.60	2.73	2.58	0.57	0.55	0.32	0.31	1.42	1.36
170	4.29	3.99	4.25	3.96	1.17	1.11	0.77	0.74	2.40	2.27
160	8.23	7.53	8.19	7.48	3.23	2.99	2.38	2.23	5.55	5.14
150	13.93	12.57	13.89	12.52	6.95	6.39	5.46	5.06	10.41	9.47
140	21.23	18.72	21.13	18.65	13.12	11.94	10.55	9.61	17.51	15.70
130	32.11	28.57	32.02	28.49	21.47	18.94	18.23	16.34	28.01	25.01
120	44.49	39.86	44.34	39.74	33.54	29.83	29.85	26.53	39.89	35.73

Table G-94. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.04	0.04	-	-	-	-	-	-
190	0.18	0.18	0.18	0.17	-	-	-	-	0.08	0.08
180	1.03	0.98	1.00	0.96	0.12	0.12	0.09	0.09	0.46	0.44
175	1.87	1.78	1.84	1.75	0.31	0.30	0.17	0.16	0.86	0.82
170	2.98	2.80	2.95	2.78	0.67	0.63	0.45	0.38	1.58	1.51
160	6.44	5.93	6.39	5.89	2.26	2.12	1.56	1.49	4.12	3.84
150	11.50	10.37	11.44	10.32	5.29	4.90	4.05	3.76	8.29	7.61
140	17.89	15.99	17.83	15.95	10.10	9.28	8.26	7.59	14.58	13.16
130	27.73	24.79	27.66	24.72	17.64	15.81	14.98	13.54	23.58	20.88
120	38.94	34.87	38.84	34.76	28.77	25.60	25.09	22.35	34.94	31.15

Table G-95. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.03	0.03
180	0.51	0.49	0.50	0.48	0.07	0.07	0.02	0.02	0.15	0.14
175	1.03	0.98	1.00	0.96	0.12	0.12	0.09	0.09	0.46	0.44
170	1.87	1.78	1.84	1.75	0.31	0.30	0.17	0.16	0.86	0.82
160	4.61	4.29	4.57	4.25	1.33	1.28	0.86	0.82	2.65	2.49
150	8.71	7.97	8.67	7.92	3.56	3.32	2.60	2.45	5.95	5.50
140	14.54	13.09	14.48	13.04	7.46	6.85	5.87	5.42	11.20	10.16
130	22.44	19.77	22.35	19.68	13.83	12.54	11.39	10.36	18.29	16.39
120	33.19	29.54	33.11	29.46	22.81	20.15	19.04	17.09	29.21	25.98

Table G-96. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.18	0.18	0.18	0.17	-	-	-	-	0.08	0.08
190	1.07	1.02	1.04	0.99	0.13	0.13	0.09	0.09	0.47	0.45
180	3.21	2.99	3.16	2.94	0.70	0.65	0.47	0.44	1.64	1.57
175	5.07	4.69	5.02	4.65	1.37	1.32	0.88	0.84	2.76	2.60
170	7.38	6.72	7.31	6.67	2.39	2.23	1.62	1.56	4.53	4.22
160	14.51	12.99	14.44	12.93	6.11	5.64	4.43	4.12	10.31	9.36
150	28.58	25.36	28.41	25.23	14.47	12.97	10.93	9.87	22.47	19.62
140	53.57	47.84	52.93	47.28	32.32	28.58	25.80	22.81	44.29	39.50
130	>90	84.97	>90	84.87	67.10	59.80	54.22	48.39	>90	83.38
120	>90	85.88	>90	85.78	>90	85.52	>90	85.09	>90	85.74

Table G-97. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.07	0.07	0.07	0.07	-	-	-	-	-	-
190	0.48	0.46	0.47	0.46	0.06	0.06	0.02	0.02	0.13	0.13
180	1.75	1.66	1.73	1.63	0.26	0.24	0.13	0.13	0.76	0.74
175	2.90	2.73	2.86	2.70	0.60	0.57	0.32	0.31	1.46	1.40
170	4.68	4.34	4.64	4.30	1.21	1.16	0.77	0.74	2.51	2.37
160	9.65	8.82	9.60	8.77	3.51	3.25	2.49	2.35	6.40	5.90
150	18.70	16.61	18.61	16.53	8.81	8.06	6.39	5.88	14.19	12.74
140	36.33	32.31	36.11	32.10	19.74	17.57	15.32	13.69	30.17	26.69
130	71.94	64.00	70.49	62.75	42.37	37.72	34.59	30.69	58.82	52.47
120	>90	85.38	>90	85.33	>90	83.40	76.30	67.86	>90	85.16

Table G-98. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.04	0.04	-	-	-	-	-	-
190	0.18	0.18	0.18	0.17	-	-	-	-	0.08	0.08
180	1.07	1.02	1.04	0.99	0.13	0.13	0.09	0.09	0.47	0.45
175	1.93	1.83	1.90	1.81	0.31	0.30	0.15	0.14	0.87	0.84
170	3.21	2.99	3.16	2.94	0.70	0.65	0.47	0.44	1.64	1.57
160	7.38	6.72	7.31	6.67	2.39	2.23	1.62	1.56	4.53	4.22
150	14.51	12.99	14.44	12.93	6.11	5.64	4.43	4.12	10.31	9.36
140	28.58	25.36	28.41	25.23	14.47	12.97	10.93	9.87	22.47	19.62
130	53.57	47.84	52.93	47.28	32.32	28.58	25.80	22.81	44.29	39.50
120	>90	84.97	>90	84.87	67.11	59.80	54.22	48.39	>90	83.38

Table G-99. Monopile foundation (16 m diameter, NNN 6600, 6600(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.09	0.09	0.09	-	-	-	-	0.02	0.02
180	0.52	0.50	0.51	0.50	0.06	0.06	0.02	0.02	0.14	0.13
175	1.07	1.02	1.04	0.99	0.13	0.13	0.09	0.09	0.47	0.45
170	1.93	1.83	1.90	1.81	0.31	0.30	0.15	0.14	0.87	0.84
160	5.07	4.69	5.02	4.65	1.37	1.32	0.88	0.84	2.76	2.60
150	10.30	9.31	10.21	9.26	3.87	3.61	2.73	2.57	6.94	6.38
140	19.81	17.63	19.73	17.56	9.49	8.71	7.00	6.42	15.23	13.63
130	38.48	34.30	38.21	34.06	21.82	19.05	16.60	14.80	32.20	28.49
120	78.89	70.02	76.82	68.21	45.62	40.69	37.02	32.93	63.30	56.44

G.3.2. 4.5 m Diameter Pin Pile (post-piled, 2 dB shift)

Table G-100. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.10	0.10	0.10	-	-	-	-	0.05	0.05
190	0.48	0.46	0.46	0.45	0.12	0.12	0.09	0.09	0.24	0.24
180	1.95	1.88	1.93	1.86	0.53	0.52	0.36	0.35	1.20	1.15
175	3.32	3.16	3.28	3.12	1.24	1.19	0.80	0.77	2.14	2.05
170	5.17	4.88	5.12	4.84	2.22	2.12	1.64	1.57	3.56	3.38
160	9.86	9.23	9.80	9.17	5.30	5.00	4.32	4.09	7.41	6.87
150	17.92	16.34	17.82	16.26	9.68	8.96	8.34	7.70	13.44	12.35
140	29.23	26.29	29.09	26.17	17.02	15.53	14.62	13.37	22.99	20.83
130	49.18	42.39	48.71	42.05	29.83	26.61	25.65	23.20	39.08	34.37
120	>90	78.61	>90	77.88	60.14	51.25	48.66	41.60	82.43	71.55

Table G-101. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.15	0.14	0.15	0.14	0.02	0.02	-	-	0.10	0.10
180	0.86	0.83	0.84	0.81	0.23	0.23	0.13	0.13	0.44	0.43
175	1.76	1.68	1.73	1.66	0.46	0.45	0.31	0.30	0.96	0.93
170	2.97	2.84	2.94	2.81	0.99	0.95	0.72	0.69	1.93	1.85
160	6.83	6.42	6.79	6.38	3.27	3.09	2.56	2.45	4.93	4.66
150	13.06	12.05	12.96	11.98	6.88	6.41	5.76	5.40	9.30	8.66
140	21.82	19.80	21.67	19.67	12.44	11.40	10.28	9.41	16.62	15.16
130	35.23	31.24	35.01	31.08	20.97	18.99	18.00	16.40	28.30	25.44
120	68.30	57.02	66.94	56.04	37.71	33.13	31.98	28.41	51.18	43.95

Table G-102. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.05	0.05
180	0.48	0.46	0.46	0.45	0.12	0.12	0.09	0.09	0.24	0.24
175	0.98	0.95	0.97	0.93	0.27	0.26	0.14	0.13	0.50	0.49
170	1.95	1.88	1.93	1.86	0.53	0.52	0.36	0.35	1.20	1.15
160	5.17	4.88	5.12	4.84	2.22	2.12	1.64	1.57	3.56	3.38
150	9.86	9.23	9.80	9.17	5.30	5.00	4.32	4.09	7.41	6.87
140	17.92	16.34	17.82	16.26	9.68	8.96	8.34	7.70	13.44	12.35
130	29.23	26.29	29.09	26.17	17.02	15.53	14.62	13.37	22.99	20.83
120	49.18	42.39	48.71	42.05	29.83	26.61	25.65	23.20	39.08	34.37

Table G-103. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.16	0.16	0.16	0.16	0.06	0.06	-	-	0.11	0.11
175	0.48	0.46	0.46	0.45	0.12	0.12	0.09	0.09	0.24	0.24
170	0.98	0.95	0.97	0.93	0.27	0.26	0.14	0.13	0.50	0.49
160	3.32	3.16	3.28	3.12	1.24	1.19	0.80	0.77	2.14	2.05
150	7.33	6.83	7.27	6.78	3.60	3.41	2.78	2.65	5.33	5.02
140	13.84	12.72	13.76	12.65	7.34	6.78	6.14	5.75	9.78	9.11
130	23.19	21.02	23.04	20.89	13.14	12.05	11.02	10.03	17.51	15.96
120	37.11	32.74	36.88	32.56	22.51	20.37	18.91	17.24	29.75	26.64

Table G-104. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
190	0.48	0.46	0.47	0.45	0.12	0.12	0.09	0.09	0.23	0.22
180	1.97	1.90	1.95	1.88	0.55	0.53	0.39	0.38	1.22	1.18
175	3.47	3.30	3.43	3.26	1.28	1.22	0.84	0.81	2.19	2.10
170	5.59	5.24	5.53	5.19	2.28	2.17	1.69	1.62	3.68	3.49
160	12.34	11.40	12.24	11.31	5.61	5.25	4.44	4.21	8.16	7.59
150	24.32	22.00	24.11	21.80	11.80	10.86	9.25	8.60	17.45	15.80
140	89.99	78.43	87.76	73.14	29.46	26.47	20.93	18.84	53.62	46.44
130	>90	85.83	>90	85.79	>90	85.24	>90	84.34	>90	85.71
120	>90	85.98	>90	85.97	>90	85.97	>90	85.97	>90	85.97

Table G-105. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.15	0.15	0.15	0.14	0.02	0.02	-	-	0.10	0.10
180	0.88	0.84	0.86	0.83	0.16	0.16	0.13	0.13	0.47	0.45
175	1.79	1.71	1.76	1.69	0.49	0.48	0.29	0.28	0.98	0.94
170	3.08	2.93	3.03	2.89	1.06	1.00	0.74	0.69	1.95	1.87
160	7.57	7.08	7.50	7.02	3.38	3.19	2.62	2.50	5.25	4.92
150	16.16	14.71	16.06	14.63	7.44	6.91	6.04	5.67	11.14	10.26
140	35.30	31.76	34.79	31.34	16.09	14.63	12.94	11.94	24.37	21.85
130	>90	85.04	>90	84.89	57.88	49.73	37.43	34.06	>90	83.81
120	>90	85.94	>90	85.89	>90	85.81	>90	85.71	>90	85.88

Table G-106. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
180	0.48	0.46	0.47	0.45	0.12	0.12	0.09	0.09	0.23	0.22
175	1.00	0.97	0.98	0.95	0.26	0.25	0.14	0.14	0.52	0.50
170	1.97	1.90	1.95	1.88	0.55	0.53	0.39	0.38	1.22	1.17
160	5.59	5.24	5.53	5.19	2.28	2.17	1.69	1.62	3.68	3.49
150	12.34	11.40	12.24	11.31	5.61	5.25	4.44	4.21	8.16	7.59
140	24.32	22.00	24.11	21.80	11.80	10.86	9.25	8.60	17.45	15.80
130	>90	78.43	87.76	73.14	29.46	26.47	20.93	18.84	53.62	46.44
120	>90	85.83	>90	85.79	>90	85.24	>90	84.34	>90	85.71

Table G-107. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.17	0.16	0.16	0.16	0.06	0.06	-	-	0.11	0.11
175	0.48	0.46	0.47	0.45	0.12	0.12	0.09	0.09	0.23	0.22
170	1.00	0.97	0.98	0.95	0.26	0.25	0.14	0.14	0.52	0.50
160	3.47	3.30	3.43	3.26	1.28	1.22	0.84	0.81	2.19	2.10
150	8.28	7.69	8.20	7.62	3.70	3.51	2.82	2.69	5.69	5.33
140	17.20	15.62	17.10	15.52	8.00	7.43	6.49	6.09	12.16	11.20
130	39.51	35.22	38.90	34.70	17.32	15.69	14.02	12.87	27.07	24.35
120	>90	85.23	>90	85.14	72.56	61.64	44.56	39.93	>90	84.60

Table G-108. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
190	0.27	0.26	0.26	0.26	0.07	0.07	0.06	0.06	0.12	0.12
180	1.44	1.39	1.42	1.37	0.34	0.34	0.25	0.24	0.77	0.74
175	2.75	2.64	2.72	2.61	0.79	0.77	0.52	0.51	1.54	1.48
170	4.95	4.66	4.90	4.62	1.63	1.57	1.16	1.11	2.86	2.75
160	12.00	10.99	11.94	10.92	5.19	4.89	3.78	3.64	8.52	7.93
150	23.50	21.37	23.36	21.24	13.10	12.04	9.96	9.31	18.60	16.93
140	44.19	38.85	43.78	38.49	27.77	25.13	22.92	20.80	37.03	32.93
130	86.72	75.74	84.49	74.42	60.17	52.24	49.81	43.86	80.58	69.38
120	>90	85.26	>90	85.15	>90	84.78	>90	84.42	>90	85.03

Table G-109. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.10	0.09	0.09	0.09	0.04	0.04	-	-	0.06	0.06
180	0.55	0.53	0.54	0.52	0.11	0.11	0.09	0.09	0.27	0.26
175	1.23	1.18	1.20	1.15	0.29	0.28	0.22	0.22	0.68	0.65
170	2.44	2.34	2.40	2.30	0.72	0.69	0.46	0.45	1.40	1.34
160	7.22	6.73	7.16	6.68	2.60	2.50	1.92	1.84	4.70	4.46
150	15.88	14.44	15.80	14.37	7.66	7.14	5.83	5.46	12.10	11.11
140	30.31	27.29	30.11	27.13	17.70	16.08	14.42	13.20	25.00	22.65
130	60.21	51.84	58.75	50.70	36.74	32.96	31.11	28.15	48.88	42.55
120	>90	83.57	>90	82.75	82.96	72.93	76.75	66.40	>90	79.75

Table G-110. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.27	0.26	0.26	0.26	0.07	0.07	0.06	0.06	0.12	0.12
175	0.74	0.72	0.72	0.70	0.16	0.16	0.10	0.09	0.31	0.30
170	1.44	1.39	1.42	1.37	0.34	0.34	0.25	0.24	0.77	0.74
160	4.95	4.66	4.90	4.62	1.63	1.57	1.16	1.11	2.86	2.75
150	12.00	10.99	11.94	10.92	5.19	4.89	3.78	3.64	8.52	7.93
140	23.50	21.37	23.36	21.24	13.10	12.04	9.96	9.31	18.60	16.93
130	44.19	38.85	43.78	38.49	27.77	25.13	22.92	20.80	37.03	32.93
120	86.72	75.74	84.49	74.42	60.17	52.24	49.81	43.86	80.58	69.38

Table G-111. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.11	0.11	0.11	0.11	0.05	0.05	0.03	0.03	0.07	0.07
175	0.27	0.26	0.26	0.26	0.07	0.07	0.06	0.06	0.12	0.12
170	0.74	0.72	0.72	0.70	0.16	0.16	0.10	0.09	0.31	0.30
160	2.75	2.64	2.72	2.61	0.79	0.77	0.52	0.51	1.54	1.48
150	7.92	7.36	7.88	7.31	2.86	2.76	2.10	2.00	5.23	4.94
140	16.94	15.37	16.86	15.30	8.42	7.83	6.36	6.00	13.10	12.03
130	32.21	28.90	31.98	28.73	18.88	17.20	15.58	14.23	26.71	24.17
120	67.15	57.06	65.18	55.37	39.41	35.29	33.43	30.24	52.78	45.84

Table G-112. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
190	0.27	0.27	0.27	0.26	0.07	0.07	0.06	0.06	0.12	0.12
180	1.43	1.38	1.41	1.36	0.37	0.36	0.23	0.23	0.80	0.77
175	2.62	2.50	2.58	2.46	0.82	0.79	0.53	0.51	1.53	1.47
170	4.96	4.68	4.90	4.62	1.61	1.55	1.18	1.13	2.74	2.63
160	14.14	13.02	14.04	12.93	5.19	4.90	3.66	3.49	9.51	8.84
150	39.60	35.16	39.00	34.69	16.56	15.31	12.02	11.24	28.84	26.27
140	>90	85.15	>90	85.04	64.75	54.18	43.00	37.88	>90	84.21
130	>90	85.87	>90	85.85	>90	85.67	>90	85.45	>90	85.82
120	>90	85.99	>90	85.97	>90	85.97	>90	85.97	>90	85.97

Table G-113. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.10	0.09	0.09	0.09	0.04	0.04	-	-	0.06	0.06
180	0.55	0.53	0.54	0.52	0.11	0.11	0.09	0.09	0.26	0.25
175	1.22	1.17	1.19	1.14	0.31	0.31	0.22	0.21	0.69	0.65
170	2.32	2.22	2.29	2.19	0.74	0.71	0.47	0.45	1.39	1.32
160	7.79	7.22	7.71	7.16	2.51	2.40	1.90	1.83	4.62	4.39
150	20.66	18.70	20.42	18.55	8.43	7.80	5.90	5.58	14.62	13.55
140	73.80	60.87	69.62	57.66	27.52	24.96	19.18	17.71	46.12	40.27
130	>90	85.55	>90	85.50	>90	84.48	>90	77.54	>90	85.34
120	>90	85.96	>90	85.92	>90	85.86	>90	85.80	>90	85.91

Table G-114. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.27	0.27	0.27	0.26	0.07	0.07	0.06	0.06	0.12	0.12
175	0.75	0.73	0.74	0.71	0.15	0.15	0.10	0.09	0.33	0.32
170	1.43	1.38	1.41	1.36	0.37	0.36	0.23	0.23	0.80	0.77
160	4.96	4.68	4.90	4.62	1.61	1.55	1.18	1.13	2.74	2.63
150	14.14	13.02	14.04	12.93	5.19	4.90	3.66	3.49	9.51	8.84
140	39.60	35.16	39.00	34.69	16.56	15.31	12.02	11.24	28.84	26.27
130	>90	85.15	>90	85.04	64.75	54.18	43.00	37.88	>90	84.21
120	>90	85.87	>90	85.85	>90	85.67	>90	85.45	>90	85.82

Table G-115. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.11	0.11	0.11	0.11	0.05	0.05	0.03	0.03	0.07	0.07
175	0.27	0.27	0.27	0.26	0.07	0.07	0.06	0.06	0.12	0.12
170	0.75	0.73	0.74	0.71	0.15	0.15	0.10	0.09	0.33	0.32
160	2.62	2.50	2.58	2.46	0.82	0.79	0.53	0.51	1.53	1.47
150	8.72	8.03	8.64	7.96	2.76	2.65	2.10	2.00	5.28	4.97
140	23.36	21.13	23.12	20.90	9.44	8.77	6.62	6.28	16.24	14.99
130	89.99	77.77	87.16	72.30	31.01	28.18	22.06	19.98	53.07	45.45
120	>90	85.62	>90	85.55	>90	84.97	>90	82.64	>90	85.45

Table G-116. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.04	0.04	-	-	-	-	-	-
190	0.14	0.14	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
180	0.87	0.84	0.86	0.83	0.20	0.20	0.11	0.10	0.40	0.38
175	1.82	1.75	1.78	1.71	0.42	0.40	0.26	0.25	0.85	0.82
170	3.28	3.11	3.20	3.05	0.86	0.83	0.60	0.58	1.78	1.70
160	8.68	8.05	8.62	7.99	3.08	2.95	2.30	2.20	5.60	5.26
150	17.68	16.01	17.58	15.91	9.38	8.73	7.62	7.13	13.78	12.60
140	33.43	30.08	32.91	29.64	22.43	20.05	19.58	17.60	28.21	25.56
130	78.53	67.65	72.09	62.38	50.63	45.14	45.41	41.09	62.04	54.19
120	>90	85.34	>90	85.13	>90	84.91	>90	84.73	>90	85.07

Table G-117. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.36	0.35	0.34	0.33	0.07	0.07	0.06	0.06	0.12	0.12
175	0.81	0.78	0.80	0.77	0.15	0.15	0.09	0.09	0.33	0.32
170	1.58	1.51	1.53	1.48	0.34	0.33	0.23	0.23	0.78	0.76
160	5.10	4.80	5.04	4.74	1.59	1.52	1.13	1.08	2.82	2.69
150	11.96	10.91	11.86	10.82	5.09	4.76	3.88	3.67	8.22	7.66
140	22.72	20.65	22.52	20.45	13.76	12.54	11.62	10.58	18.24	16.53
130	43.45	38.73	42.57	37.88	31.20	28.02	28.30	25.41	37.11	33.51
120	>90	82.90	>90	78.94	80.21	70.32	74.23	64.82	85.21	75.98

Table G-118. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.04	0.04	0.04	0.04	-	-	-	-	-	-
180	0.14	0.14	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
175	0.46	0.44	0.44	0.43	0.08	0.08	0.06	0.06	0.18	0.18
170	0.87	0.84	0.86	0.83	0.20	0.20	0.11	0.10	0.40	0.38
160	3.28	3.11	3.20	3.05	0.86	0.83	0.60	0.58	1.78	1.70
150	8.68	8.05	8.62	7.99	3.08	2.95	2.30	2.20	5.60	5.26
140	17.68	16.01	17.58	15.91	9.38	8.73	7.62	7.13	13.78	12.60
130	33.43	30.08	32.91	29.64	22.43	20.05	19.58	17.60	28.21	25.56
120	78.53	67.65	72.09	62.38	50.63	45.14	45.41	41.09	62.04	54.19

Table G-119. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.07	0.07	0.07	0.07	-	-	-	-	0.05	0.05
175	0.14	0.14	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
170	0.46	0.44	0.44	0.43	0.08	0.08	0.06	0.06	0.18	0.18
160	1.82	1.75	1.78	1.71	0.42	0.40	0.26	0.25	0.85	0.82
150	5.59	5.27	5.52	5.21	1.80	1.72	1.30	1.24	3.16	3.01
140	12.84	11.75	12.76	11.68	5.65	5.32	4.33	4.08	8.99	8.36
130	24.33	22.19	24.10	21.98	15.00	13.58	12.80	11.69	19.36	17.58
120	47.45	41.59	45.69	40.30	33.60	30.28	30.65	27.46	39.75	35.87

Table G-120. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.04	0.04	-	-	-	-	-	-
190	0.16	0.16	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
180	0.89	0.86	0.88	0.84	0.20	0.19	0.11	0.11	0.40	0.38
175	1.79	1.72	1.75	1.66	0.42	0.41	0.24	0.24	0.87	0.84
170	3.20	3.04	3.13	2.97	0.88	0.84	0.57	0.55	1.74	1.66
160	9.63	8.94	9.57	8.88	3.04	2.90	2.28	2.17	5.86	5.53
150	25.16	22.88	24.82	22.55	10.69	9.93	7.98	7.47	17.50	16.14
140	89.99	81.87	89.99	79.46	38.95	35.06	30.98	28.10	62.82	53.20
130	>90	85.83	>90	85.76	>90	85.60	>90	85.30	>90	85.72
120	>90	85.98	>90	85.97	>90	85.97	>90	85.97	>90	85.97

Table G-121. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.36	0.35	0.34	0.34	0.07	0.07	0.06	0.06	0.13	0.13
175	0.83	0.80	0.82	0.79	0.15	0.15	0.09	0.09	0.34	0.33
170	1.55	1.49	1.52	1.46	0.35	0.34	0.23	0.22	0.81	0.78
160	5.24	4.91	5.17	4.85	1.56	1.50	1.12	1.07	2.74	2.62
150	13.96	12.84	13.86	12.74	5.25	4.94	3.70	3.53	9.42	8.74
140	38.23	34.07	37.34	33.36	17.16	15.96	13.12	12.33	28.40	25.87
130	>90	85.24	89.99	85.02	77.44	66.42	56.49	48.84	>90	84.26
120	>90	85.97	>90	85.94	>90	85.86	>90	85.80	>90	85.91

Table G-122. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.04	0.04	0.04	0.04	-	-	-	-	-	-
180	0.16	0.16	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
175	0.46	0.44	0.44	0.42	0.08	0.08	0.06	0.06	0.18	0.17
170	0.89	0.86	0.88	0.84	0.20	0.19	0.11	0.11	0.40	0.38
160	3.20	3.04	3.13	2.97	0.88	0.84	0.57	0.55	1.74	1.66
150	9.63	8.94	9.57	8.88	3.04	2.90	2.28	2.17	5.86	5.53
140	25.16	22.88	24.82	22.55	10.69	9.93	7.98	7.47	17.50	16.14
130	>90	81.87	>90	79.46	38.95	35.06	30.98	28.10	62.82	53.20
120	>90	85.83	>90	85.76	>90	85.60	>90	85.30	>90	85.72

Table G-123. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.07	0.07	0.07	0.07	-	-	-	-	0.05	0.05
175	0.16	0.16	0.14	0.13	0.05	0.05	0.03	0.03	0.08	0.08
170	0.46	0.44	0.44	0.42	0.08	0.08	0.06	0.06	0.18	0.17
160	1.79	1.71	1.75	1.66	0.42	0.41	0.24	0.24	0.87	0.84
150	5.80	5.47	5.73	5.40	1.79	1.71	1.28	1.22	3.06	2.92
140	15.20	13.96	15.08	13.85	5.80	5.51	4.23	4.03	10.26	9.55
130	42.78	37.63	41.54	36.68	19.44	18.06	14.88	13.94	31.81	28.90
120	>90	85.40	>90	85.20	89.98	79.62	68.57	59.15	>90	84.90

Table G-124. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.10	0.10	0.10	-	-	-	-	0.06	0.06
190	0.46	0.44	0.45	0.43	0.12	0.12	0.09	0.09	0.28	0.27
180	1.74	1.66	1.73	1.64	0.64	0.61	0.41	0.40	1.18	1.13
175	2.76	2.59	2.75	2.58	1.22	1.17	0.85	0.80	1.93	1.84
170	4.14	3.84	4.12	3.82	1.99	1.89	1.58	1.50	2.94	2.76
160	7.98	7.27	7.95	7.23	4.46	4.12	3.73	3.44	6.00	5.51
150	14.19	12.66	14.13	12.61	8.27	7.53	6.85	6.30	11.27	10.06
140	22.78	19.84	22.70	19.75	14.96	13.25	12.74	11.44	18.99	16.78
130	33.80	30.01	33.69	29.91	25.17	22.09	21.50	18.66	30.36	26.90
120	48.69	43.08	48.42	42.85	37.59	33.32	33.90	30.05	43.98	39.01

Table G-125. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.02	0.02	0.02	0.02	-	-	-	-	-	-
190	0.18	0.18	0.18	0.17	0.06	0.06	-	-	0.10	0.10
180	0.87	0.82	0.85	0.81	0.23	0.23	0.17	0.16	0.48	0.46
175	1.59	1.51	1.58	1.50	0.52	0.50	0.37	0.35	1.05	0.99
170	2.56	2.41	2.55	2.39	1.10	1.05	0.75	0.72	1.76	1.68
160	5.37	4.97	5.35	4.94	2.85	2.66	2.31	2.17	4.11	3.81
150	9.93	9.06	9.90	9.02	5.68	5.22	4.80	4.44	7.78	7.07
140	17.13	15.14	17.07	15.09	10.38	9.35	8.82	8.06	14.20	12.64
130	27.07	23.99	26.97	23.92	18.27	16.10	15.78	14.00	23.62	20.59
120	38.81	34.51	38.69	34.38	29.76	26.35	26.46	23.37	35.36	31.34

Table G-126. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.06	0.06
180	0.46	0.44	0.45	0.43	0.12	0.12	0.09	0.09	0.28	0.27
175	1.01	0.96	1.00	0.94	0.31	0.30	0.20	0.20	0.58	0.55
170	1.74	1.66	1.73	1.64	0.64	0.61	0.41	0.40	1.18	1.13
160	4.14	3.84	4.12	3.82	1.99	1.89	1.58	1.50	2.94	2.76
150	7.98	7.27	7.95	7.23	4.46	4.12	3.73	3.44	6.00	5.51
140	14.19	12.66	14.13	12.61	8.27	7.53	6.85	6.30	11.27	10.07
130	22.78	19.84	22.70	19.75	14.96	13.25	12.74	11.44	18.99	16.78
120	33.80	30.01	33.69	29.91	25.17	22.09	21.50	18.66	30.36	26.90

Table G-127. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	-	-
180	0.21	0.20	0.20	0.20	0.07	0.07	0.02	0.02	0.11	0.11
175	0.46	0.44	0.45	0.43	0.12	0.12	0.09	0.09	0.28	0.27
170	1.01	0.96	1.00	0.94	0.31	0.30	0.20	0.20	0.58	0.55
160	2.76	2.59	2.75	2.58	1.22	1.17	0.85	0.80	1.93	1.84
150	5.76	5.29	5.72	5.27	3.04	2.82	2.54	2.36	4.38	4.05
140	10.68	9.57	10.61	9.52	6.02	5.54	5.10	4.71	8.29	7.54
130	17.89	15.81	17.83	15.76	11.17	10.00	9.31	8.50	14.96	13.27
120	28.09	24.94	27.99	24.86	19.12	16.88	16.66	14.70	24.81	21.76

Table G-128. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.10	0.10	0.10	0.10	-	-	-	-	0.06	0.06
190	0.48	0.46	0.48	0.45	0.12	0.12	0.09	0.09	0.28	0.27
180	1.84	1.75	1.81	1.73	0.68	0.65	0.42	0.40	1.24	1.18
175	2.90	2.72	2.88	2.70	1.29	1.23	0.93	0.87	2.02	1.91
170	4.43	4.11	4.40	4.08	2.11	2.00	1.66	1.58	3.17	2.92
160	9.35	8.54	9.31	8.49	4.78	4.40	4.00	3.69	6.69	6.14
150	18.77	16.63	18.68	16.56	9.65	8.78	7.92	7.19	14.60	13.02
140	38.50	34.20	38.14	33.89	21.78	18.94	16.97	15.04	31.94	28.17
130	>90	82.87	89.99	82.14	52.13	46.39	40.74	36.21	75.01	66.37
120	>90	85.80	>90	85.77	>90	85.45	>90	84.87	>90	85.71

Table G-129. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.02	0.02	0.02	0.02	-	-	-	-	-	-
190	0.17	0.17	0.17	0.16	0.06	0.06	-	-	0.11	0.10
180	0.91	0.87	0.90	0.86	0.23	0.22	0.13	0.13	0.48	0.47
175	1.67	1.58	1.65	1.57	0.54	0.52	0.38	0.37	1.10	1.05
170	2.69	2.53	2.66	2.51	1.17	1.12	0.79	0.75	1.87	1.77
160	5.98	5.50	5.95	5.47	2.97	2.78	2.45	2.30	4.37	4.05
150	12.60	11.34	12.53	11.28	6.27	5.74	5.21	4.78	9.14	8.33
140	25.43	22.44	25.27	22.30	13.38	11.98	10.47	9.41	19.55	17.33
130	53.33	47.42	52.57	46.73	30.80	27.16	24.28	21.26	43.63	38.73
120	>90	85.22	>90	85.14	78.19	69.72	60.50	53.84	>90	84.71

Table G-130. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.06	0.06
180	0.48	0.46	0.48	0.45	0.12	0.12	0.09	0.09	0.28	0.27
175	1.07	1.01	1.05	0.99	0.31	0.31	0.20	0.19	0.63	0.60
170	1.84	1.75	1.81	1.73	0.68	0.65	0.42	0.40	1.24	1.18
160	4.43	4.11	4.40	4.08	2.11	2.00	1.66	1.58	3.17	2.92
150	9.35	8.54	9.31	8.49	4.78	4.40	4.00	3.69	6.69	6.14
140	18.77	16.63	18.68	16.56	9.65	8.78	7.92	7.19	14.60	13.02
130	38.50	34.20	38.14	33.89	21.78	18.94	16.97	15.04	31.94	28.17
120	>90	82.87	>90	82.14	52.13	46.39	40.74	36.21	75.01	66.37

Table G-131. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 at 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.04	0.04	0.03	0.03	-	-	-	-	-	-
180	0.20	0.20	0.20	0.20	0.07	0.07	0.02	0.02	0.11	0.11
175	0.48	0.46	0.48	0.45	0.12	0.12	0.09	0.09	0.28	0.27
170	1.07	1.01	1.05	0.99	0.31	0.31	0.20	0.19	0.63	0.60
160	2.90	2.72	2.88	2.70	1.29	1.23	0.93	0.87	2.02	1.91
150	6.46	5.93	6.41	5.89	3.27	3.03	2.65	2.49	4.68	4.33
140	13.48	12.10	13.41	12.05	6.70	6.14	5.56	5.10	9.73	8.89
130	27.20	24.09	27.01	23.94	14.45	12.88	11.47	10.26	21.37	18.63
120	58.12	51.58	57.16	50.74	33.38	29.49	26.46	23.33	47.60	42.31

Table G-132. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500 (b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
190	0.32	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.16
180	1.52	1.45	1.50	1.43	0.42	0.41	0.28	0.27	0.81	0.77
175	2.66	2.53	2.64	2.50	0.93	0.89	0.63	0.61	1.62	1.55
170	4.35	4.06	4.31	4.03	1.67	1.60	1.25	1.18	2.78	2.63
160	9.09	8.34	9.05	8.30	4.58	4.28	3.60	3.32	6.93	6.38
150	16.53	14.78	16.48	14.73	9.82	9.03	8.27	7.57	13.83	12.47
140	27.18	24.27	27.07	24.19	18.61	16.64	16.19	14.47	23.91	21.23
130	39.40	35.26	39.21	35.09	31.13	27.66	27.85	24.99	36.10	32.25
120	58.85	52.61	57.98	51.79	47.85	42.48	44.40	39.34	53.88	48.16

Table G-133. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500 (b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	0.04	0.04	0.02	0.02	0.06	0.06
180	0.67	0.64	0.65	0.62	0.16	0.16	0.08	0.08	0.31	0.31
175	1.32	1.26	1.30	1.25	0.35	0.34	0.22	0.21	0.74	0.71
170	2.39	2.28	2.37	2.25	0.75	0.72	0.53	0.50	1.45	1.37
160	5.98	5.53	5.95	5.50	2.57	2.44	1.93	1.84	4.22	3.95
150	11.84	10.70	11.80	10.65	6.42	5.92	5.10	4.73	9.25	8.49
140	19.88	17.80	19.83	17.75	13.18	11.93	10.86	9.83	17.30	15.44
130	31.96	28.42	31.83	28.30	23.50	20.81	19.88	17.86	28.73	25.56
120	45.96	41.09	45.51	40.70	36.13	32.29	33.23	29.59	41.76	37.38

Table G-134. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500 (b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.32	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.16
175	0.75	0.72	0.74	0.72	0.19	0.18	0.10	0.10	0.40	0.38
170	1.52	1.45	1.50	1.43	0.42	0.41	0.28	0.27	0.81	0.77
160	4.35	4.06	4.31	4.03	1.67	1.60	1.24	1.18	2.78	2.63
150	9.09	8.34	9.05	8.30	4.58	4.28	3.60	3.32	6.93	6.38
140	16.53	14.78	16.48	14.73	9.82	9.03	8.27	7.57	13.83	12.47
130	27.18	24.27	27.07	24.19	18.61	16.64	16.19	14.47	23.92	21.23
120	39.40	35.26	39.21	35.09	31.13	27.66	27.85	24.99	36.10	32.25

Table G-135. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500 (b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.13	0.12	0.12	0.12	0.05	0.05	0.03	0.03	0.07	0.07
175	0.32	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.16
170	0.75	0.72	0.74	0.72	0.19	0.18	0.10	0.10	0.40	0.38
160	2.66	2.53	2.64	2.50	0.93	0.89	0.63	0.61	1.62	1.55
150	6.44	5.94	6.40	5.91	2.83	2.66	2.14	2.03	4.60	4.30
140	12.60	11.39	12.56	11.35	6.93	6.37	5.54	5.13	9.76	8.98
130	21.17	18.68	21.06	18.59	14.03	12.64	11.77	10.65	18.19	16.24
120	33.14	29.49	33.00	29.36	24.76	22.07	21.31	18.83	29.96	26.63

Table G-136. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
190	0.33	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.15
180	1.57	1.51	1.55	1.49	0.43	0.41	0.29	0.28	0.85	0.81
175	2.82	2.68	2.80	2.66	0.94	0.88	0.64	0.61	1.67	1.60
170	4.88	4.54	4.84	4.51	1.68	1.61	1.26	1.20	3.00	2.85
160	12.19	11.07	12.12	11.00	5.37	5.01	3.95	3.71	8.97	8.19
150	28.24	25.15	28.00	24.94	15.64	14.06	11.63	10.61	23.38	20.57
140	69.01	61.24	65.72	58.46	40.86	36.43	33.14	29.50	55.98	49.84
130	>90	85.90	>90	85.74	>90	85.49	>90	85.20	>90	85.68
120	>90	85.80	>90	85.75	>90	85.74	>90	85.73	>90	85.75

Table G-137. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	0.04	0.04	-	-	0.06	0.06
180	0.67	0.64	0.65	0.62	0.15	0.15	0.09	0.09	0.32	0.31
175	1.38	1.32	1.36	1.30	0.37	0.35	0.24	0.20	0.74	0.72
170	2.56	2.43	2.53	2.40	0.77	0.74	0.52	0.50	1.47	1.41
160	7.10	6.51	7.05	6.47	2.69	2.57	1.92	1.84	4.85	4.53
150	17.35	15.48	17.24	15.38	8.31	7.56	6.05	5.62	13.32	12.09
140	38.13	34.02	37.59	33.53	23.50	20.67	18.19	16.28	32.15	28.59
130	>90	84.77	>90	84.31	64.09	57.14	52.98	47.34	>90	81.52
120	>90	85.82	>90	85.83	>90	85.84	>90	85.85	>90	85.83

Table G-138. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.06	0.06	0.06	0.06	-	-	-	-	0.04	0.04
180	0.33	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.15
175	0.75	0.73	0.75	0.72	0.18	0.17	0.10	0.09	0.41	0.39
170	1.57	1.51	1.55	1.49	0.43	0.41	0.29	0.28	0.85	0.81
160	4.88	4.54	4.84	4.51	1.68	1.61	1.26	1.20	3.00	2.85
150	12.19	11.07	12.12	11.00	5.37	5.01	3.95	3.71	8.97	8.19
140	28.24	25.15	28.00	24.94	15.64	14.06	11.63	10.61	23.38	20.57
130	69.01	61.24	65.72	58.46	40.86	36.43	33.14	29.50	55.98	49.84
120	>90	85.90	>90	85.74	>90	85.49	>90	85.20	>90	85.68

Table G-139. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.13	0.13	0.13	0.13	0.05	0.05	0.03	0.03	0.07	0.07
175	0.33	0.31	0.32	0.31	0.07	0.07	0.06	0.06	0.16	0.15
170	0.75	0.73	0.75	0.72	0.18	0.17	0.10	0.09	0.41	0.39
160	2.82	2.68	2.80	2.66	0.94	0.88	0.64	0.61	1.67	1.60
150	7.82	7.14	7.77	7.10	2.99	2.83	2.17	2.07	5.39	5.02
140	18.78	16.73	18.67	16.63	9.15	8.34	6.77	6.25	14.72	13.23
130	41.89	37.29	41.01	36.57	25.78	22.84	19.90	17.82	34.75	30.96
120	>90	85.12	>90	84.77	73.21	65.35	59.48	53.21	>90	84.02

Table G-140. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
180	0.40	0.39	0.39	0.38	0.11	0.10	0.05	0.05	0.20	0.19
175	0.76	0.73	0.74	0.72	0.20	0.19	0.14	0.14	0.40	0.39
170	1.43	1.35	1.39	1.32	0.44	0.42	0.27	0.26	0.78	0.74
160	3.64	3.37	3.58	3.32	1.53	1.46	1.16	1.10	2.43	2.28
150	7.75	7.09	7.69	7.05	4.20	3.96	3.38	3.18	5.95	5.54
140	15.05	13.53	14.98	13.47	9.73	9.01	8.45	7.78	12.86	11.74
130	26.19	23.45	26.02	23.31	19.57	17.65	17.71	15.96	23.76	21.16
120	39.98	35.88	39.55	35.44	33.75	30.16	31.46	28.06	37.27	33.41

Table G-141. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.18	0.17	0.17	0.16	0.03	0.03	0.02	0.02	0.10	0.10
175	0.35	0.34	0.33	0.32	0.10	0.10	0.04	0.04	0.16	0.16
170	0.69	0.66	0.67	0.64	0.17	0.16	0.13	0.13	0.35	0.34
160	2.08	1.94	2.02	1.90	0.74	0.70	0.55	0.53	1.30	1.24
150	4.98	4.61	4.92	4.57	2.33	2.20	1.82	1.74	3.55	3.32
140	9.94	9.13	9.90	9.09	6.02	5.60	4.98	4.66	8.27	7.61
130	18.75	16.80	18.67	16.72	13.44	12.28	11.50	10.59	16.69	14.98
120	31.50	28.07	31.27	27.87	25.27	22.72	22.60	20.29	29.12	26.00

Table G-142. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
175	0.21	0.20	0.20	0.20	0.03	0.03	0.02	0.02	0.10	0.10
170	0.40	0.39	0.39	0.38	0.11	0.10	0.05	0.05	0.20	0.19
160	1.43	1.35	1.39	1.32	0.44	0.42	0.27	0.26	0.78	0.74
150	3.64	3.37	3.58	3.32	1.53	1.46	1.16	1.10	2.43	2.28
140	7.75	7.09	7.69	7.05	4.20	3.96	3.38	3.18	5.95	5.54
130	15.05	13.53	14.98	13.47	9.73	9.01	8.45	7.78	12.86	11.74
120	26.19	23.45	26.02	23.31	19.57	17.65	17.71	15.96	23.76	21.16

Table G-143. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.02	0.02	0.02	0.02	-	-	-	-	-	-
175	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
170	0.21	0.20	0.20	0.20	0.03	0.03	0.02	0.02	0.10	0.10
160	0.76	0.73	0.74	0.72	0.20	0.19	0.14	0.14	0.40	0.39
150	2.32	2.17	2.27	2.12	0.85	0.80	0.61	0.59	1.45	1.38
140	5.35	4.96	5.30	4.92	2.60	2.46	1.99	1.90	3.92	3.66
130	10.79	9.77	10.73	9.71	6.56	6.10	5.38	5.06	8.88	8.19
120	19.66	17.63	19.56	17.55	14.36	13.11	12.54	11.50	17.68	15.86

Table G-144. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
180	0.41	0.40	0.40	0.38	0.11	0.10	0.05	0.05	0.21	0.20
175	0.78	0.75	0.76	0.73	0.22	0.21	0.14	0.13	0.41	0.39
170	1.41	1.34	1.37	1.31	0.46	0.44	0.31	0.30	0.81	0.77
160	3.53	3.26	3.47	3.20	1.53	1.46	1.17	1.11	2.33	2.19
150	8.08	7.38	8.02	7.33	4.03	3.76	3.17	2.94	5.83	5.41
140	19.43	17.40	19.29	17.28	10.24	9.44	8.36	7.67	15.81	14.26
130	49.78	44.67	48.38	43.44	31.01	27.59	24.90	22.15	41.68	37.34
120	>90	85.69	>90	85.61	>90	84.60	84.64	76.14	>90	85.48

Table G-145. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.19	0.18	0.18	0.17	0.03	0.03	0.02	0.02	0.10	0.09
175	0.36	0.35	0.34	0.33	0.10	0.09	0.04	0.04	0.18	0.17
170	0.71	0.68	0.69	0.66	0.18	0.17	0.12	0.12	0.37	0.35
160	2.02	1.90	1.97	1.87	0.76	0.73	0.55	0.53	1.30	1.23
150	4.91	4.55	4.85	4.50	2.26	2.13	1.78	1.69	3.36	3.12
140	11.43	10.40	11.34	10.31	5.81	5.38	4.70	4.37	8.51	7.83
130	28.33	25.29	28.00	24.99	16.35	14.78	12.80	11.75	23.41	20.73
120	85.58	77.00	77.87	70.12	47.38	42.55	38.25	34.16	64.86	58.26

Table G-146. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
175	0.22	0.21	0.21	0.20	0.03	0.03	0.02	0.02	0.10	0.10
170	0.41	0.40	0.40	0.38	0.11	0.10	0.05	0.05	0.21	0.20
160	1.41	1.34	1.37	1.31	0.46	0.44	0.31	0.30	0.81	0.77
150	3.53	3.26	3.47	3.20	1.53	1.46	1.17	1.11	2.33	2.19
140	8.08	7.38	8.02	7.33	4.03	3.76	3.17	2.94	5.83	5.41
130	19.43	17.40	19.29	17.28	10.24	9.44	8.36	7.67	15.81	14.26
120	49.78	44.67	48.38	43.44	31.01	27.59	24.90	22.15	41.68	37.34

Table G-147. Post-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.02	0.02	0.02	0.02	-	-	-	-	-	-
175	0.10	0.10	0.10	0.10	-	-	-	-	0.03	0.03
170	0.22	0.21	0.21	0.20	0.03	0.03	0.02	0.02	0.10	0.10
160	0.78	0.75	0.76	0.73	0.22	0.21	0.14	0.13	0.41	0.39
150	2.25	2.11	2.19	2.05	0.88	0.84	0.63	0.60	1.45	1.37
140	5.32	4.92	5.26	4.87	2.50	2.36	1.93	1.84	3.71	3.45
130	12.63	11.48	12.53	11.40	6.37	5.89	5.16	4.79	9.31	8.59
120	31.05	27.64	30.63	27.27	18.10	16.30	14.35	13.06	25.82	23.03

G.3.3. 4.5 m Diameter Pin Pile (pre-piled)

Table G-148. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.08	0.08	0.08	0.08	-	-	-	-	-	-
190	0.30	0.29	0.30	0.28	0.10	0.09	0.08	0.08	0.14	0.14
180	1.57	1.51	1.55	1.49	0.41	0.40	0.28	0.28	0.83	0.80
175	2.73	2.61	2.70	2.59	0.89	0.86	0.55	0.54	1.73	1.65
170	4.38	4.18	4.34	4.14	1.80	1.71	1.28	1.22	2.89	2.77
160	8.85	8.25	8.80	8.20	4.60	4.34	3.69	3.48	6.53	6.11
150	16.24	14.83	16.16	14.75	8.74	8.08	7.40	6.83	11.98	11.01
140	26.76	24.23	26.64	24.12	15.36	14.03	13.18	12.07	20.11	18.32
130	43.43	37.97	43.13	37.72	26.76	24.15	22.72	20.57	34.81	30.83
120	83.96	73.46	83.52	72.81	50.52	43.23	41.39	36.17	75.51	62.89

Table G-149. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.13	0.13	0.12	0.12	-	-	-	-	0.09	0.09
180	0.64	0.62	0.62	0.60	0.13	0.13	0.11	0.11	0.31	0.30
175	1.36	1.31	1.34	1.29	0.33	0.31	0.26	0.25	0.76	0.73
170	2.50	2.40	2.47	2.37	0.77	0.74	0.48	0.47	1.54	1.48
160	5.98	5.64	5.94	5.60	2.72	2.60	2.02	1.93	4.24	4.01
150	11.48	10.61	11.40	10.52	6.08	5.70	5.00	4.72	8.36	7.76
140	19.49	17.83	19.40	17.76	10.98	10.00	9.24	8.57	14.94	13.70
130	31.94	28.58	31.80	28.45	18.85	17.18	16.24	14.78	25.64	23.24
120	56.46	48.34	55.78	47.80	33.25	29.49	28.64	25.62	44.01	38.52

Table G-150. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.08	0.08	0.08	0.08	-	-	-	-	-	-
180	0.30	0.29	0.30	0.28	0.10	0.09	0.08	0.08	0.14	0.14
175	0.76	0.73	0.75	0.73	0.14	0.14	0.12	0.12	0.38	0.37
170	1.57	1.51	1.55	1.49	0.41	0.40	0.28	0.28	0.83	0.80
160	4.38	4.18	4.34	4.14	1.80	1.71	1.28	1.22	2.89	2.77
150	8.85	8.25	8.80	8.20	4.60	4.34	3.69	3.48	6.53	6.11
140	16.24	14.83	16.16	14.75	8.74	8.08	7.40	6.83	11.98	11.01
130	26.76	24.23	26.64	24.12	15.36	14.03	13.18	12.07	20.11	18.32
120	43.43	37.97	43.13	37.72	26.76	24.15	22.72	20.57	34.81	30.83

Table G-151. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.13	0.13	0.13	0.13	-	-	-	-	0.09	0.09
175	0.30	0.29	0.30	0.28	0.10	0.09	0.08	0.08	0.14	0.14
170	0.76	0.73	0.75	0.73	0.14	0.14	0.12	0.12	0.38	0.37
160	2.73	2.61	2.70	2.59	0.89	0.86	0.55	0.54	1.73	1.65
150	6.40	6.03	6.36	5.99	2.93	2.80	2.30	2.19	4.58	4.34
140	12.28	11.36	12.20	11.28	6.48	6.05	5.37	5.06	8.84	8.20
130	20.46	18.62	20.32	18.51	11.74	10.71	9.72	8.99	15.76	14.42
120	33.52	29.84	33.33	29.69	19.70	17.98	17.06	15.56	26.92	24.33

Table G-152. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%
200	0.08	0.08	0.08	0.08	-	-	-	-	-	-
190	0.27	0.26	0.27	0.26	0.10	0.10	0.06	0.06	0.15	0.14
180	1.61	1.54	1.58	1.52	0.44	0.43	0.27	0.26	0.86	0.83
175	2.78	2.66	2.75	2.64	0.90	0.87	0.57	0.55	1.76	1.69
170	4.66	4.41	4.61	4.37	1.83	1.75	1.32	1.26	2.96	2.83
160	10.36	9.59	10.26	9.51	4.75	4.50	3.76	3.57	7.02	6.58
150	20.48	18.49	20.28	18.36	9.80	9.14	8.06	7.47	15.18	13.86
140	60.08	50.89	57.59	49.13	22.67	20.22	17.65	16.01	39.46	35.39
130	>90	85.69	>90	85.57	>90	84.47	87.10	74.27	>90	85.39
120	>90	85.98	>90	85.97	>90	85.96	>90	85.93	>90	85.97

Table G-153. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%
200	-	-	-	-	-	-	-	-	-	-
190	0.13	0.13	0.12	0.12	-	-	-	-	0.09	0.09
180	0.62	0.60	0.61	0.59	0.14	0.13	0.11	0.11	0.34	0.34
175	1.38	1.32	1.36	1.30	0.35	0.34	0.22	0.22	0.78	0.76
170	2.56	2.45	2.52	2.42	0.81	0.78	0.51	0.49	1.58	1.52
160	6.48	6.11	6.43	6.06	2.76	2.64	2.07	1.98	4.40	4.18
150	14.22	13.02	14.12	12.94	6.46	6.06	5.22	4.90	9.41	8.78
140	28.70	26.07	28.42	25.81	13.84	12.70	10.86	9.99	19.80	17.94
130	>90	84.11	>90	83.71	39.77	35.91	27.54	24.76	83.35	70.06
120	>90	85.88	>90	85.85	>90	85.68	>90	85.26	>90	85.82

Table G-154. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%
200	-	-	-	-	-	-	-	-	-	-
190	0.08	0.08	0.08	0.08	-	-	-	-	-	-
180	0.27	0.26	0.27	0.26	0.10	0.10	0.06	0.06	0.15	0.14
175	0.77	0.74	0.75	0.73	0.15	0.14	0.12	0.12	0.41	0.39
170	1.61	1.54	1.58	1.52	0.44	0.43	0.27	0.26	0.86	0.83
160	4.66	4.41	4.61	4.37	1.83	1.75	1.32	1.26	2.96	2.83
150	10.36	9.59	10.26	9.51	4.75	4.50	3.76	3.57	7.02	6.58
140	20.48	18.49	20.28	18.36	9.80	9.14	8.06	7.47	15.18	13.86
130	60.08	50.89	57.59	49.13	22.67	20.22	17.65	16.01	39.46	35.39
120	>90	85.69	>90	85.57	>90	84.47	87.10	74.28	>90	85.39

Table G-155. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.13	0.13	0.13	0.13	-	-	-	-	0.09	0.09
175	0.27	0.26	0.27	0.26	0.10	0.10	0.06	0.06	0.15	0.14
170	0.77	0.74	0.75	0.73	0.15	0.14	0.12	0.12	0.41	0.39
160	2.78	2.66	2.75	2.64	0.90	0.87	0.57	0.55	1.76	1.69
150	6.97	6.55	6.91	6.51	2.99	2.86	2.35	2.25	4.79	4.54
140	15.18	13.86	15.08	13.77	6.91	6.46	5.66	5.29	10.04	9.39
130	31.63	28.66	31.23	28.32	14.90	13.64	11.92	10.98	21.91	19.55
120	>90	84.71	>90	84.49	47.07	41.79	32.23	28.95	>90	81.81

Table G-156. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.20	0.19	0.19	0.19	0.06	0.06	0.05	0.05	0.10	0.09
180	1.02	0.98	0.98	0.94	0.26	0.25	0.19	0.19	0.54	0.52
175	2.08	2.00	2.05	1.97	0.58	0.56	0.38	0.37	1.18	1.12
170	3.98	3.79	3.94	3.75	1.26	1.20	0.83	0.80	2.27	2.17
160	9.96	9.28	9.92	9.23	4.18	3.98	2.92	2.81	7.00	6.58
150	20.06	18.28	19.96	18.21	10.94	10.05	8.51	7.91	16.32	14.84
140	38.99	34.52	38.67	34.24	23.90	21.75	19.34	17.60	32.40	29.07
130	81.79	70.74	80.96	69.53	50.03	43.79	41.47	37.42	70.25	60.09
120	>90	85.06	>90	84.90	>90	83.11	>90	81.19	>90	84.70

Table G-157. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.07	0.07	0.03	0.03	-	-	0.05	0.05
180	0.45	0.44	0.44	0.42	0.09	0.09	0.07	0.07	0.21	0.21
175	0.87	0.84	0.86	0.83	0.23	0.23	0.11	0.11	0.48	0.46
170	1.88	1.81	1.85	1.78	0.50	0.48	0.31	0.30	1.00	0.94
160	6.00	5.66	5.95	5.61	2.00	1.92	1.54	1.48	3.74	3.58
150	13.90	12.69	13.82	12.63	6.30	5.93	4.75	4.48	9.94	9.28
140	26.83	24.31	26.68	24.18	15.28	13.96	12.26	11.26	21.23	19.28
130	51.16	44.34	50.39	43.70	31.86	28.75	26.87	24.41	42.24	37.32
120	>90	80.42	>90	79.47	75.12	64.64	60.86	53.10	84.52	74.78

Table G-158. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.20	0.19	0.19	0.19	0.06	0.06	0.05	0.05	0.10	0.09
175	0.49	0.48	0.48	0.47	0.11	0.10	0.07	0.07	0.24	0.23
170	1.02	0.98	0.98	0.94	0.26	0.25	0.19	0.19	0.54	0.52
160	3.98	3.79	3.94	3.75	1.26	1.20	0.83	0.80	2.27	2.17
150	9.96	9.28	9.92	9.23	4.18	3.98	2.92	2.81	7.00	6.58
140	20.06	18.28	19.96	18.21	10.94	10.05	8.51	7.91	16.32	14.84
130	38.99	34.52	38.67	34.24	23.90	21.75	19.34	17.60	32.40	29.07
120	81.79	70.74	80.96	69.53	50.03	43.79	41.47	37.42	70.25	60.09

Table G-159. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.09	0.09	0.09	0.09	0.03	0.03	-	-	0.06	0.06
175	0.20	0.19	0.19	0.19	0.06	0.06	0.05	0.05	0.10	0.09
170	0.49	0.48	0.48	0.47	0.11	0.10	0.07	0.07	0.24	0.23
160	2.08	2.00	2.05	1.97	0.58	0.56	0.38	0.37	1.18	1.13
150	6.58	6.19	6.54	6.14	2.30	2.20	1.73	1.64	4.19	4.00
140	14.86	13.55	14.80	13.48	6.92	6.50	5.26	4.95	11.02	10.12
130	28.53	25.75	28.36	25.61	16.46	14.98	13.32	12.23	23.13	21.01
120	55.25	47.76	54.25	46.92	34.25	30.79	28.88	26.18	45.01	39.69

Table G-160. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.20	0.20	0.20	0.20	0.06	0.06	0.05	0.05	0.10	0.09
180	1.01	0.97	1.00	0.96	0.24	0.24	0.18	0.18	0.54	0.52
175	2.04	1.95	2.00	1.92	0.57	0.55	0.41	0.39	1.18	1.13
170	3.86	3.69	3.80	3.63	1.28	1.22	0.86	0.83	2.16	2.08
160	11.66	10.79	11.56	10.70	4.05	3.88	2.84	2.72	7.53	7.04
150	31.91	28.86	31.54	28.55	13.20	12.33	9.54	8.87	22.98	20.78
140	>90	84.52	>90	84.29	45.64	39.93	32.99	29.79	>90	80.54
130	>90	85.83	>90	85.80	>90	85.44	89.99	85.16	>90	85.72
120	>90	85.98	>90	85.97	>90	85.97	>90	85.97	>90	85.97

Table G-161. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.07	0.07	0.02	0.02	-	-	0.05	0.05
180	0.45	0.44	0.43	0.42	0.09	0.09	0.07	0.07	0.20	0.20
175	0.89	0.85	0.88	0.84	0.23	0.22	0.11	0.11	0.48	0.47
170	1.82	1.76	1.81	1.73	0.50	0.48	0.34	0.34	0.99	0.94
160	6.20	5.86	6.14	5.80	1.98	1.91	1.54	1.47	3.56	3.40
150	17.06	15.61	16.94	15.50	6.51	6.19	4.68	4.44	11.82	11.03
140	50.22	43.33	49.05	42.47	21.02	19.08	15.06	14.03	36.29	32.56
130	>90	85.38	>90	85.31	>90	80.73	59.60	50.33	>90	85.07
120	>90	85.92	>90	85.89	>90	85.79	>90	85.70	>90	85.86

Table G-162. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.20	0.20	0.20	0.20	0.06	0.06	0.05	0.05	0.10	0.09
175	0.50	0.48	0.49	0.48	0.11	0.10	0.07	0.07	0.23	0.22
170	1.01	0.97	1.00	0.96	0.24	0.24	0.18	0.18	0.54	0.52
160	3.86	3.69	3.80	3.63	1.28	1.22	0.86	0.83	2.16	2.08
150	11.66	10.79	11.56	10.70	4.05	3.88	2.84	2.72	7.53	7.04
140	31.91	28.86	31.54	28.55	13.20	12.33	9.54	8.87	22.98	20.78
130	>90	84.52	>90	84.29	45.64	39.93	32.99	29.79	>90	80.54
120	>90	85.83	>90	85.80	>90	85.44	>90	85.16	>90	85.72

Table G-163. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.09	0.09	0.09	0.09	0.03	0.03	-	-	0.06	0.06
175	0.20	0.20	0.20	0.20	0.06	0.06	0.05	0.05	0.10	0.09
170	0.50	0.48	0.49	0.48	0.11	0.10	0.07	0.07	0.23	0.22
160	2.04	1.95	2.00	1.92	0.57	0.55	0.41	0.39	1.18	1.13
150	6.91	6.50	6.84	6.44	2.27	2.17	1.75	1.64	4.07	3.90
140	18.76	17.15	18.62	17.03	7.40	6.93	5.30	5.00	13.16	12.26
130	59.16	49.79	56.87	48.21	24.26	22.00	17.00	15.74	40.77	36.14
120	>90	85.49	>90	85.42	>90	83.38	74.19	62.02	>90	85.23

Table G-164. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
180	0.74	0.72	0.60	0.58	0.11	0.11	0.08	0.08	0.27	0.27
175	1.43	1.37	1.40	1.34	0.28	0.27	0.21	0.20	0.69	0.66
170	2.62	2.50	2.56	2.45	0.69	0.67	0.45	0.44	1.41	1.35
160	7.34	6.81	7.26	6.74	2.54	2.44	1.87	1.80	4.52	4.30
150	15.64	14.20	15.54	14.12	7.70	7.21	6.10	5.79	11.76	10.76
140	29.43	26.65	29.10	26.36	18.92	17.02	16.76	15.05	24.48	22.23
130	62.87	54.51	58.52	50.92	41.93	37.82	38.69	34.83	50.85	44.79
120	>90	85.11	>90	84.75	>90	83.95	>90	83.36	>90	84.58

Table G-165. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.23	0.23	0.23	0.22	0.06	0.06	0.05	0.05	0.10	0.09
175	0.54	0.52	0.53	0.51	0.10	0.10	0.07	0.07	0.24	0.23
170	1.22	1.17	1.17	1.12	0.25	0.24	0.17	0.17	0.55	0.54
160	4.15	3.94	4.09	3.89	1.24	1.18	0.80	0.77	2.22	2.12
150	9.98	9.26	9.92	9.21	4.01	3.81	2.88	2.76	6.78	6.38
140	19.64	17.89	19.54	17.79	11.50	10.47	9.38	8.72	15.92	14.48
130	38.20	34.16	37.52	33.51	26.74	24.04	23.83	21.22	32.32	29.23
120	86.07	76.38	81.91	71.61	64.10	56.23	56.37	50.22	77.58	67.09

Table G-166. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
175	0.26	0.26	0.26	0.26	0.06	0.06	0.05	0.05	0.11	0.11
170	0.74	0.72	0.60	0.58	0.11	0.11	0.08	0.08	0.27	0.27
160	2.62	2.50	2.56	2.45	0.69	0.67	0.45	0.44	1.41	1.35
150	7.34	6.81	7.26	6.74	2.54	2.44	1.87	1.80	4.52	4.30
140	15.64	14.20	15.54	14.12	7.70	7.21	6.10	5.79	11.76	10.76
130	29.43	26.65	29.10	26.36	18.92	17.02	16.76	15.05	24.48	22.23
120	62.87	54.51	58.52	50.92	41.93	37.82	38.69	34.83	50.85	44.79

Table G-167. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.06	0.06	0.06	0.06	-	-	-	-	0.03	0.03
175	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
170	0.26	0.26	0.26	0.26	0.06	0.06	0.05	0.05	0.11	0.11
160	1.43	1.37	1.40	1.34	0.28	0.27	0.21	0.20	0.69	0.66
150	4.62	4.36	4.55	4.30	1.44	1.38	0.91	0.87	2.52	2.42
140	10.96	9.99	10.88	9.90	4.55	4.29	3.40	3.22	7.48	6.98
130	21.06	19.04	20.86	18.87	12.64	11.53	10.28	9.48	17.06	15.48
120	40.80	36.39	39.99	35.64	28.81	25.96	26.11	23.36	34.63	31.32

Table G-168. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	-	-	-	-	-	-
190	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
180	0.75	0.73	0.60	0.58	0.11	0.11	0.08	0.08	0.29	0.28
175	1.42	1.36	1.38	1.32	0.31	0.30	0.20	0.20	0.72	0.68
170	2.52	2.41	2.48	2.36	0.70	0.68	0.44	0.43	1.39	1.33
160	8.03	7.41	7.94	7.33	2.42	2.32	1.85	1.77	4.59	4.36
150	19.88	18.20	19.70	18.03	8.69	7.97	6.12	5.81	14.22	13.16
140	69.23	57.84	62.95	53.02	30.08	27.31	23.32	21.04	45.57	39.94
130	>90	85.76	>90	85.61	>90	85.09	>90	84.26	>90	85.48
120	>90	85.98	>90	85.97	>90	85.97	>90	85.97	>90	85.97

Table G-169. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.24	0.24	0.24	0.23	0.06	0.06	0.05	0.05	0.10	0.09
175	0.55	0.53	0.54	0.52	0.10	0.10	0.07	0.07	0.23	0.22
170	1.20	1.15	1.16	1.11	0.24	0.23	0.17	0.17	0.55	0.53
160	4.15	3.94	4.08	3.88	1.22	1.17	0.83	0.80	2.15	2.06
150	11.70	10.79	11.60	10.68	4.02	3.84	2.84	2.72	7.45	6.96
140	30.88	28.03	30.33	27.55	13.46	12.63	10.17	9.49	22.32	20.12
130	>90	84.59	>90	83.98	52.46	45.55	40.93	36.41	>90	79.58
120	>90	85.93	>90	85.84	>90	85.75	>90	85.70	>90	85.80

Table G-170. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.03	0.03	0.03	0.03	-	-	-	-	-	-
180	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
175	0.27	0.26	0.26	0.26	0.06	0.06	0.05	0.05	0.11	0.11
170	0.75	0.73	0.60	0.58	0.11	0.11	0.08	0.08	0.29	0.28
160	2.52	2.41	2.48	2.36	0.70	0.68	0.44	0.43	1.39	1.33
150	8.03	7.41	7.94	7.33	2.42	2.32	1.85	1.77	4.59	4.36
140	19.88	18.20	19.70	18.03	8.69	7.97	6.12	5.81	14.22	13.16
130	69.23	57.84	62.95	53.02	30.08	27.31	23.32	21.04	45.57	39.94
120	>90	85.76	>90	85.61	>90	85.09	>90	84.26	>90	85.48

Table G-171. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L01 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.06	0.06	0.06	0.06	-	-	-	-	0.03	0.03
175	0.11	0.11	0.11	0.11	0.04	0.04	-	-	0.06	0.06
170	0.27	0.26	0.26	0.26	0.06	0.06	0.05	0.05	0.11	0.11
160	1.42	1.36	1.38	1.32	0.31	0.30	0.20	0.20	0.72	0.68
150	4.67	4.40	4.59	4.33	1.42	1.35	0.92	0.89	2.42	2.32
140	12.82	11.83	12.72	11.74	4.57	4.34	3.22	3.08	8.45	7.81
130	34.36	30.92	33.65	30.36	15.16	14.16	11.68	10.94	25.38	23.02
120	>90	85.04	>90	84.66	63.41	54.22	47.50	41.74	>90	82.87

Table G-172. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.08	0.08	0.08	0.08	-	-	-	-	0.02	0.02
190	0.36	0.34	0.35	0.34	0.10	0.09	0.08	0.08	0.20	0.19
180	1.42	1.36	1.41	1.34	0.45	0.43	0.32	0.31	0.91	0.85
175	2.35	2.20	2.32	2.18	0.96	0.91	0.67	0.64	1.61	1.53
170	3.56	3.29	3.53	3.27	1.67	1.59	1.26	1.21	2.56	2.41
160	6.96	6.38	6.93	6.35	3.92	3.63	3.15	2.90	5.30	4.88
150	12.84	11.52	12.79	11.47	7.27	6.62	6.09	5.61	9.79	8.91
140	20.27	17.87	20.17	17.82	13.44	12.00	11.23	10.08	17.37	15.31
130	31.42	27.91	31.31	27.82	22.67	19.64	19.21	16.98	28.04	24.83
120	44.86	39.80	44.62	39.61	34.89	30.91	31.27	27.73	40.76	36.22

Table G-173. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.12	0.12	0.12	0.12	-	-	-	-	0.09	0.09
180	0.67	0.64	0.66	0.63	0.19	0.18	0.11	0.11	0.37	0.36
175	1.27	1.21	1.26	1.20	0.40	0.38	0.24	0.23	0.76	0.73
170	2.10	1.98	2.08	1.96	0.81	0.77	0.56	0.53	1.45	1.39
160	4.74	4.38	4.71	4.35	2.46	2.30	1.90	1.80	3.54	3.27
150	9.00	8.20	8.97	8.16	5.02	4.64	4.26	3.95	6.80	6.22
140	15.60	13.86	15.54	13.81	9.26	8.44	7.84	7.15	12.76	11.42
130	25.05	22.06	24.96	21.99	16.58	14.62	14.21	12.68	21.00	18.31
120	36.29	32.22	36.15	32.10	27.42	24.21	24.17	21.11	32.81	29.07

Table G-174. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.08	0.08	0.08	0.08	-	-	-	-	0.02	0.02
180	0.36	0.34	0.35	0.34	0.10	0.09	0.08	0.08	0.20	0.19
175	0.75	0.72	0.74	0.72	0.22	0.21	0.12	0.12	0.42	0.41
170	1.42	1.36	1.41	1.34	0.45	0.43	0.32	0.31	0.91	0.85
160	3.56	3.29	3.53	3.27	1.67	1.59	1.26	1.21	2.56	2.41
150	6.96	6.38	6.93	6.35	3.92	3.63	3.15	2.90	5.30	4.88
140	12.84	11.52	12.79	11.47	7.27	6.62	6.09	5.61	9.79	8.91
130	20.27	17.87	20.17	17.82	13.44	12.00	11.23	10.08	17.37	15.31
120	31.42	27.91	31.31	27.82	22.67	19.64	19.21	16.98	28.04	24.83

Table G-175. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.13	0.13	0.13	0.13	0.03	0.03	-	-	0.09	0.09
175	0.36	0.34	0.35	0.34	0.10	0.09	0.08	0.08	0.20	0.19
170	0.75	0.72	0.74	0.72	0.22	0.21	0.12	0.12	0.42	0.41
160	2.35	2.20	2.32	2.18	0.96	0.91	0.67	0.64	1.61	1.53
150	5.05	4.66	5.02	4.64	2.66	2.48	2.07	1.94	3.82	3.55
140	9.48	8.64	9.45	8.60	5.33	4.92	4.53	4.19	7.27	6.62
130	16.35	14.48	16.29	14.44	9.73	8.88	8.33	7.61	13.48	12.04
120	26.02	23.06	25.95	22.99	17.41	15.35	15.02	13.32	22.35	19.37

Table G-176. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.09	0.08	0.08	0.08	-	-	-	-	0.02	0.02
190	0.37	0.36	0.37	0.35	0.10	0.10	0.08	0.08	0.19	0.18
180	1.50	1.43	1.47	1.41	0.45	0.43	0.34	0.33	0.95	0.90
175	2.48	2.33	2.46	2.31	1.02	0.96	0.71	0.68	1.69	1.61
170	3.82	3.54	3.79	3.51	1.76	1.68	1.33	1.27	2.71	2.54
160	8.16	7.44	8.12	7.40	4.17	3.86	3.39	3.14	5.77	5.31
150	16.46	14.63	16.38	14.56	8.43	7.67	6.82	6.22	12.56	11.29
140	33.52	29.62	33.28	29.40	18.34	16.23	14.47	12.89	27.41	24.23
130	77.13	68.14	74.93	66.19	43.19	38.38	34.11	30.19	61.84	54.84
120	>90	85.73	>90	85.69	>90	84.92	>90	82.98	>90	85.58

Table G-177. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.13	0.12	0.12	0.12	-	-	-	-	0.09	0.09
180	0.70	0.68	0.69	0.67	0.18	0.17	0.12	0.12	0.39	0.37
175	1.33	1.27	1.32	1.26	0.41	0.39	0.24	0.23	0.80	0.77
170	2.24	2.11	2.21	2.09	0.86	0.81	0.59	0.57	1.53	1.47
160	5.13	4.74	5.10	4.71	2.58	2.42	1.98	1.88	3.80	3.51
150	10.78	9.70	10.71	9.63	5.46	5.01	4.58	4.22	7.86	7.17
140	21.74	18.95	21.60	18.84	11.41	10.22	9.11	8.29	16.97	15.04
130	45.26	40.21	44.72	39.73	26.09	23.02	19.79	17.56	37.00	32.81
120	>90	84.80	>90	84.63	63.12	56.08	49.67	44.34	>90	82.39

Table G-178. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.09	0.08	0.08	0.08	-	-	-	-	0.02	0.02
180	0.37	0.36	0.37	0.35	0.10	0.10	0.08	0.08	0.19	0.18
175	0.78	0.76	0.78	0.75	0.21	0.20	0.13	0.12	0.43	0.42
170	1.50	1.43	1.47	1.41	0.45	0.43	0.34	0.33	0.95	0.90
160	3.82	3.54	3.79	3.51	1.76	1.68	1.33	1.27	2.71	2.54
150	8.16	7.44	8.12	7.40	4.17	3.86	3.39	3.14	5.77	5.31
140	16.46	14.63	16.38	14.56	8.43	7.67	6.82	6.22	12.56	11.29
130	33.52	29.62	33.28	29.40	18.34	16.23	14.47	12.89	27.41	24.23
120	77.13	68.14	74.93	66.19	43.19	38.38	34.11	30.19	61.84	54.84

Table G-179. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(a) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.13	0.13	0.13	0.13	0.02	0.02	-	-	0.09	0.09
175	0.37	0.36	0.37	0.35	0.10	0.10	0.08	0.08	0.19	0.18
170	0.78	0.76	0.78	0.75	0.21	0.20	0.13	0.12	0.43	0.42
160	2.48	2.33	2.46	2.31	1.02	0.96	0.71	0.68	1.69	1.61
150	5.54	5.11	5.51	5.07	2.78	2.61	2.20	2.08	4.09	3.78
140	11.72	10.54	11.65	10.47	5.84	5.36	4.88	4.49	8.49	7.75
130	23.65	20.71	23.49	20.56	12.39	11.11	9.70	8.83	18.29	16.18
120	49.16	43.71	48.52	43.14	28.33	25.03	21.96	19.11	39.99	35.51

Table G-180. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.24	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.09
180	1.19	1.13	1.17	1.12	0.30	0.29	0.20	0.19	0.64	0.61
175	2.11	2.01	2.08	1.98	0.68	0.65	0.44	0.42	1.26	1.21
170	3.63	3.39	3.60	3.36	1.33	1.27	0.97	0.93	2.24	2.13
160	8.02	7.34	7.98	7.30	3.83	3.58	2.89	2.71	5.94	5.49
150	14.89	13.36	14.85	13.32	8.74	8.00	7.06	6.47	12.23	11.08
140	24.96	22.23	24.86	22.14	16.74	14.96	14.34	12.89	21.21	18.74
130	36.76	32.89	36.61	32.74	28.47	25.40	25.41	22.73	33.66	29.94
120	54.26	48.43	53.51	47.74	43.65	38.79	40.40	35.67	49.50	44.30

Table G-181. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.07	0.07	0.03	0.03	-	-	0.05	0.05
180	0.47	0.46	0.47	0.45	0.09	0.09	0.06	0.06	0.23	0.22
175	1.04	0.98	1.01	0.96	0.26	0.26	0.17	0.17	0.51	0.49
170	1.90	1.81	1.87	1.79	0.60	0.58	0.38	0.37	1.14	1.09
160	5.11	4.75	5.09	4.73	2.04	1.94	1.58	1.51	3.47	3.23
150	10.15	9.27	10.10	9.23	5.45	5.05	4.31	4.02	8.13	7.43
140	18.26	16.30	18.20	16.24	11.51	10.43	9.43	8.65	15.49	13.90
130	29.57	26.30	29.45	26.20	20.61	18.30	18.09	16.16	26.30	23.48
120	42.16	37.85	41.94	37.64	33.64	29.94	30.61	27.27	38.68	34.62

Table G-182. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.24	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.09
175	0.57	0.53	0.55	0.51	0.11	0.10	0.07	0.07	0.27	0.27
170	1.19	1.13	1.17	1.12	0.30	0.29	0.20	0.19	0.64	0.61
160	3.63	3.39	3.60	3.36	1.33	1.27	0.97	0.93	2.24	2.13
150	8.02	7.34	7.98	7.30	3.83	3.58	2.89	2.71	5.94	5.49
140	14.89	13.36	14.85	13.32	8.74	8.00	7.06	6.47	12.23	11.08
130	24.96	22.23	24.86	22.14	16.75	14.96	14.34	12.89	21.21	18.74
120	36.76	32.89	36.61	32.75	28.47	25.40	25.41	22.73	33.66	29.94

Table G-183. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.09	0.09	0.09	0.09	0.03	0.03	-	-	0.06	0.06
175	0.24	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.09
170	0.57	0.53	0.55	0.51	0.11	0.10	0.07	0.07	0.27	0.27
160	2.11	2.01	2.08	1.98	0.68	0.65	0.44	0.42	1.26	1.21
150	5.54	5.13	5.51	5.10	2.32	2.19	1.75	1.67	3.81	3.58
140	11.00	9.95	10.95	9.90	5.93	5.48	4.68	4.36	8.71	7.97
130	19.08	17.06	19.02	17.01	12.36	11.21	9.96	9.15	16.39	14.66
120	30.77	27.35	30.64	27.24	22.06	19.45	19.01	17.03	27.50	24.53

Table G-184. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
190	0.26	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.10
180	1.20	1.15	1.19	1.14	0.31	0.30	0.18	0.18	0.65	0.62
175	2.27	2.15	2.24	2.13	0.70	0.67	0.44	0.43	1.29	1.23
170	4.01	3.75	3.97	3.72	1.35	1.29	0.98	0.93	2.42	2.31
160	9.90	9.11	9.86	9.07	4.32	4.06	3.05	2.88	7.35	6.73
150	24.38	21.54	24.18	21.35	12.57	11.48	9.33	8.51	19.26	17.18
140	55.65	49.59	53.98	48.14	33.42	29.75	27.52	24.41	46.08	41.10
130	>90	85.74	>90	85.52	>90	84.63	>90	82.47	>90	85.39
120	>90	85.78	>90	85.70	>90	85.71	>90	85.73	>90	85.69

Table G-185. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.07	0.07	0.07	0.07	0.03	0.03	-	-	0.05	0.05
180	0.48	0.46	0.47	0.45	0.10	0.10	0.07	0.07	0.24	0.23
175	1.02	0.97	1.00	0.96	0.27	0.26	0.17	0.16	0.51	0.49
170	1.97	1.89	1.95	1.87	0.60	0.57	0.39	0.38	1.12	1.08
160	5.91	5.47	5.87	5.43	2.12	2.02	1.59	1.52	3.92	3.68
150	14.61	13.13	14.51	13.05	6.65	6.15	4.89	4.58	10.75	9.80
140	32.73	29.10	32.41	28.80	19.05	17.00	14.62	13.24	27.55	24.48
130	>90	81.69	85.37	75.97	51.05	45.74	41.44	37.04	69.51	61.73
120	>90	85.88	>90	85.87	>90	85.84	>90	85.73	>90	85.87

Table G-186. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.05	0.05	-	-	-	-	0.03	0.03
180	0.26	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.10
175	0.55	0.52	0.53	0.51	0.11	0.10	0.08	0.08	0.28	0.27
170	1.20	1.15	1.19	1.13	0.31	0.30	0.19	0.18	0.65	0.62
160	4.01	3.75	3.97	3.72	1.35	1.29	0.98	0.93	2.42	2.31
150	9.90	9.11	9.86	9.07	4.32	4.06	3.05	2.88	7.35	6.73
140	24.38	21.54	24.18	21.35	12.57	11.48	9.33	8.51	19.26	17.18
130	55.65	49.59	53.98	48.14	33.42	29.75	27.52	24.41	46.08	41.10
120	>90	85.74	>90	85.52	>90	84.63	>90	82.47	>90	85.39

Table G-187. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(b) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.02	0.02	0.02	0.02	-	-	-	-	-	-
180	0.09	0.09	0.09	0.09	0.03	0.03	-	-	0.06	0.06
175	0.26	0.24	0.24	0.24	0.06	0.06	0.05	0.05	0.10	0.10
170	0.55	0.52	0.53	0.51	0.11	0.10	0.08	0.08	0.28	0.27
160	2.27	2.15	2.24	2.13	0.70	0.67	0.44	0.43	1.29	1.23
150	6.49	5.98	6.45	5.94	2.41	2.30	1.75	1.67	4.36	4.09
140	15.92	14.26	15.83	14.17	7.41	6.78	5.46	5.08	12.05	10.96
130	35.21	31.38	34.78	31.00	20.93	18.48	16.32	14.69	29.71	26.45
120	>90	84.14	>90	82.81	57.02	50.82	46.99	42.17	79.52	70.74

Table G-188. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
180	0.30	0.29	0.29	0.28	0.06	0.06	0.03	0.03	0.15	0.15
175	0.61	0.58	0.58	0.57	0.15	0.15	0.11	0.10	0.30	0.28
170	1.12	1.06	1.09	1.03	0.32	0.30	0.21	0.20	0.61	0.59
160	2.97	2.78	2.92	2.75	1.25	1.18	0.89	0.84	1.94	1.85
150	6.66	6.14	6.62	6.10	3.53	3.30	2.79	2.63	5.05	4.71
140	13.32	12.07	13.27	12.02	8.49	7.83	7.09	6.56	11.03	10.07
130	23.70	21.04	23.55	20.89	17.55	15.81	15.53	14.09	20.82	18.51
120	36.81	33.00	36.56	32.75	31.01	27.64	28.47	25.54	34.58	30.88

Table G-189. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.13	0.13	0.13	0.12	0.02	0.02	-	-	0.04	0.04
175	0.26	0.26	0.26	0.25	0.05	0.05	0.03	0.03	0.13	0.13
170	0.53	0.51	0.51	0.49	0.14	0.13	0.10	0.10	0.25	0.24
160	1.75	1.66	1.70	1.61	0.58	0.56	0.39	0.38	1.03	0.97
150	4.27	3.96	4.21	3.92	1.89	1.81	1.46	1.39	2.88	2.72
140	8.87	8.13	8.83	8.10	5.09	4.75	4.12	3.87	7.01	6.48
130	16.90	15.12	16.83	15.05	11.51	10.59	9.72	8.99	14.69	13.29
120	28.79	25.73	28.59	25.56	22.37	19.96	19.71	17.82	26.36	23.65

Table G-190. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
175	0.14	0.14	0.14	0.14	0.02	0.02	-	-	0.05	0.05
170	0.30	0.29	0.29	0.28	0.06	0.06	0.03	0.03	0.15	0.15
160	1.12	1.06	1.09	1.03	0.32	0.30	0.21	0.20	0.61	0.59
150	2.97	2.78	2.92	2.75	1.24	1.18	0.89	0.84	1.94	1.85
140	6.66	6.14	6.62	6.10	3.53	3.30	2.79	2.63	5.05	4.71
130	13.32	12.07	13.27	12.02	8.49	7.83	7.09	6.56	11.03	10.07
120	23.70	21.04	23.55	20.89	17.55	15.81	15.53	14.09	20.82	18.51

Table G-191. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during summer at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.02	0.02	-	-	-	-	-	-	-	-
175	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
170	0.14	0.14	0.14	0.14	0.02	0.02	-	-	0.05	0.05
160	0.61	0.58	0.58	0.57	0.15	0.15	0.11	0.10	0.30	0.28
150	1.90	1.79	1.86	1.76	0.65	0.63	0.48	0.46	1.15	1.08
140	4.61	4.28	4.56	4.24	2.08	1.97	1.64	1.56	3.17	2.95
130	9.42	8.64	9.38	8.61	5.54	5.16	4.56	4.27	7.65	7.04
120	17.85	15.96	17.76	15.88	12.49	11.48	10.44	9.64	15.66	14.12

Table G-192. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 0 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
180	0.31	0.30	0.29	0.28	0.08	0.08	0.04	0.04	0.14	0.14
175	0.62	0.60	0.60	0.58	0.15	0.14	0.11	0.10	0.32	0.30
170	1.14	1.07	1.10	1.04	0.34	0.32	0.22	0.22	0.63	0.61
160	2.90	2.71	2.86	2.68	1.24	1.18	0.93	0.88	1.90	1.80
150	6.79	6.23	6.73	6.19	3.31	3.06	2.65	2.50	4.87	4.52
140	16.53	14.83	16.42	14.73	8.54	7.84	6.85	6.31	12.91	11.79
130	40.65	36.39	39.79	35.63	25.10	22.36	19.55	17.62	34.42	30.67
120	>90	85.45	>90	85.20	80.99	72.95	61.38	55.03	>90	84.82

Table G-193. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 6 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.12	0.12	0.12	0.12	0.02	0.02	-	-	0.04	0.04
175	0.26	0.26	0.26	0.25	0.05	0.05	0.03	0.03	0.13	0.13
170	0.54	0.52	0.52	0.51	0.13	0.13	0.10	0.10	0.26	0.25
160	1.71	1.62	1.66	1.58	0.59	0.57	0.40	0.39	1.04	0.98
150	4.18	3.89	4.13	3.84	1.85	1.76	1.46	1.40	2.78	2.61
140	9.43	8.67	9.39	8.62	4.81	4.48	3.91	3.65	7.00	6.45
130	23.72	20.98	23.45	20.73	13.17	12.04	9.98	9.22	19.01	17.07
120	62.40	55.98	59.60	53.50	37.97	33.95	30.97	27.55	51.47	46.09

Table G-194. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 10 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
175	0.14	0.13	0.14	0.13	0.02	0.02	-	-	0.05	0.05
170	0.31	0.30	0.29	0.28	0.08	0.08	0.04	0.04	0.14	0.14
160	1.14	1.07	1.10	1.04	0.34	0.32	0.22	0.22	0.63	0.61
150	2.90	2.71	2.86	2.68	1.24	1.18	0.93	0.88	1.90	1.80
140	6.79	6.23	6.73	6.19	3.31	3.06	2.65	2.50	4.87	4.52
130	16.53	14.83	16.42	14.73	8.54	7.84	6.85	6.31	12.91	11.79
120	40.65	36.39	39.79	35.63	25.10	22.36	19.55	17.62	34.42	30.67

Table G-195. Pre-piled jacket foundation (4.5 m diameter, MHU 3500S, 3500(c) kJ max energy level) acoustic ranges (R_{max} and $R_{95\%}$ in km) for each of the flat and frequency weighted SPL categories (Finneran et al. 2017, NMFS 2018) during winter at location L02 for 15 dB.

Level	FLAT		LFC		MFC		HFC		PPW	
	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%	Rmax	R95%
200	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-
180	0.02	0.02	-	-	-	-	-	-	-	-
175	0.05	0.05	0.04	0.04	-	-	-	-	0.02	0.02
170	0.14	0.13	0.14	0.13	0.02	0.02	-	-	0.05	0.05
160	0.62	0.60	0.60	0.58	0.15	0.14	0.11	0.10	0.32	0.30
150	1.87	1.76	1.83	1.73	0.69	0.66	0.48	0.46	1.16	1.10
140	4.53	4.20	4.47	4.15	1.99	1.90	1.60	1.53	2.99	2.81
130	10.23	9.34	10.13	9.28	5.28	4.90	4.29	4.00	7.76	7.12
120	25.92	23.11	25.65	22.85	14.69	13.35	11.32	10.43	20.85	18.53

G.4. Impact Pile Driving Per Pile SEL Acoustic Ranges with Attenuation

G.4.1. 16 m Monopile Foundation

Table G-196. Monopile (summer, 16 m diameter, NNN 6600) foundation SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	11.67	7.92	6.09	4.24
MF	185	-	-	-	-
HF	155	1.15	0.52	0.26	0.14
PPW	185	2.71	1.41	0.79	0.35

Table G-197. Monopile (winter, 16 m diameter, NNN 6600) foundation SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	14.42	9.05	6.68	4.53
MF	185	-	-	-	-
HF	155	1.10	0.49	0.30	0.13
PPW	185	2.84	1.46	0.79	0.34

Table G-198. Monopile (summer, 16 m diameter, NNN 6600) foundation SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	9.01	6.25	4.79	3.27
MF	185	-	-	-	-
HF	155	0.96	0.41	0.20	0.12
PPW	185	2.10	1.11	0.65	0.30

Table G-199. Monopile (winter, 16 m diameter, NNN 6600) foundation SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	12.25	7.63	5.46	3.56
MF	185	-	-	-	-
HF	155	1.00	0.41	0.22	0.13
PPW	185	2.24	1.16	0.68	0.31

G.4.2. 4.5 m Diameter Pin Pile, 4 Legs (post-piled, 2 dB shift)

Table G-200. Post-piled jacket foundation with 4 pin piles (summer, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	12.45	7.95	5.83	3.78
MF	185	-	-	-	-
HF	155	0.63	0.26	0.11	0.06
PPW	185	2.53	1.21	0.67	0.28

Table G-201. Post-piled jacket foundation with 4 pin piles (winter, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	16.43	8.99	6.21	3.86
MF	185	-	-	-	-
HF	155	0.60	0.23	0.12	0.06
PPW	185	2.54	1.23	0.67	0.27

Table G-202. Post-piled jacket foundation with 4 pin piles (summer, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	8.95	6.04	4.56	2.99
MF	185	-	-	-	-
HF	155	0.64	0.25	0.11	0.05
PPW	185	2.16	1.16	0.68	0.32

Table G-203. Post-piled jacket foundation with 4 pin piles (winter, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	12.62	7.28	5.14	3.31
MF	185	-	-	-	-
HF	155	0.65	0.25	0.12	0.06
PPW	185	2.29	1.20	0.71	0.34

G.4.3. 4.5 m Diameter Pin Pile, 4 Legs (pre-piled)

Table G-204. Pre-piled jacket foundation with 4 pin piles (summer, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	10.73	6.78	4.94	3.00
MF	185	-	-	-	-
HF	155	0.48	0.19	0.09	0.04
PPW	185	1.95	0.85	0.48	0.22

Table G-205. Pre-piled jacket foundation with 4 pin piles (winter, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L01.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	13.45	7.47	5.16	3.07
MF	185	-	-	-	-
HF	155	0.48	0.17	0.09	0.04
PPW	185	1.99	0.88	0.48	0.20

Table G-206. Pre-piled jacket foundation with 4 pin piles (summer, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	7.96	5.26	3.93	2.55
MF	185	-	-	-	-
HF	155	0.48	0.19	0.08	0.03
PPW	185	1.78	0.90	0.48	0.22

Table G-207. Pre-piled jacket foundation with 4 pin piles (winter, 4.5 m diameter, MHU 3500S) SEL acoustic ranges ($R_{95\%}$ in km) with attenuation (Finneran et al. 2017, NMFS 2018) for location L02.

Hearing group	Threshold (dB)	Attenuation level (dB)			
		0	6	10	15
LF	183	10.46	6.09	4.34	2.71
MF	185	-	-	-	-
HF	155	0.48	0.17	0.09	0.03
PPW	185	1.84	0.93	0.49	0.22

G.5. Fish and Sea Turtle Acoustic Distances to Threshold

G.5.1. 16 m Monopile Foundation

Table G-208. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	15.23		
	$L_{pk}{}^a$	206	0.57	0.55	0.58
	$L_p{}^b$	150	21.63	22.90	21.32
Fish < 2 g	$L_E{}^a$	183	18.40		
	$L_{pk}{}^a$	206	0.57	0.55	0.58
	$L_p{}^b$	150	21.63	22.90	21.32
Fish without swim bladder	$L_E{}^c$	216	1.76		
	$L_{pk}{}^c$	213	0.18	0.18	0.18
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	5.72		
	$L_{pk}{}^c$	207	0.50	0.50	0.54
Fish with swim bladder involved in hearing	$L_E{}^c$	203	5.72		
	$L_{pk}{}^c$	207	0.50	0.50	0.54
Sea turtles	$L_E{}^d$	204	5.33		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	4.54	5.14	4.93

Table G-209. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	10.99		
	$L_{pk}{}^a$	206	0.25	0.20	0.27
	$L_p{}^b$	150	15.47	16.89	15.73
Fish < 2 g	$L_E{}^a$	183	13.75		
	$L_{pk}{}^a$	206	0.25	0.20	0.27
	$L_p{}^b$	150	15.47	16.89	15.73
Fish without swim bladder	$L_E{}^c$	216	0.75		
	$L_{pk}{}^c$	213	0.10	0.11	0.12
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	3.60		
	$L_{pk}{}^c$	207	0.18	0.18	0.18
Fish with swim bladder involved in hearing	$L_E{}^c$	203	3.60		
	$L_{pk}{}^c$	207	0.18	0.18	0.18
Sea turtles	$L_E{}^d$	204	3.25		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	2.75	2.94	3.00

Table G-210. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges (*$R_{95\%}$* in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	6.12		
	$L_{pk}{}^a$	206	0.07	0.08	0.09
	$L_p{}^b$	150	8.92	10.30	9.42
Fish < 2 g	$L_E{}^a$	183	7.99		
	$L_{pk}{}^a$	206	0.07	0.08	0.09
	$L_p{}^b$	150	8.92	10.30	9.42
Fish without swim bladder	$L_E{}^c$	216	0.16		
	$L_{pk}{}^c$	213	-	-	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	1.40		
	$L_{pk}{}^c$	207	0.04	0.06	0.08
Fish with swim bladder involved in hearing	$L_E{}^c$	203	1.40		
	$L_{pk}{}^c$	207	0.04	0.06	0.08
Sea turtles	$L_E{}^d$	204	1.20		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	1.14	1.08	1.14

Table G-211. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges (*$R_{95\%}$* in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	19.74		
	$L_{pk}{}^a$	206	0.50	0.51	0.56
	$L_p{}^b$	150	32.04	33.62	27.62
Fish < 2 g	$L_E{}^a$	183	26.43		
	$L_{pk}{}^a$	206	0.50	0.51	0.56
	$L_p{}^b$	150	32.04	33.62	27.62
Fish without swim bladder	$L_E{}^c$	216	1.81		
	$L_{pk}{}^c$	213	0.18	0.19	0.20
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	6.23		
	$L_{pk}{}^c$	207	0.43	0.47	0.52
Fish with swim bladder involved in hearing	$L_E{}^c$	203	6.23		
	$L_{pk}{}^c$	207	0.43	0.47	0.52
Sea turtles	$L_E{}^d$	204	5.77		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	5.02	5.68	5.18

Table G-212. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	13.19		
	L_{pk}[a]	206	0.23	0.20	0.26
	L_p[b]	150	21.44	22.47	18.36
Fish < 2 g	L_E[a]	183	17.17		
	L_{pk}[a]	206	0.23	0.20	0.26
	L_p[b]	150	21.44	22.47	18.36
Fish without swim bladder	L_E[c]	216	0.77		
	L_{pk}[c]	213	0.10	0.11	0.12
Fish with swim bladder not involved in hearing	L_E[c]	203	3.79		
	L_{pk}[c]	207	0.18	0.19	0.20
Fish with swim bladder involved in hearing	L_E[c]	203	3.79		
	L_{pk}[c]	207	0.18	0.19	0.20
Sea turtles	L_E[d]	204	3.44		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.82	3.12	3.11

Table G-213. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	6.70		
	L_{pk}[a]	206	0.06	0.07	0.09
	L_p[b]	150	11.26	12.70	10.65
Fish < 2 g	L_E[a]	183	9.06		
	L_{pk}[a]	206	0.06	0.07	0.09
	L_p[b]	150	11.26	12.70	10.65
Fish without swim bladder	L_E[c]	216	0.17		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.43		
	L_{pk}[c]	207	0.03	0.03	0.07
Fish with swim bladder involved in hearing	L_E[c]	203	1.43		
	L_{pk}[c]	207	0.03	0.03	0.07
Sea turtles	L_E[d]	204	1.23		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.16	1.10	1.19

Table G-214. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	11.52		
	L_{pk}[a]	206	0.43	0.41	0.46
	L_p[b]	150	14.45	15.38	15.99
Fish < 2 g	L_E[a]	183	13.80		
	L_{pk}[a]	206	0.43	0.41	0.46
	L_p[b]	150	14.45	15.38	15.99
Fish without swim bladder	L_E[c]	216	1.42		
	L_{pk}[c]	213	0.17	0.13	0.14
Fish with swim bladder not involved in hearing	L_E[c]	203	4.46		
	L_{pk}[c]	207	0.38	0.38	0.41
Fish with swim bladder involved in hearing	L_E[c]	203	4.46		
	L_{pk}[c]	207	0.38	0.38	0.41
Sea turtles	L_E[d]	204	4.16		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	3.29	3.96	4.29

Table G-215. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	8.26		
	L_{pk}[a]	206	0.20	0.17	0.18
	L_p[b]	150	10.68	12.09	12.57
Fish < 2 g	L_E[a]	183	10.27		
	L_{pk}[a]	206	0.20	0.17	0.18
	L_p[b]	150	10.68	12.09	12.57
Fish without swim bladder	L_E[c]	216	0.67		
	L_{pk}[c]	213	0.06	0.07	0.08
Fish with swim bladder not involved in hearing	L_E[c]	203	2.74		
	L_{pk}[c]	207	0.17	0.13	0.14
Fish with swim bladder involved in hearing	L_E[c]	203	2.74		
	L_{pk}[c]	207	0.17	0.13	0.14
Sea turtles	L_E[d]	204	2.55		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.03	2.40	2.60

Table G-216. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	4.77		
	$L_{pk}{}^a$	206	0.06	0.06	0.06
	$L_p{}^b$	150	6.16	7.45	7.97
Fish < 2 g	$L_E{}^a$	183	6.14		
	$L_{pk}{}^a$	206	0.06	0.06	0.06
	$L_p{}^b$	150	6.16	7.45	7.97
Fish without swim bladder	$L_E{}^c$	216	0.14		
	$L_{pk}{}^c$	213	-	-	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	1.13		
	$L_{pk}{}^c$	207	0.05	0.05	0.06
Fish with swim bladder involved in hearing	$L_E{}^c$	203	1.13		
	$L_{pk}{}^c$	207	0.05	0.05	0.06
Sea turtles	$L_E{}^d$	204	0.99		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	0.85	0.88	0.98

Table G-217. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	$L_E{}^a$	187	15.02		
	$L_{pk}{}^a$	206	0.42	0.40	0.46
	$L_p{}^b$	150	21.26	21.96	25.36
Fish < 2 g	$L_E{}^a$	183	19.16		
	$L_{pk}{}^a$	206	0.42	0.40	0.46
	$L_p{}^b$	150	21.26	21.96	25.36
Fish without swim bladder	$L_E{}^c$	216	1.48		
	$L_{pk}{}^c$	213	0.18	0.14	0.15
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	4.93		
	$L_{pk}{}^c$	207	0.38	0.37	0.40
Fish with swim bladder involved in hearing	$L_E{}^c$	203	4.93		
	$L_{pk}{}^c$	207	0.38	0.37	0.40
Sea turtles	$L_E{}^d$	204	4.56		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	3.60	4.34	4.69

Table G-218. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	10.10		
	L_{pk}[a]	206	0.20	0.17	0.17
	L_p[b]	150	14.46	15.34	16.61
Fish < 2 g	L_E[a]	183	13.28		
	L_{pk}[a]	206	0.20	0.17	0.17
	L_p[b]	150	14.46	15.34	16.61
Fish without swim bladder	L_E[c]	216	0.70		
	L_{pk}[c]	213	0.06	0.07	0.08
Fish with swim bladder not involved in hearing	L_E[c]	203	2.91		
	L_{pk}[c]	207	0.18	0.14	0.15
Fish with swim bladder involved in hearing	L_E[c]	203	2.91		
	L_{pk}[c]	207	0.18	0.14	0.15
Sea turtles	L_E[d]	204	2.68		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.13	2.54	2.73

Table G-219. Monopile foundation (16 m diameter, NNN 6600 kJ hammer) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			6600 (a)	6600 (b)	6600c
Fish ≥ 2 g	L_E[a]	187	5.32		
	L_{pk}[a]	206	0.06	0.06	0.06
	L_p[b]	150	7.56	8.88	9.31
Fish < 2 g	L_E[a]	183	7.15		
	L_{pk}[a]	206	0.06	0.06	0.06
	L_p[b]	150	7.56	8.88	9.31
Fish without swim bladder	L_E[c]	216	0.14		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.17		
	L_{pk}[c]	207	0.05	0.05	0.06
Fish with swim bladder involved in hearing	L_E[c]	203	1.17		
	L_{pk}[c]	207	0.05	0.05	0.06
Sea turtles	L_E[d]	204	1.04		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.89	0.92	1.02

G.5.2. 4.5 m Diameter Pin Pile, 4 Legs (post-piled, 2 dB shift)

Table G-220. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187		14.56	
	L_{pk}[a]	206	0.44	0.20	0.11
	L_p[b]	150	16.34	21.37	16.01
Fish < 2 g	L_E[a]	183		18.24	
	L_{pk}[a]	206	0.44	0.20	0.11
	L_p[b]	150	16.34	21.37	16.01
Fish without swim bladder	L_E[c]	216		0.92	
	L_{pk}[c]	213	0.13	0.09	0.05
Fish with swim bladder not involved in hearing	L_E[c]	203		4.53	
	L_{pk}[c]	207	0.40	0.17	0.11
Fish with swim bladder involved in hearing	L_E[c]	203		4.53	
	L_{pk}[c]	207	0.40	0.17	0.11
Sea turtles	L_E[d]	204		4.14	
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	3.16	2.64	1.75

Table G-221. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187		9.63	
	L_{pk}[a]	206	0.14	0.09	0.06
	L_p[b]	150	12.05	14.44	10.91
Fish < 2 g	L_E[a]	183		12.90	
	L_{pk}[a]	206	0.14	0.09	0.06
	L_p[b]	150	12.05	14.44	10.91
Fish without swim bladder	L_E[c]	216		0.37	
	L_{pk}[c]	213	0.06	0.04	-
Fish with swim bladder not involved in hearing	L_E[c]	203		2.44	
	L_{pk}[c]	207	0.13	0.09	0.05
Fish with swim bladder involved in hearing	L_E[c]	203		2.44	
	L_{pk}[c]	207	0.13	0.09	0.05
Sea turtles	L_E[d]	204		2.13	
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.68	1.18	0.78

Table G-222. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	4.95		
	L_{pk}[a]	206	-	0.03	-
	L_p[b]	150	6.83	7.36	5.27
Fish < 2 g	L_E[a]	183	6.78		
	L_{pk}[a]	206	-	0.03	-
	L_p[b]	150	6.83	7.36	5.27
Fish without swim bladder	L_E[c]	216	0.09		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.74		
	L_{pk}[c]	207	-	0.02	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.74		
	L_{pk}[c]	207	-	0.02	-
Sea turtles	L_E[d]	204	0.58		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.46	0.26	0.14

Table G-223. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	19.56		
	L_{pk}[a]	206	0.44	0.20	0.12
	L_p[b]	150	22.00	35.16	22.88
Fish < 2 g	L_E[a]	183	28.91		
	L_{pk}[a]	206	0.44	0.20	0.12
	L_p[b]	150	22.00	35.16	22.88
Fish without swim bladder	L_E[c]	216	0.93		
	L_{pk}[c]	213	0.13	0.09	0.05
Fish with swim bladder not involved in hearing	L_E[c]	203	4.73		
	L_{pk}[c]	207	0.39	0.17	0.11
Fish with swim bladder involved in hearing	L_E[c]	203	4.73		
	L_{pk}[c]	207	0.39	0.17	0.11
Sea turtles	L_E[d]	204	4.28		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	3.30	2.50	1.72

Table G-224. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	11.78		
	L_{pk}[a]	206	0.15	0.10	0.06
	L_p[b]	150	14.71	18.70	12.84
Fish < 2 g	L_E[a]	183	16.51		
	L_{pk}[a]	206	0.15	0.10	0.06
	L_p[b]	150	14.71	18.70	12.84
Fish without swim bladder	L_E[c]	216	0.38		
	L_{pk}[c]	213	0.06	0.04	-
Fish with swim bladder not involved in hearing	L_E[c]	203	2.45		
	L_{pk}[c]	207	0.13	0.09	0.05
Fish with swim bladder involved in hearing	L_E[c]	203	2.45		
	L_{pk}[c]	207	0.13	0.09	0.05
Sea turtles	L_E[d]	204	2.15		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.71	1.17	0.80

Table G-225. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	5.21		
	L_{pk}[a]	206	-	0.03	-
	L_p[b]	150	7.69	8.03	5.47
Fish < 2 g	L_E[a]	183	7.50		
	L_{pk}[a]	206	-	0.03	-
	L_p[b]	150	7.69	8.03	5.47
Fish without swim bladder	L_E[c]	216	0.09		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.75		
	L_{pk}[c]	207	-	0.02	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.75		
	L_{pk}[c]	207	-	0.02	-
Sea turtles	L_E[d]	204	0.57		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.46	0.27	0.16

Table G-226. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	10.37		
	L_{pk}[a]	206	0.36	0.31	0.04
	L_p[b]	150	12.66	14.78	7.09
Fish < 2 g	L_E[a]	183	13.00		
	L_{pk}[a]	206	0.36	0.31	0.04
	L_p[b]	150	12.66	14.78	7.09
Fish without swim bladder	L_E[c]	216	0.91		
	L_{pk}[c]	213	0.12	0.09	-
Fish with swim bladder not involved in hearing	L_E[c]	203	3.52		
	L_{pk}[c]	207	0.34	0.28	0.03
Fish with swim bladder involved in hearing	L_E[c]	203	3.52		
	L_{pk}[c]	207	0.34	0.28	0.03
Sea turtles	L_E[d]	204	3.20		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.59	2.53	0.73

Table G-227. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	7.17		
	L_{pk}[a]	206	0.13	0.10	0.02
	L_p[b]	150	9.06	10.70	4.61
Fish < 2 g	L_E[a]	183	9.07		
	L_{pk}[a]	206	0.13	0.10	0.02
	L_p[b]	150	9.06	10.70	4.61
Fish without swim bladder	L_E[c]	216	0.37		
	L_{pk}[c]	213	0.07	0.04	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.99		
	L_{pk}[c]	207	0.12	0.09	-
Fish with swim bladder involved in hearing	L_E[c]	203	1.99		
	L_{pk}[c]	207	0.12	0.09	-
Sea turtles	L_E[d]	204	1.82		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.51	1.26	0.34

Table G-228. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	3.83		
	$L_{pk}{}^a$	206	0.05	0.03	-
	$L_p{}^b$	150	5.29	5.94	2.17
Fish < 2 g	$L_E{}^a$	183	5.12		
	$L_{pk}{}^a$	206	0.05	0.03	-
	$L_p{}^b$	150	5.29	5.94	2.17
Fish without swim bladder	$L_E{}^c$	216	0.09		
	$L_{pk}{}^c$	213	-	-	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	0.69		
	$L_{pk}{}^c$	207	-	0.02	-
Fish with swim bladder involved in hearing	$L_E{}^c$	203	0.69		
	$L_{pk}{}^c$	207	-	0.02	-
Sea turtles	$L_E{}^d$	204	0.60		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	0.44	0.31	0.10

Table G-229. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	14.25		
	$L_{pk}{}^a$	206	0.36	0.30	0.04
	$L_p{}^b$	150	16.63	25.15	7.38
Fish < 2 g	$L_E{}^a$	183	19.30		
	$L_{pk}{}^a$	206	0.36	0.30	0.04
	$L_p{}^b$	150	16.63	25.15	7.38
Fish without swim bladder	$L_E{}^c$	216	0.93		
	$L_{pk}{}^c$	213	0.13	0.09	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	3.84		
	$L_{pk}{}^c$	207	0.33	0.28	0.03
Fish with swim bladder involved in hearing	$L_E{}^c$	203	3.84		
	$L_{pk}{}^c$	207	0.33	0.28	0.03
Sea turtles	$L_E{}^d$	204	3.51		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	2.72	2.68	0.75

Table G-230. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	8.74		
	L_{pk}[a]	206	0.13	0.10	0.02
	L_p[b]	150	11.34	15.48	4.55
Fish < 2 g	L_E[a]	183	12.25		
	L_{pk}[a]	206	0.13	0.10	0.02
	L_p[b]	150	11.34	15.48	4.55
Fish without swim bladder	L_E[c]	216	0.38		
	L_{pk}[c]	213	0.07	0.04	-
Fish with swim bladder not involved in hearing	L_E[c]	203	2.14		
	L_{pk}[c]	207	0.13	0.09	-
Fish with swim bladder involved in hearing	L_E[c]	203	2.14		
	L_{pk}[c]	207	0.13	0.09	-
Sea turtles	L_E[d]	204	1.90		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.58	1.32	0.35

Table G-231. Post-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	4.18		
	L_{pk}[a]	206	0.04	0.03	-
	L_p[b]	150	5.93	7.14	2.11
Fish < 2 g	L_E[a]	183	5.82		
	L_{pk}[a]	206	0.04	0.03	-
	L_p[b]	150	5.93	7.14	2.11
Fish without swim bladder	L_E[c]	216	0.09		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.72		
	L_{pk}[c]	207	-	0.02	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.72		
	L_{pk}[c]	207	-	0.02	-
Sea turtles	L_E[d]	204	0.62		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.46	0.31	0.10

G.5.3. 4.5 m Diameter Pin Pile, 4 Legs (pre-piled)

Table G-232. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	12.90		
	L_{pk}[a]	206	0.26	0.15	0.09
	L_p[b]	150	14.83	18.28	14.20
Fish < 2 g	L_E[a]	183	16.39		
	L_{pk}[a]	206	0.26	0.15	0.09
	L_p[b]	150	14.83	18.28	14.20
Fish without swim bladder	L_E[c]	216	0.74		
	L_{pk}[c]	213	0.11	0.07	0.04
Fish with swim bladder not involved in hearing	L_E[c]	203	3.78		
	L_{pk}[c]	207	0.17	0.13	0.09
Fish with swim bladder involved in hearing	L_E[c]	203	3.78		
	L_{pk}[c]	207	0.17	0.13	0.09
Sea turtles	L_E[d]	204	3.39		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.61	2.00	1.37

Table G-233. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	8.50		
	L_{pk}[a]	206	0.12	0.08	0.05
	L_p[b]	150	10.61	12.69	9.26
Fish < 2 g	L_E[a]	183	11.34		
	L_{pk}[a]	206	0.12	0.08	0.05
	L_p[b]	150	10.61	12.69	9.26
Fish without swim bladder	L_E[c]	216	0.24		
	L_{pk}[c]	213	-	0.03	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.88		
	L_{pk}[c]	207	0.11	0.07	0.04
Fish with swim bladder involved in hearing	L_E[c]	203	1.88		
	L_{pk}[c]	207	0.11	0.07	0.04
Sea turtles	L_E[d]	204	1.67		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.31	0.84	0.52

Table G-234. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	4.14		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	6.03	6.19	4.36
Fish < 2 g	L_E[a]	183	5.84		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	6.03	6.19	4.36
Fish without swim bladder	L_E[c]	216	0.07		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.51		
	L_{pk}[c]	207	-	-	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.51		
	L_{pk}[c]	207	-	-	-
Sea turtles	L_E[d]	204	0.46		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.29	0.19	0.11

Table G-235. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	16.51		
	L_{pk}[a]	206	0.24	0.15	0.09
	L_p[b]	150	18.49	28.86	18.20
Fish < 2 g	L_E[a]	183	24.05		
	L_{pk}[a]	206	0.24	0.15	0.09
	L_p[b]	150	18.49	28.86	18.20
Fish without swim bladder	L_E[c]	216	0.75		
	L_{pk}[c]	213	0.11	0.07	0.04
Fish with swim bladder not involved in hearing	L_E[c]	203	3.86		
	L_{pk}[c]	207	0.19	0.13	0.09
Fish with swim bladder involved in hearing	L_E[c]	203	3.86		
	L_{pk}[c]	207	0.19	0.13	0.09
Sea turtles	L_E[d]	204	3.44		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.66	1.95	1.36

Table G-236. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	9.63		
	L_{pk}[a]	206	0.13	0.08	0.05
	L_p[b]	150	13.02	15.61	10.79
Fish < 2 g	L_E[a]	183	13.95		
	L_{pk}[a]	206	0.13	0.08	0.05
	L_p[b]	150	13.02	15.61	10.79
Fish without swim bladder	L_E[c]	216	0.24		
	L_{pk}[c]	213	-	0.03	-
Fish with swim bladder not involved in hearing	L_E[c]	203	1.88		
	L_{pk}[c]	207	0.11	0.07	0.04
Fish with swim bladder involved in hearing	L_E[c]	203	1.88		
	L_{pk}[c]	207	0.11	0.07	0.04
Sea turtles	L_E[d]	204	1.68		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	1.32	0.85	0.53

Table G-237. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L01 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	4.28		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	6.55	6.50	4.40
Fish < 2 g	L_E[a]	183	6.26		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	6.55	6.50	4.40
Fish without swim bladder	L_E[c]	216	0.06		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.51		
	L_{pk}[c]	207	-	-	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.51		
	L_{pk}[c]	207	-	-	-
Sea turtles	L_E[d]	204	0.46		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.26	0.20	0.11

Table G-238. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	9.07		
	$L_{pk}{}^a$	206	0.32	0.16	0.03
	$L_p{}^b$	150	11.52	13.36	6.14
Fish < 2 g	$L_E{}^a$	183	11.74		
	$L_{pk}{}^a$	206	0.32	0.16	0.03
	$L_p{}^b$	150	11.52	13.36	6.14
Fish without swim bladder	$L_E{}^c$	216	0.69		
	$L_{pk}{}^c$	213	0.11	0.07	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	2.88		
	$L_{pk}{}^c$	207	0.30	0.13	0.03
Fish with swim bladder involved in hearing	$L_E{}^c$	203	2.88		
	$L_{pk}{}^c$	207	0.30	0.13	0.03
Sea turtles	$L_E{}^d$	204	2.67		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	2.20	2.01	0.58

Table G-239. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	6.26		
	$L_{pk}{}^a$	206	0.12	0.08	-
	$L_p{}^b$	150	8.20	9.27	3.96
Fish < 2 g	$L_E{}^a$	183	8.15		
	$L_{pk}{}^a$	206	0.12	0.08	-
	$L_p{}^b$	150	8.20	9.27	3.96
Fish without swim bladder	$L_E{}^c$	216	0.28		
	$L_{pk}{}^c$	213	0.05	0.03	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	1.64		
	$L_{pk}{}^c$	207	0.11	0.07	-
Fish with swim bladder involved in hearing	$L_E{}^c$	203	1.64		
	$L_{pk}{}^c$	207	0.11	0.07	-
Sea turtles	$L_E{}^d$	204	1.49		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	1.21	0.98	0.26

Table G-240. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during summer at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	3.20		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	4.66	5.13	1.79
Fish < 2 g	L_E[a]	183	4.44		
	L_{pk}[a]	206	-	-	-
	L_p[b]	150	4.66	5.13	1.79
Fish without swim bladder	L_E[c]	216	0.07		
	L_{pk}[c]	213	-	-	-
Fish with swim bladder not involved in hearing	L_E[c]	203	0.48		
	L_{pk}[c]	207	-	-	-
Fish with swim bladder involved in hearing	L_E[c]	203	0.48		
	L_{pk}[c]	207	-	-	-
Sea turtles	L_E[d]	204	0.42		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	0.34	0.24	0.05

Table G-241. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 0 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	L_E[a]	187	12.25		
	L_{pk}[a]	206	0.31	0.16	0.03
	L_p[b]	150	14.63	21.54	6.23
Fish < 2 g	L_E[a]	183	16.57		
	L_{pk}[a]	206	0.31	0.16	0.03
	L_p[b]	150	14.63	21.54	6.23
Fish without swim bladder	L_E[c]	216	0.72		
	L_{pk}[c]	213	0.11	0.07	-
Fish with swim bladder not involved in hearing	L_E[c]	203	3.15		
	L_{pk}[c]	207	0.28	0.14	0.03
Fish with swim bladder involved in hearing	L_E[c]	203	3.15		
	L_{pk}[c]	207	0.28	0.14	0.03
Sea turtles	L_E[d]	204	2.82		
	L_{pk}[d]	232	-	-	-
	L_p[e]	175	2.33	2.15	0.60

Table G-242. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 6 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	7.48		
	$L_{pk}{}^a$	206	0.12	0.08	-
	$L_p{}^b$	150	9.70	13.13	3.89
Fish < 2 g	$L_E{}^a$	183	10.35		
	$L_{pk}{}^a$	206	0.12	0.08	-
	$L_p{}^b$	150	9.70	13.13	3.89
Fish without swim bladder	$L_E{}^c$	216	0.28		
	$L_{pk}{}^c$	213	0.04	0.03	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	1.73		
	$L_{pk}{}^c$	207	0.11	0.07	-
Fish with swim bladder involved in hearing	$L_E{}^c$	203	1.73		
	$L_{pk}{}^c$	207	0.11	0.07	-
Sea turtles	$L_E{}^d$	204	1.55		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	1.27	0.97	0.26

Table G-243. Pre-piled jacket foundation with 4 pin piles (4.5 m diameter, MHU 3500S) acoustic ranges ($R_{95\%}$ in km) to fish and sea turtle injury and behavioral thresholds during winter at location L02 for different energy levels with 15 dB attenuation.

Faunal group	Metric	Threshold (dB)	Hammer energy (kJ)		
			3500 (a)	3500 (b)	3500c
Fish ≥ 2 g	$L_E{}^a$	187	3.51		
	$L_{pk}{}^a$	206	-	-	-
	$L_p{}^b$	150	5.11	5.98	1.76
Fish < 2 g	$L_E{}^a$	183	4.94		
	$L_{pk}{}^a$	206	-	-	-
	$L_p{}^b$	150	5.11	5.98	1.76
Fish without swim bladder	$L_E{}^c$	216	0.07		
	$L_{pk}{}^c$	213	-	-	-
Fish with swim bladder not involved in hearing	$L_E{}^c$	203	0.51		
	$L_{pk}{}^c$	207	-	-	-
Fish with swim bladder involved in hearing	$L_E{}^c$	203	0.51		
	$L_{pk}{}^c$	207	-	-	-
Sea turtles	$L_E{}^d$	204	0.44		
	$L_{pk}{}^d$	232	-	-	-
	$L_p{}^e$	175	0.36	0.24	0.05

G.6. Vibratory and Impact Pile Driving

Tables G-244 to G-247 show distances to vibratory pile driving injury thresholds (non-impulsive signals, Table 15), and distances to impact pile driving injury thresholds (impulsive signals, Table 15) from the combined sound fields produced by vibratory and impact pile driving, for marine mammals and sea turtles. See Section 2.6 for details on combining the sound field from vibratory and impact pile driving. Distances to the behavioral threshold of 120 dB, valid for all marine mammal species considering vibratory pile driving only are shown in Table G-248 for jacket foundations and Table G-249 for monopiles.

Table G-244. Jacket pile (4.5 m diameter, S-CV640) SEL acoustic ranges ($R_{95\%}$ in km) to acoustic threshold criteria (Finneran et al. 2017, NMFS 2018) with various levels of attenuation for location L01 in summer and winter. Ranges to impact pile driving thresholds include the acoustic energy from vibratory driving.

Hammer type	Hearing group	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory (90 min)	LF	199	0.41	0.13	0.09	0.02	0.43	0.13	0.09	0.02
	MF	198	-	-	-	-	-	-	-	-
	HF	173	-	-	-	-	-	-	-	-
	PW	201	-	-	-	-	-	-	-	-
	TUW	220	0.02	-	-	-	0.02	-	-	-
Vibratory and Impact	LF	183	6.13	3.45	2.11	1.14	6.55	3.46	2.15	1.15
	MF	185	-	-	-	-	-	-	-	-
	HF	155	0.11	0.05	0.02	-	0.11	0.05	0.02	-
	PW	185	0.65	0.23	0.11	0.06	0.60	0.22	0.11	0.06
	TUW	204	0.94	0.38	0.19	0.09	0.95	0.38	0.18	0.09

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

Table G-245. Jacket pile (4.5 m diameter, S-CV640) SEL acoustic ranges ($R_{95\%}$ in km) to acoustic threshold criteria (Finneran et al. 2017, NMFS 2018) with various levels of attenuation for location L02 in summer and winter. Ranges to impact pile driving thresholds include the acoustic energy from vibratory driving.

Hammer type	Hearing group	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory (90 min)	LF	199	0.36	0.13	0.06	0.03	0.36	0.12	0.06	0.03
	MF	198	-	-	-	-	-	-	-	-
	HF	173	-	-	-	-	-	-	-	-
	PW	201	-	-	-	-	-	-	-	-
	TUW	220	0.03	-	-	-	0.03	-	-	-
Vibratory and Impact	LF	183	4.77	2.71	1.81	0.99	5.65	2.97	1.87	0.99
	MF	185	-	-	-	-	-	-	-	-
	HF	155	0.11	0.05	0.02	-	0.09	0.03	-	-
	PW	185	0.60	0.21	0.09	0.06	0.60	0.22	0.10	0.06
	TUW	204	0.89	0.34	0.17	0.07	0.89	0.35	0.17	0.07

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

Table G-246. Monopile (16 m diameter, HXCV640) SEL acoustic ranges ($R_{95\%}$ in km to acoustic threshold criteria(Finneran et al. 2017, NMFS 2018) with various levels of attenuation for locations L01 in summer and winter. Ranges to impact pile driving thresholds include the acoustic energy from vibratory driving.

Hammer type	Hearing group	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory (20 min)	LF	199	2.43	1.25	0.74	0.29	2.54	1.28	0.68	0.29
	MF	198	-	-	-	-	-	-	-	-
	HF	173	-	-	-	-	-	-	-	-
	PW	201	0.13	0.03	-	-	0.13	0.03	-	-
	TUW	220	0.40	0.13	0.09	-	0.42	0.13	0.09	-
Vibratory and Impact	LF	183	11.88	8.05	6.19	4.35	14.63	9.22	6.80	4.62
	MF	185	-	-	-	-	-	-	-	-
	HF	155	0.96	0.30	0.20	0.11	0.89	0.35	0.20	0.10
	PW	185	2.74	1.44	0.81	0.36	2.87	1.48	0.85	0.39
	TUW	204	4.42	2.56	1.64	0.84	4.69	2.68	1.72	0.88

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

Table G-247. Monopile (16 m diameter, HXCV640) SEL acoustic ranges ($R_{95\%}$ in km) to acoustic threshold criteria(Finneran et al. 2017, NMFS 2018) with various levels of attenuation for locations L02 in summer and winter. Ranges to impact pile driving thresholds include the acoustic energy from vibratory driving.

Hammer type	Hearing group	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory (20 min)	LF	199	1.91	1.00	0.67	0.32	2.01	1.05	0.69	0.32
	MF	198	-	-	-	-	-	-	-	-
	HF	173	-	-	-	-	-	-	-	-
	PW	201	0.11	0.05	-	-	0.12	0.05	-	-
	TUW	220	0.33	0.11	0.06	0.03	0.34	0.12	0.06	0.02
Vibratory and Impact	LF	183	9.16	6.46	5.03	3.47	12.36	7.80	5.69	3.78
	MF	185	-	-	-	-	-	-	-	-
	HF	155	0.96	0.41	0.20	0.12	1.00	0.41	0.22	0.13
	PW	185	2.21	1.18	0.72	0.32	2.35	1.231.23	0.68	0.28
	TUW	204	4.06	2.23	1.40	0.67	4.41	2.33	1.48	0.70

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

Table G-248. Jacket pile (4.5 m diameter, SCV640) SPL acoustic ranges ($R_{95\%}$ in km) to behavior acoustic threshold criteria (Finneran et al. 2017, NMFS 2018) with various levels of attenuation for locations L01 and L02 in summer and winter.

Hammer type	Location	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory	L01	120	26.32	19.25	15.83	12.47	49.36	29.26	21.92	15.14
	L02		22.11	16.45	13.93	10.32	44.38	29.13	21.32	14.72

Table G-249. Monopile (16 m diameter, HXCV640) SPL acoustic ranges ($R_{95\%}$ in km) to behavior acoustic threshold criteria (Finneran et al. 2017, NMFS 2018) with various levels of attenuation for locations L01 and L02 in summer and winter.

Hammer type	Location	Threshold (dB)	Summer				Winter			
			Attenuation (dB)				Attenuation (dB)			
			0	6	10	15	0	6	10	15
Vibratory	L01	120	71.81	51.82	42.02	33.90	85.56	85.15	84.63	74.57
	L02		36.53	31.32	28.25	23.78	84.36	57.42	44.88	34.38

Appendix H. Animal Movement and Exposure Modeling

H.1. Animal Movement Parameters

H.1.1. Exposure Integration Time

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

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that might be present in the Project Area during sound-producing activities is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited in this analysis to a maximum distance of 38 miles (70 km) from the OCS-A 0521 Lease Area. In the simulation, every animat that reaches and leaves a border of the simulation area is replaced by another animat entering at an opposite border—e.g., an animat departing at the northern border of the simulation area is replaced by an animat entering the simulation area at the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

H.1.2. Aversion

Aversion is a common response of animals to sound, particularly at relatively high sound exposure levels (Ellison et al. 2012). As received sound level generally decreases with distance from a source, this aspect of natural behavior can strongly influence the estimated maximum sound levels an animal is predicted to receive and significantly affects the probability of more pronounced direct or subsequent behavioral effects. Additionally, animals are less likely to respond to sound levels distant from a source, even when those same levels elicit response at closer distances; both proximity and received levels are important factors in aversive responses (Dunlop et al. 2017). As a supplement to this modeling study for comparison purposes only, parameters determining aversion at specified sound levels were implemented for the North Atlantic right whale, in recognition of its Endangered status, and harbor porpoise, a species known to have a strong aversive response to loud sounds.

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

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

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

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

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

H.1.3. Simulation Area: Animat Seeding

The exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 0.5 animats/km^2 over the entire simulation area. Some species have depth preference restrictions, e.g., sperm whales prefer water greater than 1000 m (Aoki et al. 2007), and the simulation included a relatively high portion of shallow water areas. Seeding maps displaying seeding areas for each modeled species are displayed in Section H.3.

H.2. Animal Movement Modeling Supplemental Results

H.2.1. Animal Densities

As described in Section 3.2, densities were calculated within buffered polygons around the Lease Area perimeter for the following buffer ranges: 1, 5, 10, 15, 20, 30, 40, and 50 km. The following section contains density values for all buffer ranges excluding the 5 km as those results are displayed in Section 3.2.

H.2.1.1. Marine Mammals

Table H-3. Mean monthly marine mammal density estimates for all species in a 1 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.209	0.169	0.134	0.142	0.297	0.287	0.466	0.353	0.263	0.070	0.050	0.142	0.215	0.241
Minke whale	0.104	0.132	0.137	0.763	1.558	1.874	0.855	0.507	0.580	0.491	0.051	0.069	0.593	0.748
Humpback whale	0.026	0.023	0.051	0.180	0.320	0.357	0.222	0.134	0.179	0.274	0.212	0.026	0.167	0.216
North Atlantic right whale[b]	0.390	0.441	0.396	0.399	0.310	0.055	0.029	0.019	0.029	0.048	0.074	0.222	0.201	0.098
Sei whale[b]	0.038	0.024	0.048	0.113	0.186	0.060	0.015	0.011	0.019	0.038	0.087	0.066	0.059	0.060
Atlantic white-sided dolphin	2.365	1.346	0.981	1.560	3.611	3.654	2.019	0.961	2.042	3.072	2.266	3.131	2.251	2.595
Atlantic spotted dolphin	0.001	0.000	0.001	0.006	0.027	0.041	0.046	0.079	0.416	0.507	0.144	0.013	0.107	0.159
Common dolphin	8.460	2.987	2.774	4.247	7.239	15.867	15.046	20.206	33.428	27.913	14.911	13.249	13.861	18.482
Bottlenose dolphin, offshore	0.479	0.107	0.068	0.196	0.890	1.485	1.671	1.935	1.858	1.676	1.455	1.263	1.090	1.529
Risso's dolphin	0.040	0.005	0.003	0.021	0.122	0.077	0.099	0.223	0.271	0.131	0.136	0.185	0.109	0.156
Long-finned pilot whale[c]	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
Short-finned pilot whale[c]	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Sperm whale[b]	0.043	0.016	0.016	0.004	0.017	0.032	0.058	0.165	0.103	0.079	0.045	0.028	0.051	0.066
Harbor porpoise	11.540	12.307	11.704	10.035	7.966	1.680	1.612	1.483	1.759	2.282	2.349	7.565	6.024	3.337
Gray seal	5.991	5.981	4.335	3.481	4.827	0.509	0.086	0.086	0.188	0.519	2.470	5.238	2.809	1.740
Harbor seal	13.461	13.437	9.739	7.821	10.845	1.145	0.194	0.193	0.422	1.166	5.550	11.769	6.312	3.911
Harp seal	5.991	5.981	4.335	3.481	4.827	0.509	0.086	0.086	0.188	0.519	2.470	5.238	2.809	1.740

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-4. Mean monthly marine mammal density estimates for all species in a 10 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.222	0.175	0.149	0.154	0.300	0.290	0.470	0.356	0.265	0.088	0.054	0.142	0.222	0.246
Minke whale	0.106	0.132	0.144	0.753	1.508	1.751	0.804	0.475	0.535	0.504	0.053	0.072	0.570	0.713
Humpback whale	0.028	0.025	0.049	0.180	0.306	0.347	0.210	0.124	0.165	0.249	0.200	0.029	0.159	0.204
North Atlantic right whale[b]	0.536	0.604	0.537	0.500	0.372	0.075	0.044	0.026	0.039	0.057	0.107	0.328	0.269	0.131
Sei whale[b]	0.037	0.025	0.051	0.121	0.194	0.065	0.016	0.011	0.019	0.040	0.088	0.066	0.061	0.062
Atlantic white-sided dolphin	2.634	1.579	1.111	1.685	3.685	3.803	2.043	0.868	1.927	2.976	2.248	3.208	2.314	2.595
Atlantic spotted dolphin	0.001	0.000	0.001	0.006	0.036	0.063	0.051	0.080	0.428	0.677	0.168	0.016	0.127	0.190
Common dolphin	9.331	3.623	3.200	4.737	7.994	17.206	15.493	20.083	33.336	33.312	17.320	14.672	15.026	19.927
Bottlenose dolphin, offshore	0.509	0.124	0.078	0.221	0.972	1.625	1.765	2.003	1.976	1.810	1.595	1.287	1.164	1.629
Risso's dolphin	0.054	0.007	0.004	0.025	0.143	0.101	0.132	0.281	0.351	0.171	0.149	0.195	0.134	0.190
Long-finned pilot whale[c]	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
Short-finned pilot whale[c]	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Sperm whale[b]	0.046	0.016	0.016	0.004	0.016	0.031	0.053	0.167	0.093	0.063	0.041	0.029	0.048	0.062
Harbor porpoise	10.500	11.354	10.806	9.355	7.200	1.738	1.737	1.555	1.651	2.027	2.189	6.748	5.572	3.106
Gray seal	5.942	5.850	4.187	3.785	4.987	0.745	0.193	0.165	0.280	0.644	2.459	4.986	2.852	1.807
Harbor seal	13.350	13.143	9.407	8.504	11.204	1.675	0.434	0.370	0.630	1.446	5.525	11.203	6.408	4.061
Harp seal	5.942	5.850	4.187	3.785	4.987	0.745	0.193	0.165	0.280	0.644	2.459	4.986	2.852	1.807

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-5. Mean monthly marine mammal density estimates for all species in a 15 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.224	0.175	0.155	0.160	0.303	0.293	0.468	0.362	0.268	0.093	0.056	0.143	0.225	0.248
Minke whale	0.109	0.134	0.148	0.752	1.492	1.701	0.784	0.459	0.514	0.501	0.054	0.075	0.560	0.698
Humpback whale	0.029	0.026	0.049	0.185	0.309	0.349	0.211	0.123	0.163	0.244	0.200	0.031	0.160	0.204
North Atlantic right whale[b]	0.625	0.702	0.615	0.557	0.411	0.089	0.055	0.031	0.047	0.063	0.128	0.391	0.310	0.152
Sei whale[b]	0.036	0.025	0.052	0.124	0.197	0.066	0.017	0.011	0.018	0.041	0.088	0.066	0.062	0.063
Atlantic white-sided dolphin	2.724	1.675	1.163	1.753	3.732	3.856	2.068	0.840	1.879	2.962	2.241	3.231	2.344	2.601
Atlantic spotted dolphin	0.001	0.000	0.001	0.006	0.043	0.085	0.054	0.083	0.448	0.764	0.180	0.018	0.140	0.209
Common dolphin	9.781	3.991	3.463	5.020	8.430	18.025	15.884	20.041	33.068	34.945	18.434	15.312	15.533	20.517
Bottlenose dolphin, offshore	0.518	0.130	0.084	0.233	1.009	1.687	1.829	2.042	2.028	1.868	1.666	1.309	1.200	1.680
Risso's dolphin	0.061	0.009	0.005	0.027	0.155	0.118	0.151	0.314	0.396	0.192	0.155	0.198	0.148	0.210
Long-finned pilot whale[c]	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174
Short-finned pilot whale[c]	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
Sperm whale[b]	0.045	0.017	0.016	0.004	0.016	0.032	0.052	0.164	0.088	0.061	0.040	0.030	0.047	0.060
Harbor porpoise	10.027	10.902	10.379	9.102	6.930	1.814	1.831	1.588	1.596	1.959	2.163	6.459	5.396	3.043
Gray seal	5.846	5.733	4.147	3.958	5.122	0.939	0.290	0.236	0.351	0.732	2.518	4.893	2.897	1.885
Harbor seal	13.135	12.880	9.317	8.892	11.509	2.111	0.652	0.530	0.789	1.645	5.657	10.993	6.509	4.236
Harp seal	5.846	5.733	4.147	3.958	5.122	0.939	0.290	0.236	0.351	0.732	2.518	4.893	2.897	1.885

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-6. Mean monthly marine mammal density estimates for all species in a 20 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.223	0.175	0.161	0.165	0.303	0.295	0.467	0.367	0.272	0.099	0.058	0.143	0.227	0.251
Minke whale	0.109	0.133	0.151	0.748	1.471	1.642	0.757	0.441	0.490	0.496	0.054	0.078	0.548	0.679
Humpback whale	0.031	0.027	0.049	0.192	0.314	0.354	0.212	0.123	0.161	0.241	0.201	0.033	0.162	0.205
North Atlantic right whale[b]	0.717	0.804	0.691	0.614	0.449	0.105	0.070	0.039	0.057	0.070	0.150	0.460	0.352	0.175
Sei whale[b]	0.036	0.026	0.052	0.128	0.201	0.068	0.018	0.011	0.018	0.041	0.088	0.066	0.063	0.064
Atlantic white-sided dolphin	2.839	1.794	1.236	1.828	3.807	3.931	2.086	0.813	1.829	2.955	2.245	3.263	2.386	2.616
Atlantic spotted dolphin	0.002	0.000	0.001	0.007	0.053	0.119	0.059	0.089	0.483	0.881	0.198	0.020	0.159	0.238
Common dolphin	10.412	4.503	3.839	5.415	9.060	19.232	16.440	20.181	32.859	36.777	19.821	16.106	16.220	21.310
Bottlenose dolphin, offshore	0.545	0.141	0.092	0.251	1.060	1.773	1.916	2.102	2.101	1.952	1.768	1.360	1.255	1.754
Risso's dolphin	0.072	0.011	0.006	0.030	0.173	0.142	0.183	0.366	0.462	0.223	0.164	0.205	0.170	0.240
Long-finned pilot whale[c]	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185
Short-finned pilot whale[c]	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
Sperm whale[b]	0.044	0.019	0.016	0.004	0.016	0.034	0.052	0.163	0.084	0.060	0.040	0.032	0.047	0.060
Harbor porpoise	9.539	10.433	9.961	8.850	6.667	1.909	1.945	1.618	1.536	1.899	2.145	6.138	5.220	2.982
Gray seal	5.705	5.597	4.142	4.114	5.270	1.196	0.423	0.336	0.443	0.843	2.562	4.803	2.953	1.985
Harbor seal	12.818	12.574	9.307	9.242	11.841	2.687	0.950	0.754	0.995	1.895	5.756	10.791	6.634	4.459
Harp seal	5.705	5.597	4.142	4.114	5.270	1.196	0.423	0.336	0.443	0.843	2.562	4.803	2.953	1.985

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-7. Mean monthly marine mammal density estimates for all species in a 30 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.223	0.175	0.167	0.181	0.305	0.309	0.475	0.384	0.286	0.109	0.064	0.144	0.235	0.260
Minke whale	0.112	0.135	0.155	0.740	1.433	1.536	0.711	0.410	0.449	0.482	0.055	0.083	0.525	0.645
Humpback whale	0.034	0.030	0.051	0.207	0.330	0.372	0.220	0.124	0.157	0.236	0.206	0.039	0.167	0.211
North Atlantic right whale[b]	0.809	0.923	0.780	0.688	0.490	0.129	0.089	0.048	0.068	0.078	0.173	0.529	0.400	0.201
Sei whale[b]	0.035	0.027	0.054	0.136	0.210	0.072	0.020	0.011	0.017	0.042	0.089	0.065	0.065	0.066
Atlantic white-sided dolphin	3.106	2.066	1.411	1.986	3.981	4.171	2.169	0.773	1.729	2.944	2.302	3.363	2.500	2.679
Atlantic spotted dolphin	0.002	0.000	0.001	0.008	0.083	0.228	0.071	0.113	0.590	1.166	0.242	0.025	0.211	0.315
Common dolphin	11.793	5.855	4.950	6.497	10.737	22.564	18.087	20.701	32.014	39.347	22.696	17.529	17.731	22.959
Bottlenose dolphin, offshore	0.682	0.194	0.125	0.305	1.196	2.003	2.103	2.214	2.295	2.191	2.061	1.588	1.413	1.956
Risso's dolphin	0.104	0.020	0.009	0.041	0.244	0.238	0.319	0.582	0.707	0.334	0.202	0.235	0.253	0.358
Long-finned pilot whale[c]	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
Short-finned pilot whale[c]	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
Sperm whale[b]	0.043	0.024	0.022	0.006	0.019	0.038	0.055	0.160	0.079	0.062	0.041	0.038	0.049	0.062
Harbor porpoise	8.670	9.536	9.174	8.394	6.228	2.052	2.067	1.611	1.422	1.798	2.106	5.601	4.888	2.861
Gray seal	5.450	5.328	4.168	4.377	5.574	2.287	0.960	0.756	0.805	1.277	2.680	4.652	3.193	2.374
Harbor seal	12.245	11.971	9.364	9.835	12.523	5.138	2.157	1.698	1.808	2.868	6.021	10.453	7.173	5.333
Harp seal	5.450	5.328	4.168	4.377	5.574	2.287	0.960	0.756	0.805	1.277	2.680	4.652	3.193	2.374

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-8. Mean monthly marine mammal density estimates for all species in a 40 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.217	0.177	0.169	0.193	0.307	0.319	0.480	0.388	0.290	0.116	0.069	0.142	0.239	0.264
Minke whale	0.114	0.135	0.156	0.709	1.367	1.436	0.676	0.388	0.416	0.462	0.056	0.087	0.500	0.611
Humpback whale	0.038	0.033	0.055	0.215	0.340	0.386	0.224	0.122	0.150	0.227	0.205	0.043	0.170	0.212
North Atlantic right whale[b]	0.816	0.949	0.807	0.703	0.507	0.144	0.097	0.051	0.070	0.082	0.182	0.537	0.412	0.209
Sei whale[b]	0.034	0.028	0.055	0.144	0.218	0.077	0.022	0.011	0.017	0.042	0.089	0.062	0.067	0.067
Atlantic white-sided dolphin	3.359	2.305	1.575	2.119	4.145	4.477	2.249	0.750	1.641	2.880	2.362	3.431	2.608	2.742
Atlantic spotted dolphin	0.002	0.001	0.001	0.008	0.102	0.298	0.082	0.145	0.659	1.340	0.272	0.028	0.245	0.366
Common dolphin	12.952	7.140	6.102	7.501	12.386	25.925	19.318	20.940	30.839	40.227	24.746	18.507	18.882	24.111
Bottlenose dolphin, offshore	0.911	0.302	0.190	0.405	1.447	2.435	2.486	2.507	2.687	2.641	2.517	1.935	1.705	2.332
Risso's dolphin	0.155	0.037	0.017	0.062	0.371	0.408	0.605	0.988	1.115	0.522	0.273	0.293	0.404	0.572
Long-finned pilot whale[c]	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242
Short-finned pilot whale[c]	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178
Sperm whale[b]	0.048	0.028	0.027	0.007	0.021	0.040	0.057	0.157	0.086	0.070	0.041	0.040	0.052	0.064
Harbor porpoise	7.917	8.730	8.492	7.966	5.964	2.104	2.101	1.631	1.378	1.744	2.050	5.134	4.601	2.763
Gray seal	5.315	5.169	4.316	4.691	6.175	3.817	1.566	1.288	1.312	2.033	2.887	4.571	3.595	2.956
Harbor seal	11.943	11.614	9.697	10.540	13.873	8.575	3.518	2.894	2.948	4.568	6.486	10.269	8.077	6.641
Harp seal	5.315	5.169	4.316	4.691	6.175	3.817	1.566	1.288	1.312	2.033	2.887	4.571	3.595	2.956

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

Table H-9. Mean monthly marine mammal density estimates for all species in a 50 km buffer around the Lease Area.

Species of interest	Monthly densities (animals/100 km^2) [a]												Annual mean	May to December mean
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fin whale[b]	0.208	0.180	0.175	0.203	0.311	0.318	0.472	0.378	0.287	0.120	0.074	0.139	0.239	0.262
Minke whale	0.115	0.133	0.154	0.665	1.280	1.327	0.638	0.368	0.385	0.435	0.055	0.089	0.470	0.572
Humpback whale	0.042	0.038	0.060	0.216	0.343	0.394	0.224	0.118	0.141	0.213	0.199	0.047	0.170	0.210
North Atlantic right whale[b]	0.750	0.885	0.765	0.666	0.485	0.146	0.093	0.049	0.066	0.078	0.171	0.493	0.387	0.198
Sei whale[b]	0.032	0.028	0.055	0.149	0.222	0.080	0.023	0.011	0.016	0.041	0.088	0.058	0.067	0.067
Atlantic white-sided dolphin	3.524	2.484	1.695	2.219	4.242	4.727	2.245	0.730	1.544	2.743	2.367	3.419	2.662	2.752
Atlantic spotted dolphin	0.002	0.001	0.001	0.008	0.106	0.313	0.089	0.163	0.674	1.357	0.282	0.029	0.252	0.377
Common dolphin	14.007	8.455	7.295	8.494	14.052	28.739	19.763	20.417	28.820	39.171	26.010	19.233	19.538	24.526
Bottlenose dolphin, offshore	1.185	0.453	0.296	0.567	1.804	3.027	2.958	2.883	3.185	3.230	3.040	2.323	2.079	2.806
Risso's dolphin	0.229	0.066	0.032	0.098	0.546	0.643	1.072	1.560	1.611	0.763	0.376	0.379	0.615	0.869
Long-finned pilot whale[c]	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268
Short-finned pilot whale[c]	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
Sperm whale[b]	0.051	0.033	0.030	0.008	0.024	0.044	0.062	0.158	0.097	0.077	0.041	0.040	0.055	0.068
Harbor porpoise	7.211	7.963	7.826	7.531	5.744	2.094	2.075	1.632	1.348	1.699	1.956	4.696	4.315	2.656
Gray seal	5.277	5.066	4.480	5.124	6.857	5.053	1.771	1.497	1.662	2.768	3.186	4.597	3.945	3.424
Harbor seal	11.857	11.382	10.066	11.512	15.407	11.353	3.979	3.364	3.734	6.220	7.158	10.327	8.863	7.693
Harp seal	5.277	5.066	4.480	5.124	6.857	5.053	1.771	1.497	1.662	2.768	3.186	4.597	3.945	3.424

[a] Density estimates are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (EEZ) (Roberts et al. 2016, 2022).
[b] Listed as Endangered under the ESA.
[c] Density adjusted by relative abundance.

H.2.1.2. Sea Turtles

Table H-10. Sea turtle density estimates for all modeled species in a 1 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	<0.001	<0.001	<0.001	<0.001
Leatherback sea turtle	0.025	0.630[c]	0.873[c]	0.025
Loggerhead sea turtle	0.077	0.206[d]	0.633[d]	0.077
Kemp's ridley sea turtle	<0.001	<0.001	<0.001	<0.001

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 1 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-11. Sea turtle density estimates for all modeled species in a 10 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.007	0.007	0.007	0.007
Leatherback sea turtle	0.023	0.630[c]	0.873[c]	0.023
Loggerhead sea turtle	0.083	0.206[d]	0.633[d]	0.083
Kemp's ridley sea turtle	0.007	0.007	0.007	0.007

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 10 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-12. Sea turtle density estimates for all modeled species in a 15 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.009	0.009	0.009	0.009
Leatherback sea turtle	0.027	0.630[c]	0.873[c]	0.027
Loggerhead sea turtle	0.082	0.206[d]	0.633[d]	0.082
Kemp's ridley sea turtle	0.009	0.009	0.009	0.009

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 15 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-13. Sea turtle density estimates for all modeled species in a 20 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.009	0.009	0.009	0.009
Leatherback sea turtle	0.028	0.630[c]	0.873[c]	0.028
Loggerhead sea turtle	0.085	0.206[d]	0.633[d]	0.085
Kemp's ridley sea turtle	0.009	0.009	0.009	0.009

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 20 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-14. Sea turtle density estimates for all modeled species in a 30 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.007	0.007	0.007	0.007
Leatherback sea turtle	0.029	0.630[c]	0.873[c]	0.029
Loggerhead sea turtle	0.087	0.206[d]	0.633[d]	0.087
Kemp's ridley sea turtle	0.007	0.007	0.007	0.007

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 30 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-15. Sea turtle density estimates for all modeled species in a 40 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.007	0.007	0.007	0.007
Leatherback sea turtle	0.032	0.630[c]	0.873[c]	0.032
Loggerhead sea turtle	0.086	0.206[d]	0.633[d]	0.086
Kemp's ridley sea turtle	0.007	0.007	0.007	0.007

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 40 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

Table H-16. Sea turtle density estimates for all modeled species in a 50 km buffer around the Lease Area.

Common name	Density (animals/100 km^2)[a]			
	Spring	Summer	Fall	Winter
Green sea turtle[b]	0.006	0.006	0.006	0.006
Leatherback sea turtle	0.034	0.630[c]	0.873[c]	0.034
Loggerhead sea turtle	0.085	0.206[d]	0.633[d]	0.085
Kemp's ridley sea turtle	0.006	0.006	0.006	0.006

[a] Density estimates are extracted from SERDP-SDSS NODE database within a 50 km buffer of the Project, unless otherwise noted.
[b] Kraus et al. (2016) did not observe any green sea turtles in the RI/MA WEA. Densities of Kemp's ridley sea turtles are used as a conservative estimate.
[c] Densities calculated as averaged seasonal densities from 2011 to 2015 (Kraus et al. 2016).
[d] Densities calculated as the averaged seasonal leatherback sea turtle densities scaled by the relative, seasonal sighting rates of loggerhead and leatherback sea turtles (Kraus et al. 2016).

H.2.2. Exposure Estimates

H.2.2.1. Marine Mammals

This section contains mean marine mammal exposure estimates for each year of the proposed construction schedules described in Section 1.2.2, assuming 0, 6, 10, and 15 dB of broadband attenuation.

Table H-17. Construction schedule 1 (monopile), year 1: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	43.94	22.02	13.15	5.76	0.38	0.11	0.01	0.01	109.77	61.24	38.76	21.96	97.54	58.31	40.55	25.59
LF	Minke whale (migrating)	121.17	70.88	45.73	20.67	0.39	0.05	<0.01	<0.01	382.98	238.45	168.58	112.80	969.91	729.65	567.39	431.41
LF	Humpback whale	28.78	15.95	9.33	4.73	0.11	0.06	<0.01	<0.01	74.48	43.56	28.37	17.63	66.88	40.91	28.67	19.12
LF	North Atlantic right whale[c]	7.87	3.45	2.07	0.98	0.01	<0.01	<0.01	<0.01	26.96	13.21	8.80	4.42	24.78	12.62	8.74	4.51
LF	Sei whale[c] (migrating)	4.20	2.13	1.30	0.61	0.04	0.02	<0.01	<0.01	12.82	7.15	4.69	2.64	53.74	35.90	27.14	17.63
MF	Atlantic white-sided dolphin	0	0	0	0	0.27	0.02	0	0	1170.81	723.18	520.75	349.51	397.00	241.76	164.08	100.10
MF	Atlantic spotted dolphin	0	0	0	0	<0.01	<0.01	0	0	62.68	33.16	22.71	13.60	20.13	10.72	7.16	4.41
MF	Common dolphin	0	0	0	0	10.50	6.39	0	0	15007.89	9527.34	6975.27	4688.53	5075.58	3113.09	2207.95	1377.48
MF	Bottlenose dolphin, offshore	0	0	0	0	0.05	0.05	0	0	620.99	370.02	267.39	171.70	216.27	133.56	93.69	56.75
MF	Risso's dolphin	0	0	0	0	<0.01	<0.01	0	0	101.83	53.86	36.45	20.83	30.21	15.89	10.70	6.60
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	80.81	48.53	34.61	22.59	26.82	15.90	10.95	6.62
MF	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	61.60	36.55	26.09	16.86	20.01	11.77	8.14	5.02
MF	Sperm whale[c]	0	0	0	0	<0.01	<0.01	0	0	32.28	18.64	12.42	7.70	10.39	6.08	4.05	2.35
HF	Harbor porpoise (sensitive)	1.27	0	0	0	23.40	11.04	5.25	1.48	796.19	458.67	312.22	176.69	3552.44	2252.38	1618.93	1028.36
PW	Gray seal	3.19	0.47	0.03	0.01	<0.01	<0.01	<0.01	0	239.14	110.00	68.74	28.55	130.86	67.30	36.70	20.67
PW	Harbor seal	13.07	2.75	0.39	0	0.93	0.39	0.18	0.18	518.51	256.86	171.44	82.59	288.70	158.48	89.25	54.09
PW	Harp seal	5.75	1.19	0.10	0	0.61	0.16	<0.01	0	274.71	129.85	83.17	40.83	148.47	79.15	44.80	26.73

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

Table H-18. Construction schedule 1 (monopile), year 2: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	36.36	18.34	10.95	4.86	0.31	0.09	0.01	0.01	89.17	49.88	31.90	18.09	79.02	47.18	32.97	20.78
LF	Minke whale (migrating)	118.58	69.43	45.01	20.32	0.42	0.08	<0.01	<0.01	366.84	230.71	163.90	110.19	909.25	687.17	536.65	409.02
LF	Humpback whale	29.37	16.47	9.70	4.93	0.11	0.06	<0.01	<0.01	74.44	43.71	28.78	18.10	66.33	40.75	28.69	19.27
LF	North Atlantic right whale[c]	8.15	3.62	2.19	1.03	0.02	<0.01	<0.01	<0.01	27.30	13.56	9.07	4.61	24.92	12.85	8.92	4.66
LF	Sei whale[c] (migrating)	4.67	2.40	1.47	0.69	0.05	0.02	<0.01	<0.01	13.90	7.82	5.18	2.96	57.07	38.30	29.01	18.94
MF	Atlantic white-sided dolphin	0	0	0	0	0.24	0.02	0	0	1222.67	760.05	550.05	371.11	415.29	254.43	173.57	106.18
MF	Atlantic spotted dolphin	0	0	0	0	<0.01	<0.01	0	0	72.47	37.96	26.05	15.49	22.78	12.02	8.01	4.93
MF	Common dolphin	0	0	0	0	9.63	5.81	0	0	14832.54	9399.14	6912.30	4610.68	5011.21	3045.63	2165.84	1352.47
MF	Bottlenose dolphin, offshore	0	0	0	0	0.06	0.06	0	0	575.24	344.78	249.70	160.14	200.05	123.85	87.15	53.08
MF	Risso's dolphin	0	0	0	0	<0.01	<0.01	0	0	88.35	46.87	31.93	18.28	26.36	13.90	9.39	5.81
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	75.89	45.89	32.86	21.56	25.29	15.06	10.42	6.32
MF	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	57.69	34.40	24.65	15.97	18.80	11.09	7.69	4.74
MF	Sperm whale[c]	0	0	0	0	<0.01	<0.01	0	0	26.74	15.52	10.37	6.58	8.68	5.16	3.44	1.99
HF	Harbor porpoise (sensitive)	1.18	0	0	0	23.57	11.15	5.41	1.45	765.51	446.16	304.34	175.77	3331.69	2122.59	1533.99	975.67
PW	Gray seal	3.60	0.53	0.04	0.02	0.01	0.01	0.01	0	259.58	122.20	76.79	32.87	142.27	73.93	41.27	23.39
PW	Harbor seal	14.98	3.10	0.43	0	1.02	0.45	0.20	0.19	562.61	285.50	191.51	94.72	315.42	174.47	100.62	61.22
PW	Harp seal	6.56	1.38	0.12	0	0.69	0.18	0.01	0	297.46	144.30	92.84	46.68	161.76	87.06	50.40	30.22

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

Table H-19. Construction schedule 2 (monopile), year 1: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	40.18	20.56	12.71	5.82	0.30	0.09	0.01	0.01	877.88	596.89	458.20	339.44	78.23	47.23	33.16	21.05
	Minke whale (migrating)	124.55	73.39	48.19	22.70	0.38	0.08	<0.01	<0.01	1469.48	1038.50	892.16	673.19	847.54	642.62	502.02	384.19
	Humpback whale	29.33	16.75	10.28	5.31	0.10	0.05	0.01	0.01	521.38	361.62	288.90	212.12	60.65	37.21	26.37	17.64
	North Atlantic right whale[c]	7.32	3.31	2.05	1.01	0.01	<0.01	<0.01	<0.01	166.64	121.75	99.91	74.30	18.70	9.94	7.19	3.85
	Sei whale[c] (migrating)	4.28	2.24	1.41	0.67	0.04	0.01	<0.01	<0.01	87.09	59.08	45.42	32.86	47.38	32.01	24.20	15.71
MF	Atlantic white-sided dolphin	0	0	0	0	0.04	0.02	0	0	5481.17	3898.70	3121.74	2347.02	368.20	226.22	156.20	95.43
	Atlantic spotted dolphin	0	0	0	0	<0.01	<0.01	0	0	669.10	422.45	314.61	215.63	21.28	11.35	7.66	4.78
	Common dolphin	0	0	0	0	7.22	3.73	0	0	72313.63	50381.83	39749.14	29477.99	4703.13	2873.44	2045.32	1281.06
	Bottlenose dolphin, offshore	0	0	0	0	0.08	0.08	0	0	4810.63	3380.58	2239.22	1418.07	193.05	119.24	84.56	51.87
	Risso's dolphin	0	0	0	0	0.02	<0.01	0	0	3134.84	2120.71	1637.79	777.95	25.41	13.53	9.19	5.67
	Long-finned pilot whale	0	0	0	0	0	0	0	0	646.39	458.23	345.90	244.66	23.85	14.41	10.00	6.14
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	501.73	345.44	270.46	180.25	17.66	10.50	7.29	4.52
	Sperm whale[c]	0	0	0	0	<0.01	<0.01	0	0	218.17	147.14	114.23	79.79	8.97	5.34	3.55	2.06
HF	Harbor porpoise (sensitive)	0.89	0	0	0	21.64	10.23	5.43	1.26	4007.84	2854.36	2325.99	1739.29	2739.50	1739.93	1260.77	838.08
PW	Gray seal	2.92	0.43	0.05	0.02	0.01	0.01	0.01	0	5350.59	3659.93	2852.04	1646.69	92.62	51.52	28.19	16.31
	Harbor seal	12.34	2.72	0.28	0	0.71	0.33	0.13	0.13	11819.47	8181.62	5077.60	3729.50	211.99	124.63	70.10	43.53
	Harp seal	5.32	1.10	0.09	0	0.50	0.13	0.01	0	6623.36	4478.15	3444.19	2015.04	106.91	61.57	34.94	21.31

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

Table H-20. Construction schedule 2 (monopile), year 2: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	44.59	23.12	14.30	6.66	0.33	0.10	0.02	0.02	912.84	622.77	480.18	357.11	84.93	51.24	36.19	23.03
	Minke whale (migrating)	127.07	75.40	49.58	23.14	0.41	0.10	<0.01	<0.01	1417.19	1007.47	868.22	657.88	828.91	630.66	494.57	380.64
	Humpback whale	30.09	17.37	10.70	5.53	0.09	0.04	0.01	0.01	504.01	350.64	281.97	207.84	60.97	37.47	26.64	17.95
	North Atlantic right whale[c]	8.27	3.67	2.27	1.12	0.02	<0.01	<0.01	<0.01	166.80	121.35	99.95	74.57	23.23	11.98	8.31	4.34
	Sei whale[c] (migrating)	4.35	2.28	1.44	0.69	0.04	0.01	<0.01	<0.01	80.31	54.48	41.91	30.48	48.00	32.27	24.53	16.13
MF	Atlantic white-sided dolphin	0	0	0	0	0.05	0.02	0	0	5293.38	3773.58	3044.96	2299.01	385.78	237.34	163.98	100.50
	Atlantic spotted dolphin	0	0	0	0	<0.01	<0.01	0	0	676.43	429.94	319.59	221.33	22.43	12.09	8.17	5.12
	Common dolphin	0	0	0	0	7.82	4.24	0	0	73617.48	51666.17	41092.18	30737.33	5118.15	3145.85	2244.35	1407.30
	Bottlenose dolphin, offshore	0	0	0	0	0.11	0.11	0	0	4982.13	3517.37	2341.10	1492.57	209.81	129.76	92.16	56.71
	Risso's dolphin	0	0	0	0	0.02	0.01	0	0	3344.43	2272.51	1759.84	841.50	28.59	15.25	10.40	6.43
	Long-finned pilot whale	0	0	0	0	0	0	0	0	663.77	473.94	353.79	254.92	25.96	15.71	10.92	6.72
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	517.02	357.05	280.24	187.78	19.13	11.37	7.91	4.90
	Sperm whale[c]	0	0	0	0	<0.01	<0.01	0	0	230.36	155.86	121.35	84.83	9.84	5.89	3.94	2.28
HF	Harbor porpoise (sensitive)	0.98	0	0	0	24.38	11.54	6.14	1.42	4099.96	2917.91	2381.32	1783.32	3204.87	2055.90	1488.80	952.93
PW	Gray seal	3.34	0.50	0.06	0.02	0.01	0.01	0.01	0	5119.14	3504.07	2732.53	1596.43	126.21	65.04	35.92	20.33
	Harbor seal	14.03	3.07	0.35	0	0.83	0.38	0.16	0.15	11229.79	7808.29	4902.30	3607.20	278.53	153.50	87.41	53.07
	Harp seal	6.08	1.27	0.11	0	0.58	0.15	0.01	0	6285.16	4259.63	3281.75	1944.79	143.23	76.36	43.80	26.14

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

Table H-21. Construction schedule 3 (jacket), year 1: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species		Injury								Behavior							
		L_E				L_{PK}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	37.79	18.95	10.31	4.44	0.12	0	0	0	73.32	34.28	22.44	11.75	90.60	48.60	32.14	18.07
	Minke whale (migrating)	184.96	89.42	45.61	11.14	0.34	0	0	0	465.21	278.25	196.07	115.43	1468.04	1077.11	856.56	603.48
	Humpback whale	37.34	19.86	11.69	5.73	0.10	0	0	0	79.47	40.62	28.36	15.43	87.39	48.70	34.15	19.65
	North Atlantic right whale[c]	14.95	7.20	3.88	1.05	<0.01	0	0	0	39.63	21.34	11.96	6.97	45.52	24.30	13.35	7.94
	Sei whale[c] (migrating)	8.06	3.97	2.29	0.96	0.05	0.01	0.01	0	18.55	9.51	6.11	3.41	123.61	79.47	57.29	35.97
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	1686.70	1013.35	727.05	400.07	801.14	435.02	289.65	163.78
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	71.24	38.84	24.35	14.47	32.18	16.78	10.91	5.59
	Common dolphin	0	0	0	0	9.63	0	0	0	20103.00	12385.92	8552.10	5142.45	8776.47	5065.36	3422.27	1937.65
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	729.42	438.99	303.48	174.94	344.46	200.22	137.32	79.73
	Risso's dolphin	0	0	0	0	0.04	0	0	0	87.87	47.17	29.05	17.87	41.05	21.77	14.08	7.03
	Long-finned pilot whale	0	0	0	0	0.03	0	0	0	95.11	56.41	39.75	24.98	45.55	25.67	17.18	9.25
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	72.81	42.67	29.91	17.94	34.56	19.07	12.58	6.95
	Sperm whale[c]	0	0	0	0	0	0	0	0	28.14	14.87	10.01	5.68	14.78	7.82	4.89	2.53
HF	Harbor porpoise (sensitive)	0	0	0	0	28.37	5.66	0.74	0.61	1054.08	572.76	377.27	218.28	8909.31	5658.46	4223.20	2497.95
PW	Gray seal	8.50	1.13	0.06	<0.01	<0.01	0	0	0	311.78	134.24	73.77	30.87	345.89	145.43	84.30	40.85
	Harbor seal	25.53	1.33	0	0	0.65	0.61	0.61	0	916.84	499.43	293.12	161.75	837.46	391.25	242.85	141.54
	Harp seal	12.96	0.34	0	0	0.56	0	0	0	460.95	228.08	140.93	77.78	442.35	200.58	126.41	69.77

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

Table H-22. Construction schedule 3 (jacket), year 2: Mean number of marine mammals predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species		Injury								Behavior							
		L_E				L_{PK}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	28.68	14.35	8.10	3.35	0.16	0.03	0.03	0	258.28	155.97	113.00	69.57	70.68	37.08	24.34	13.84
	Minke whale (migrating)	136.46	67.66	34.86	7.41	0.25	0	0	0	857.29	625.29	491.14	344.77	1110.32	816.07	649.79	459.53
	Humpback whale	27.45	14.40	8.67	3.86	0.04	0	0	0	213.03	132.87	97.70	64.17	64.33	35.64	25.05	14.44
	North Atlantic right whale[c]	12.68	5.69	3.07	0.89	0.01	0	0	0	103.05	55.88	39.95	23.03	42.97	21.16	11.22	6.50
	Sei whale[c] (migrating)	6.04	2.95	1.69	0.71	0.03	<0.01	<0.01	0	41.32	24.74	18.01	11.51	95.94	60.72	44.74	28.50
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	3227.32	2161.72	1647.54	1152.83	646.85	345.52	226.65	129.85
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	213.78	106.38	74.62	41.32	25.35	13.40	8.80	4.58
	Common dolphin	0	0	0	0	7.00	0	0	0	39890.04	25868.33	20176.85	13919.65	6563.41	3758.63	2507.74	1403.89
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	1788.80	1118.05	829.54	566.20	264.44	150.13	102.19	58.70
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	429.19	180.45	135.72	78.41	31.76	16.47	10.62	5.18
	Long-finned pilot whale	0	0	0	0	<0.01	0	0	0	246.98	146.73	112.19	73.29	35.83	19.60	13.01	7.06
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	184.23	108.68	82.78	54.87	26.86	14.53	9.50	5.26
	Sperm whale[c]	0	0	0	0	0	0	0	0	72.74	47.24	35.11	23.42	10.80	5.63	3.51	1.85
HF	Harbor porpoise (sensitive)	0	0	0	0	23.91	5.53	0.84	0.22	2191.44	1384.36	1001.11	666.32	7868.63	5372.33	4087.78	2255.64
PW	Gray seal	6.91	0.92	0.09	<0.01	0.08	0	0	0	1201.64	472.31	325.63	170.68	347.39	136.51	76.29	35.30
	Harbor seal	21.66	0.93	0	0	0.85	0.49	0.49	0	2955.95	1271.65	796.36	528.24	808.23	355.61	214.89	119.56
	Harp seal	10.72	0.21	0	0	0.45	0	0	0	1533.99	631.67	460.30	261.00	431.21	183.43	112.02	58.84

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

H.2.2.2. Sea Turtles

This section contains mean sea turtle exposure estimates for each year of the proposed construction schedules described in Section 1.2, assuming 0, 6, 10, and 15 dB of broadband attenuation.

Table H-23. Construction schedule 1 (monopile), year 1: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.13	<0.01	<0.01	<0.01	0	0	0	0	0.38	0.19	0.12	<0.01
Leatherback turtle[a]	14.67	4.00	2.03	0.25	0	0	0	0	38.60	13.28	5.69	2.65
Loggerhead turtle	4.12	0.99	0.10	0.01	0	0	0	0	14.28	7.37	3.83	1.87
Green turtle	0.15	0.05	<0.01	<0.01	<0.01	0	0	0	0.41	0.18	0.10	0.05

[a] Listed as Endangered under the ESA.

Table H-24. Construction schedule 1 (monopile), year 2: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.12	<0.01	<0.01	<0.01	0	0	0	0	0.36	0.18	0.11	<0.01
Leatherback turtle[a]	14.65	3.97	1.97	0.25	0	0	0	0	37.66	13.23	5.71	2.59
Loggerhead turtle	4.31	1.04	0.12	0.02	0	0	0	0	15.07	7.74	4.03	1.92
Green turtle	0.15	0.05	<0.01	<0.01	<0.01	0	0	0	0.39	0.17	0.10	0.04

[a] Listed as Endangered under the ESA.

Table H-25. Construction schedule 2 (monopile), year 1: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.13	<0.01	<0.01	<0.01	0	0	0	0	0.34	0.17	0.11	<0.01
Leatherback turtle[a]	16.67	4.70	2.15	0.41	0	0	0	0	36.00	12.99	5.61	2.45
Loggerhead turtle	4.55	1.30	0.16	0.02	0	0	0	0	14.44	7.14	3.94	1.66
Green turtle	0.17	0.06	<0.01	<0.01	<0.01	0	0	0	0.37	0.17	0.10	0.04

[a] Listed as Endangered under the ESA.

Table H-26. Construction schedule 2 (monopile), year 2: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.14	<0.01	<0.01	<0.01	0	0	0	0	0.37	0.18	0.12	<0.01
Leatherback turtle[a]	18.50	5.24	2.31	0.43	0	0	0	0	38.89	14.40	6.25	2.65
Loggerhead turtle	4.93	1.40	0.19	0.03	0	0	0	0	15.81	7.79	4.29	1.78
Green turtle	0.18	0.06	<0.01	<0.01	<0.01	0	0	0	0.41	0.19	0.11	0.05

[a] Listed as Endangered under the ESA.

Table H-27. Construction schedule 3 (jacket), year 1: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{PK}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.02	<0.01	<0.01	0	0	0	0	0	0.32	0.14	<0.01	<0.01
Leatherback turtle[a]	6.87	2.34	0.59	0	0	0	0	0	12.44	4.22	1.77	0.43
Loggerhead turtle	4.05	0.11	0	0	0	0	0	0	15.23	6.64	3.45	0.76
Green turtle	0.02	<0.01	<0.01	0	0	0	0	0	0.26	0.12	<0.01	<0.01

[a] Listed as Endangered under the ESA.

Table H-28. Construction schedule 3 (jacket), year 2: Mean number of sea turtles predicted to receive sound levels above exposure criteria with sound attenuation. Construction schedule assumptions are summarized in Section 1.2.

Species	Injury								Behavior			
	L_E				L_{PK}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.01	<0.01	<0.01	0	0	0	0	0	0.24	0.11	<0.01	<0.01
Leatherback turtle[a]	5.10	1.69	0.40	0	0	0	0	0	9.27	3.00	1.25	0.29
Loggerhead turtle	2.92	0.14	0	0	0	0	0	0	10.80	5.09	2.60	0.64
Green turtle	0.07	<0.01	<0.01	0	0	0	0	0	0.20	0.09	<0.01	<0.01

[a] Listed as Endangered under the ESA.

H.2.3. Exposure Ranges

H.2.3.1. Marine Mammals

This section contains marine mammal exposure ranges for each of the modeled cases and seasons for sequential impact pile driving, concurrent impact pile driving, and vibratory and impact pile driving assuming 0, 6, 10, and 15 dB broadband attenuation.

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

Sequential Pile Driving

Table H-29. WTG monopile foundation (16 m diameter, two piles per day, summer) impact pile driving exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	8.35	5.60	4.15	2.59	0.06	0.01	<0.01	<0.01	13.17	9.29	7.03	4.85	13.24	9.27	6.97	4.82
LF	Minke whale (migrating)	5.61	3.60	2.42	1.16	0.08	0.02	0	0	12.32	8.70	6.68	4.47	32.52	24.95	20.70	16.18
LF	Humpback whale	7.27	4.72	3.46	2.01	0.05	<0.01	<0.01	<0.01	12.84	8.99	6.79	4.56	12.86	8.99	6.75	4.56
LF	North Atlantic right whale[c]	6.74	4.19	2.95	1.75	0.09	<0.01	<0.01	<0.01	12.63	8.74	6.71	4.53	12.69	8.76	6.70	4.46
LF	Sei whale[c] (migrating)	7.05	4.39	3.19	1.82	0.08	<0.01	<0.01	<0.01	12.93	9.07	6.86	4.62	33.98	25.71	21.65	16.77
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	12.23	8.51	6.54	4.48	5.13	3.30	2.33	1.27
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	12.84	8.98	6.64	4.61	5.29	3.50	2.44	1.38
MF	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	12.38	8.61	6.44	4.53	5.30	3.32	2.37	1.38
MF	Bottlenose dolphin, offshore	0	0	0	0	<0.01	<0.01	0	0	10.71	7.20	5.46	3.83	4.84	3.17	2.25	1.29
MF	Risso's dolphin	0	0	0	0	<0.01	<0.01	0	0	12.71	9.05	6.87	4.56	5.36	3.46	2.31	1.43
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	12.34	8.63	6.60	4.51	5.27	3.36	2.38	1.41
MF	Short-finned pilot whale	0	0	0	0	0	0	0	0	12.58	8.76	6.66	4.53	5.31	3.35	2.36	1.38
MF	Sperm whale[c]	0	0	0	0	<0.01	<0.01	0	0	12.65	8.89	6.75	4.62	5.18	3.36	2.56	1.35
HF	Harbor porpoise (sensitive)	0.02	0	0	0	0.76	0.33	0.25	0.03	12.39	8.80	6.67	4.43	47.02	33.23	26.28	20.26
PW	Gray seal	1.53	0.72	0.01	0.01	0.01	0.01	0.01	0	13.45	9.56	7.29	4.85	8.83	5.92	4.26	2.96
PW	Harbor seal	1.16	0.41	0.12	0	0.04	0.04	0	0	12.58	8.76	6.84	4.67	8.24	5.57	4.12	2.53
PW	Harp seal	1.26	0.38	0.05	0	0.10	0.05	0.01	0	12.82	9.12	6.79	4.76	8.71	5.79	4.19	2.84

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

Table H-30. WTG monopile foundation (16 m diameter, one pile per day, summer) impact pile driving exposure ranges ($ER_{95\%}$)in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	8.26	5.42	3.99	2.33	0.07	0.03	0	0	13.42	9.42	7.08	4.81	13.42	9.37	7.01	4.76
	Minke whale (migrating)	5.64	3.89	2.41	1.07	0.06	0	0	0	12.58	8.89	6.61	4.67	32.63	25.04	20.97	16.33
	Humpback whale	7.19	4.69	3.13	1.95	0.04	0.02	0	0	12.67	9.27	6.97	4.72	12.68	9.24	6.95	4.67
	North Atlantic right whale[c]	6.63	4.11	2.82	1.81	0.01	0.01	0	0	12.67	8.92	6.82	4.64	12.69	8.89	6.84	4.62
	Sei whale[c] (migrating)	6.69	4.32	3.06	1.79	0.08	<0.01	<0.01	<0.01	13.01	9.19	7.04	4.67	34.12	25.95	21.80	16.77
MF	Atlantic white-sided dolphin	0	0	0	0	<0.01	0	0	0	12.15	8.59	6.57	4.45	5.04	3.35	2.45	1.35
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	13.10	9.24	6.94	4.69	5.38	3.43	2.37	1.31
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	12.53	8.81	6.67	4.54	5.27	3.29	2.30	1.42
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	11.67	7.94	5.51	3.92	4.83	3.18	2.30	1.24
	Risso's dolphin	0	0	0	0	0	0	0	0	12.79	9.20	7.02	4.61	5.41	3.54	2.50	1.36
	Long-finned pilot whale	0	0	0	0	0	0	0	0	12.52	8.76	6.58	4.60	5.26	3.45	2.43	1.31
	Short-finned pilot whale	0	0	0	0	0	0	0	0	12.81	8.85	6.80	4.70	5.23	3.38	2.40	1.41
	Sperm whale[c]	0	0	0	0	0	0	0	0	12.81	9.01	6.93	4.76	5.44	3.43	2.27	1.31
HF	Harbor porpoise (sensitive)	0.03	0	0	0	0.71	0.37	0.15	0.02	12.60	8.77	6.67	4.56	47.21	33.41	26.44	20.46
PW	Gray seal	1.48	0.53	0	0	0	0	0	0	13.62	9.66	7.48	4.90	8.99	5.97	4.35	2.94
	Harbor seal	1.30	0.25	<0.01	0	0.11	<0.01	0.01	0.01	12.71	8.84	6.91	4.66	8.51	5.66	4.02	2.79
	Harp seal	1.17	0.19	0.04	0	0.11	0.03	0	0	13.13	9.27	6.93	4.72	8.84	5.66	4.19	2.90

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

Table H-31. WTG monopile foundation (16 m diameter, one pile per day, winter) impact pile driving exposure ranges ($ER_{95\%}$)in km to marine mammal threshold criteria with sound attenuation.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	9.85	6.12	4.49	2.42	0.07	0.03	0	0	16.77	11.40	8.33	5.26	16.70	11.29	8.28	5.22
	Minke whale (migrating)	6.71	4.33	3.00	1.31	0.06	0	0	0	15.78	10.78	7.64	4.96	77.71	44.35	31.37	21.69
	Humpback whale	8.70	5.36	3.66	2.23	0.04	0.02	0	0	16.34	11.10	8.03	5.15	16.33	11.10	7.99	5.04
	North Atlantic right whale[c]	7.96	4.59	3.23	2.01	0.01	0.01	0	0	16.03	10.79	7.66	5.00	16.04	10.72	7.65	4.90
	Sei whale[c] (migrating)	8.12	4.92	3.38	2.11	0.08	<0.01	<0.01	<0.01	16.35	11.27	8.17	5.20	84.07	46.02	32.47	22.58
MF	Atlantic white-sided dolphin	0	0	0	0	<0.01	0	0	0	15.64	10.23	7.53	4.93	5.71	3.43	2.48	1.36
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	16.47	11.54	8.17	5.02	5.79	3.53	2.44	1.31
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	15.58	10.37	7.61	4.99	5.82	3.50	2.41	1.43
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	14.46	9.90	6.55	4.11	5.27	3.26	2.32	1.35
	Risso's dolphin	0	0	0	0	0	0	0	0	16.17	10.91	7.89	5.12	5.92	3.58	2.53	1.35
	Long-finned pilot whale	0	0	0	0	0	0	0	0	15.80	10.61	7.65	4.96	5.84	3.54	2.49	1.32
	Short-finned pilot whale	0	0	0	0	0	0	0	0	15.99	10.52	7.71	4.95	5.99	3.59	2.50	1.42
	Sperm whale[c]	0	0	0	0	0	0	0	0	16.08	11.20	7.93	5.13	6.13	3.62	2.45	1.33
HF	Harbor porpoise (sensitive)	0.36	0	0	0	0.71	0.37	0.13	0.05	15.95	10.84	7.54	5.07	85.97	84.13	79.83	37.77
PW	Gray seal	1.58	0.53	0.34	0	0	0	0	0	16.82	11.79	8.58	5.56	11.50	6.92	4.70	2.93
	Harbor seal	1.35	0.25	<0.01	0	0.11	<0.01	0.01	0.01	16.41	10.88	7.87	5.07	10.68	6.36	4.39	2.76
	Harp seal	1.25	0.20	0.04	0	0.11	0.03	0	0	16.43	11.20	8.11	5.13	11.00	6.40	4.51	2.94

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

Table H-32. Pre-piled jacket foundation (4.5 m diameter, four piles per day, summer) impact pile driving exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	6.21	3.89	2.37	1.27	0.03	0	0	0	9.05	5.49	3.92	2.38	9.05	5.48	3.88	2.38
LF	Minke whale (migrating)	3.59	2.11	1.24	0.52	0.02	0	0	0	8.37	5.08	3.47	2.14	31.16	21.76	17.14	12.16
LF	Humpback whale	5.14	3.14	1.88	0.95	0.02	0	0	0	8.77	5.24	3.77	2.33	8.82	5.26	3.73	2.35
LF	North Atlantic right whale[c]	4.63	2.57	1.73	0.60	0	0	0	0	8.56	5.23	3.73	2.20	8.69	5.22	3.70	2.20
LF	Sei whale[c] (migrating)	5.05	2.86	1.96	0.63	<0.01	<0.01	<0.01	0	8.76	5.43	3.85	2.27	33.85	23.23	18.21	13.00
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	8.11	4.98	3.55	2.14	3.73	2.22	1.44	0.83
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	8.99	5.28	3.80	2.14	4.07	2.22	1.37	0.62
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	8.19	5.13	3.63	2.25	3.87	2.30	1.52	0.86
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	7.00	4.31	3.08	1.97	3.63	2.10	1.38	0.77
MF	Risso's dolphin	0	0	0	0	<0.01	0	0	0	8.80	5.33	3.68	2.22	4.08	2.29	1.53	0.75
MF	Long-finned pilot whale	0	0	0	0	<0.01	0	0	0	8.28	5.12	3.66	2.24	3.90	2.28	1.53	0.87
MF	Short-finned pilot whale	0	0	0	0	0	0	0	0	8.42	5.15	3.68	2.22	3.87	2.27	1.50	0.81
MF	Sperm whale[c]	0	0	0	0	0	0	0	0	8.65	5.30	3.73	2.26	3.92	2.26	1.40	0.83
HF	Harbor porpoise (sensitive)	0	0	0	0	0.38	0.17	<0.01	<0.01	8.20	5.12	3.47	2.18	67.22	41.29	31.63	22.74
PW	Gray seal	1.35	0.52	0	0	0	0	0	0	9.18	5.55	4.04	2.37	6.54	3.90	2.69	1.66
PW	Harbor seal	0.52	0.15	0	0	0.01	0.01	0.01	0	8.50	5.27	3.61	2.21	5.96	3.60	2.36	1.48
PW	Harp seal	0.65	0.05	0	0	0.05	0	0	0	9.05	5.34	3.88	2.24	6.25	3.64	2.62	1.55

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

Table H-33. Pre-piled jacket foundation (4.5 m diameter, four piles per day, winter) impact pile driving exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_E			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.59	4.32	2.55	1.35	0.03	0	0	0	10.60	5.92	4.27	2.43	10.60	5.86	4.18	2.42
	Minke whale (migrating)	4.25	2.38	1.28	0.61	0.02	0	0	0	9.87	5.46	3.67	2.26	76.93	40.63	26.69	15.87
	Humpback whale	6.40	3.45	1.96	1.07	0.02	0	0	0	10.31	5.80	4.01	2.37	10.32	5.75	3.91	2.36
	North Atlantic right whale[c]	5.38	2.82	1.85	0.64	0	0	0	0	10.14	5.58	3.85	2.30	10.15	5.51	3.86	2.31
	Sei whale[c] (migrating)	6.22	3.31	2.22	0.79	<0.01	<0.01	<0.01	0	10.25	5.80	3.90	2.31	84.05	41.83	27.96	16.51
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	9.55	5.46	3.61	2.22	3.86	2.24	1.42	0.81
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	10.15	5.63	3.87	2.20	4.10	2.22	1.36	0.62
	Common dolphin	0	0	0	0	<0.01	0	0	0	9.74	5.52	3.80	2.33	4.03	2.36	1.53	0.87
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	8.65	4.63	3.22	2.02	3.76	2.12	1.36	0.70
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	10.23	5.57	4.08	2.31	4.19	2.38	1.54	0.75
	Long-finned pilot whale	0	0	0	0	<0.01	0	0	0	9.81	5.58	3.76	2.27	4.02	2.32	1.53	0.85
	Short-finned pilot whale	0	0	0	0	0	0	0	0	9.87	5.57	3.85	2.29	4.01	2.30	1.50	0.80
	Sperm whale[c]	0	0	0	0	0	0	0	0	10.29	5.68	3.92	2.26	4.06	2.26	1.54	0.79
HF	Harbor porpoise (sensitive)	0	0	0	0	0.37	0.16	<0.01	<0.01	9.98	5.60	3.75	2.20	87.21	86.50	84.64	62.26
PW	Gray seal	1.43	0.52	0.32	0	0	0	0	0	10.82	6.08	4.29	2.62	7.06	3.92	2.71	1.66
	Harbor seal	0.54	0.15	0	0	0.01	0.01	0.01	0	10.30	5.51	4.00	2.24	6.49	3.67	2.40	1.46
	Harp seal	0.65	0.05	0	0	0.05	0	0	0	10.36	5.84	4.05	2.41	6.71	3.82	2.62	1.60

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

Table H-34. Post-piled jacket foundation (4.5 m diameter, four piles per day, summer) impact pile driving exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	7.48	4.61	3.18	1.59	0.03	0	0	0	10.70	6.51	4.55	2.83	10.70	6.51	4.55	2.79
	Minke whale (migrating)	4.24	2.55	1.58	0.81	0.02	0	0	0	9.74	5.95	4.34	2.66	34.54	24.42	19.32	13.84
	Humpback whale	6.17	3.59	2.36	1.10	0.02	0	0	0	10.35	6.33	4.45	2.76	10.36	6.32	4.43	2.73
	North Atlantic right whale[c]	5.37	3.07	2.01	0.92	0	0	0	0	10.14	6.29	4.28	2.75	10.15	6.28	4.38	2.71
	Sei whale[c] (migrating)	6.03	3.53	2.59	1.16	<0.01	<0.01	<0.01	0	10.45	6.46	4.42	2.85	38.25	26.45	20.56	14.58
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	9.32	5.82	4.14	2.61	4.40	2.66	1.75	1.05
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	10.02	6.01	4.40	2.86	4.80	2.95	1.80	0.71
	Common dolphin	0	0	0	0	<0.01	0	0	0	9.62	6.05	4.38	2.66	4.59	2.66	1.88	1.14
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	8.64	5.10	3.72	2.34	4.26	2.65	1.74	0.99
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	10.31	6.24	4.42	2.68	4.68	2.72	1.78	1.01
	Long-finned pilot whale	0	0	0	0	<0.01	0	0	0	9.74	5.99	4.31	2.65	4.60	2.66	1.82	1.08
	Short-finned pilot whale	0	0	0	0	0	0	0	0	9.87	6.18	4.30	2.64	4.54	2.65	1.91	0.94
	Sperm whale[c]	0	0	0	0	0	0	0	0	10.39	6.27	4.34	2.64	4.64	2.64	1.81	1.10
HF	Harbor porpoise (sensitive)	0	0	0	0	0.51	0.25	0.06	<0.01	9.81	6.09	4.31	2.61	74.68	48.11	35.96	26.00
PW	Gray seal	1.67	0.84	0.41	0	0	0	0	0	10.91	6.66	4.68	3.02	7.72	4.53	3.33	1.97
	Harbor seal	0.82	0.16	0	0	0.01	0.01	0.01	0.01	10.44	6.12	4.40	2.83	7.17	4.31	3.19	1.79
	Harp seal	0.88	0.17	0	0	0.05	0	0	0	10.52	6.40	4.47	2.82	7.48	4.27	3.20	1.81

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

Table H-35. Post-piled jacket foundation (4.5 m diameter, four piles per day, winter) impact pile driving exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

	Species	Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	9.31	5.10	3.50	1.94	0.03	0	0	0	12.61	6.96	4.94	3.09	12.54	6.94	4.95	2.98
LF	Minke whale (migrating)	5.49	2.89	1.79	0.90	0.02	0	0	0	11.79	6.67	4.60	2.75	81.13	55.55	32.67	19.77
LF	Humpback whale	7.87	4.30	2.54	1.15	0.02	0	0	0	12.26	7.00	4.82	2.92	12.26	6.93	4.80	2.84
LF	North Atlantic right whale[c]	6.55	3.46	2.13	1.06	0	0	0	0	11.95	6.74	4.54	2.88	11.97	6.73	4.52	2.82
LF	Sei whale[c] (migrating)	7.31	3.94	2.72	1.17	0.01	<0.01	<0.01	0	12.44	6.81	4.88	3.12	85.45	57.92	34.22	20.51
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	11.58	6.54	4.38	2.73	4.56	2.70	1.75	1.04
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	12.46	6.84	4.73	3.05	4.82	2.95	1.79	0.67
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	11.58	6.59	4.60	2.84	4.79	2.72	1.93	1.14
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	10.44	5.61	3.86	2.38	4.49	2.62	1.73	0.91
MF	Risso's dolphin	0	0	0	0	<0.01	0	0	0	12.16	6.82	4.71	2.86	4.95	2.81	1.86	1.02
MF	Long-finned pilot whale	0	0	0	0	<0.01	0	0	0	11.83	6.64	4.64	2.80	4.74	2.76	1.89	1.09
MF	Short-finned pilot whale	0	0	0	0	0	0	0	0	11.99	6.72	4.53	2.84	4.80	2.75	1.95	0.93
MF	Sperm whale[c]	0	0	0	0	0	0	0	0	12.15	6.65	4.72	2.95	4.83	2.75	1.87	1.11
HF	Harbor porpoise (sensitive)	0	0	0	0	0.43	0.25	0.06	<0.01	12.13	6.70	4.58	2.75	87.42	86.73	85.95	80.92
PW	Gray seal	1.68	0.84	0.41	0	0	0	0	0	12.84	7.27	5.18	3.17	8.79	4.69	3.36	2.19
PW	Harbor seal	0.78	0.16	0	0	0.01	0.01	0.01	0.01	12.19	6.65	4.75	3.12	8.25	4.41	3.18	1.80
PW	Harp seal	0.88	0.17	0	0	0.05	0	0	0	12.41	6.90	4.79	3.11	8.52	4.50	3.21	1.88

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

Concurrent Pile Driving

Table H-36. WTG monopile foundation (16 m diameter, summer, one pile per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	9.05	5.93	4.25	2.44	0.08	0.01	0	0	14.16	9.61	7.19	4.84	14.16	9.64	7.18	4.83
LF	Minke whale (migrating)	5.65	3.13	2.06	1.25	0.04	0.01	<0.01	<0.01	12.58	8.68	6.44	4.39	37.17	26.59	21.43	16.63
LF	Humpback whale	7.60	4.77	3.47	1.89	0.05	0.01	0	0	13.38	9.24	6.75	4.59	13.41	9.26	6.80	4.54
LF	North Atlantic right whale[c]	6.63	4.03	2.85	1.42	0.10	<0.01	0	0	12.77	8.74	6.52	4.26	12.83	8.74	6.51	4.18
LF	Sei whale[c] (migrating)	7.19	4.69	3.06	1.77	0.08	0.02	<0.01	0	13.43	9.23	6.97	4.71	44.27	28.99	23.52	18.14
MF	Atlantic white-sided dolphin	0	0	0	0	<0.01	<0.01	0	0	12.28	8.35	6.29	4.27	5.13	3.00	2.07	1.22
MF	Atlantic spotted dolphin	0	0	0	0	<0.01	<0.01	0	0	12.25	8.23	6.29	4.30	5.28	3.18	2.18	1.20
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	12.26	8.44	6.26	4.36	5.17	3.13	2.20	1.35
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	11.31	7.27	5.41	3.56	4.89	3.01	2.05	1.26
MF	Risso's dolphin	0	0	0	0	<0.01	0	0	0	13.30	9.16	6.85	4.74	5.51	3.29	2.27	1.32
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	12.48	8.60	6.46	4.39	5.32	3.15	2.24	1.40
MF	Short-finned pilot whale	0	0	0	0	0.01	0	0	0	12.63	8.70	6.55	4.33	5.31	3.20	2.25	1.34
MF	Sperm whale[c]	0	0	0	0	<0.01	0	0	0	13.18	8.96	6.60	4.45	5.39	3.28	2.37	1.34
HF	Harbor porpoise (sensitive)	0.19	0	0	0	0.73	0.35	0.27	0.03	12.73	8.70	6.50	4.39	75.34	48.71	36.18	26.20
PW	Gray seal	1.84	0.70	0.31	0.17	0	0	0	0	14.50	10.13	7.79	4.99	10.17	6.16	4.57	3.04
PW	Harbor seal	1.31	0.51	0.05	0	0.05	<0.01	<0.01	<0.01	13.35	9.06	6.81	4.62	9.12	5.43	3.88	2.67
PW	Harp seal	1.19	0.37	0.04	0	0.09	0	0	0	13.71	9.37	7.10	4.79	9.37	5.87	4.30	2.75

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

Table H-37. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to marine mammal threshold criteria with sound attenuation.

Species		Injury								Behavior							
		L_E				L_{pk}				L_p [a]				L_p [b]			
		Attenuation (dB)								Attenuation (dB)							
		0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	8.12	4.99	3.58	1.76	0.06	0	0	0	11.71	7.09	4.98	3.08	11.69	7.05	4.95	3.12
LF	Minke whale (migrating)	4.64	2.60	1.56	0.71	<0.01	0	0	0	10.86	6.59	4.59	2.73	38.83	27.19	21.20	15.27
LF	Humpback whale	6.58	4.03	2.57	1.33	0.02	0	0	0	11.43	6.87	4.80	2.94	11.43	6.87	4.79	2.89
LF	North Atlantic right whale[c]	5.68	3.25	1.92	1.00	0.04	0	0	0	11.00	6.65	4.50	2.98	11.01	6.66	4.51	2.97
LF	Sei whale[c] (migrating)	6.46	3.94	2.41	1.30	0.05	<0.01	<0.01	0	11.50	6.97	4.75	3.02	44.10	29.44	22.90	16.16
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	10.47	6.39	4.34	2.70	4.69	2.78	1.73	0.98
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	10.15	6.33	4.31	2.42	4.69	2.55	1.86	0.82
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	10.79	6.61	4.58	2.80	4.83	2.74	1.82	1.04
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	9.85	5.67	3.84	2.30	4.54	2.54	1.63	0.97
MF	Risso's dolphin	0	0	0	0	0	0	0	0	11.38	6.89	4.74	2.88	4.99	2.77	1.73	0.94
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	10.86	6.52	4.51	2.78	4.84	2.75	1.87	0.96
MF	Short-finned pilot whale	0	0	0	0	0.01	0	0	0	11.02	6.66	4.67	2.80	4.90	2.77	1.74	0.95
MF	Sperm whale[c]	0	0	0	0	0	0	0	0	11.26	6.74	4.75	2.84	4.99	2.78	1.85	1.01
HF	Harbor porpoise (sensitive)	0	0	0	0	0.49	0.23	0.01	0	10.84	6.56	4.57	2.66	77.26	58.83	41.07	29.23
PW	Gray seal	1.80	0.56	0.17	0.17	<0.01	0	0	0	11.97	7.39	4.94	3.19	8.54	4.76	3.33	2.06
PW	Harbor seal	0.84	0.17	0	0	0.05	<0.01	<0.01	0	11.25	6.80	4.73	2.82	8.22	4.53	3.13	1.77
PW	Harp seal	0.78	0.20	0	0	0.02	0	0	0	11.42	7.04	4.82	3.02	8.49	4.61	3.22	1.90

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

Vibratory and Impact

Table H-38. Injury: WTG monopile foundation (16 m diameter, summer, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

Species		Impact								Vibratory			
		L_E				L_{pk}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	8.38	5.60	4.11	2.53	0.06	0.01	<0.01	<0.01	1.23	0.41	0.08	0
	Minke whale (migrating)	5.72	3.52	2.37	1.16	0.08	0.02	0	0	0.80	0.41	0	0
	Humpback whale	7.29	4.69	3.49	2.02	0.05	<0.01	<0.01	<0.01	1.09	0.41	0.18	0
	North Atlantic right whale[a]	6.78	4.15	3.07	1.75	0.09	<0.01	<0.01	<0.01	1.10	0.27	0.13	0
	Sei whale[a] (migrating)	7.05	4.40	3.13	1.84	0.08	<0.01	<0.01	<0.01	0.80	0.31	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[a]	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0.02	0	0	0	0.78	0.34	0.24	0.03	0	0	0	0
PW	Gray seal	1.51	0.70	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0
	Harbor seal	1.16	0.44	0.11	0	0.04	0.04	0	0	0	0	0	0
	Harp seal	1.26	0.38	0.05	0	0.10	0.05	0.01	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-39. Behavior: WTG monopile foundation (16 m diameter, summer, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

Species		Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	13.19	9.29	7.00	4.79	13.27	9.26	6.95	4.78	71.34	51.92	41.69	32.87
	Minke whale (migrating)	12.34	8.68	6.69	4.47	32.62	24.93	20.70	16.20	59.57	44.91	38.49	31.16
	Humpback whale	12.85	8.99	6.84	4.57	12.91	8.97	6.81	4.55	64.08	47.02	39.06	32.09
	North Atlantic right whale[c]	12.67	8.73	6.72	4.54	12.74	8.78	6.71	4.52	57.80	45.24	38.20	30.97
	Sei whale[c] (migrating)	12.94	9.03	6.87	4.65	33.89	25.71	21.65	16.85	70.36	51.30	40.46	32.83
MF	Atlantic white-sided dolphin	12.29	8.44	6.58	4.51	5.13	3.25	2.31	1.29	59.59	44.24	37.57	30.66
	Atlantic spotted dolphin	12.91	8.96	6.65	4.61	5.28	3.50	2.45	1.37	64.30	46.89	39.53	32.64
	Common dolphin	12.32	8.62	6.43	4.52	5.28	3.30	2.37	1.38	64.74	48.88	39.94	32.13
	Bottlenose dolphin, offshore	10.71	7.12	5.42	3.79	4.87	3.21	2.30	1.29	63.69	41.75	33.05	27.04
	Risso's dolphin	12.78	9.01	6.86	4.58	5.39	3.34	2.36	1.30	70.91	51.83	41.27	32.84
	Long-finned pilot whale	12.33	8.57	6.56	4.51	5.27	3.38	2.36	1.38	63.86	48.62	39.17	31.72
	Short-finned pilot whale	12.55	8.77	6.66	4.53	5.31	3.34	2.36	1.38	69.81	50.26	40.43	32.56
	Sperm whale[c]	12.60	8.92	6.81	4.66	5.27	3.40	2.57	1.35	71.00	50.06	40.27	32.17
HF	Harbor porpoise (sensitive)	12.41	8.74	6.59	4.40	46.94	33.29	26.23	20.21	56.51	42.74	36.86	30.39
PW	Gray seal	13.44	9.54	7.30	4.85	8.83	5.92	4.26	2.97	68.52	49.09	40.38	32.35
	Harbor seal	12.56	8.79	6.84	4.59	8.23	5.63	4.13	2.60	63.37	48.11	39.28	31.76
	Harp seal	12.79	9.07	6.81	4.73	8.72	5.70	4.18	2.75	71.79	52.01	41.64	33.12

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

Table H-40. Injury: WTG monopile foundation (16 m diameter, winter, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_E				L_{pk}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	10.61	6.35	4.60	2.71	0.06	0.01	<0.01	<0.01	1.45	0.54	0.08	0
	Minke whale (migrating)	7.26	4.07	2.83	1.38	0.08	0.02	0	0	0.86	0.41	0	0
	Humpback whale	9.18	5.53	3.95	2.13	0.05	<0.01	<0.01	<0.01	1.15	0.41	0.18	0
	North Atlantic right whale[a]	8.28	4.85	3.28	1.84	0.09	<0.01	<0.01	<0.01	1.16	0.29	0.13	0
	Sei whale[a] (migrating)	8.41	5.08	3.52	1.94	0.08	<0.01	<0.01	<0.01	0.94	0.31	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Sperm whale[a]	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0.20	0	0	0	0.77	0.36	0.24	0.05	0	0	0	0
PW	Gray seal	1.71	0.76	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0
	Harbor seal	1.23	0.47	0.11	0	0.04	0.02	0	0	0	0	0	0
	Harp seal	1.30	0.38	0.05	0	0.10	0.01	0.01	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-41. Behavior: WTG monopile foundation (16 m diameter, winter, two piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	16.57	11.29	8.20	5.35	16.48	11.18	8.20	5.26	84.70	83.00	80.92	72.56
	Minke whale (migrating)	15.56	10.56	7.57	4.92	74.04	43.55	30.89	21.61	83.32	80.47	76.01	64.46
	Humpback whale	16.21	10.96	7.76	5.00	16.25	10.95	7.81	4.94	84.15	82.45	80.21	70.34
	North Atlantic right whale[c]	15.55	10.58	7.66	5.03	15.60	10.55	7.67	4.94	81.62	79.14	74.05	60.31
	Sei whale[c] (migrating)	16.32	11.00	7.81	5.07	82.58	45.85	32.15	22.36	84.46	82.71	80.73	72.13
MF	Atlantic white-sided dolphin	15.35	10.24	7.37	4.86	5.65	3.42	2.38	1.32	84.29	82.46	80.68	68.77
	Atlantic spotted dolphin	16.09	10.87	7.93	4.98	5.81	3.67	2.53	1.37	85.70	84.40	82.90	71.84
	Common dolphin	15.38	10.19	7.47	4.90	5.80	3.44	2.46	1.41	84.33	82.52	80.50	69.78
	Bottlenose dolphin, offshore	13.57	8.99	6.33	4.25	5.27	3.32	2.32	1.30	83.97	80.59	76.76	68.40
	Risso's dolphin	16.15	10.81	7.74	5.15	5.84	3.54	2.40	1.45	84.80	83.21	81.42	72.74
	Long-finned pilot whale	15.54	10.29	7.50	4.91	5.76	3.50	2.49	1.49	84.85	82.80	81.34	66.75
	Short-finned pilot whale	15.66	10.40	7.61	4.90	5.82	3.52	2.41	1.39	84.56	83.08	81.33	72.41
	Sperm whale[c]	15.93	10.89	7.67	5.02	5.77	3.56	2.62	1.37	83.97	82.23	80.33	72.13
HF	Harbor porpoise (sensitive)	15.58	10.48	7.59	4.91	85.41	83.15	78.18	37.25	84.36	82.59	80.96	67.17
PW	Gray seal	16.73	11.76	8.41	5.57	11.52	6.73	4.69	2.89	83.69	82.50	80.40	71.83
	Harbor seal	15.83	10.75	7.55	4.98	10.71	6.32	4.50	2.70	82.90	79.03	75.96	66.04
	Harp seal	16.28	11.05	7.92	5.10	10.93	6.32	4.56	2.83	84.66	82.97	81.10	73.24

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

Table H-42. Injury: WTG monopile foundation (16 m diameter, summer, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

Species		Impact								Vibratory			
		L_E				L_{pk}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	8.28	5.46	3.98	2.28	0.07	0.03	0	0	1.13	0.44	0	0
	Minke whale (migrating)	5.63	3.85	2.41	1.08	0.06	0	0	0	0.82	0.17	0	0
	Humpback whale	7.19	4.67	3.10	1.95	0.04	0.02	0	0	1.00	0.35	0	0
	North Atlantic right whale[a]	6.63	4.09	2.81	1.79	0.01	0.01	0	0	1.18	0.26	0	0
	Sei whale[a] (migrating)	6.76	4.33	3.11	1.79	0.08	<0.01	<0.01	<0.01	0.91	0.15	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	0	0	0	0
	Sperm whale[a]	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0.03	0	0	0	0.75	0.37	0.20	0.02	0	0	0	0
PW	Gray seal	1.46	0.53	0	0	0	0	0	0	0	0	0	0
	Harbor seal	1.25	0.24	0.01	0	0.11	<0.01	0.01	0.01	0	0	0	0
	Harp seal	1.12	0.22	0.04	0	0.11	0.03	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-43. Behavior: WTG monopile foundation (16 m diameter, summer, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

Species		Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	13.38	9.45	7.06	4.83	13.38	9.42	7.02	4.82	72.33	52.83	41.83	33.44
	Minke whale (migrating)	12.55	8.89	6.65	4.64	32.68	25.01	20.96	16.39	61.20	45.49	38.77	31.95
	Humpback whale	12.69	9.28	6.96	4.69	12.73	9.22	6.90	4.67	63.99	46.89	39.71	32.55
	North Atlantic right whale[c]	12.63	8.93	6.77	4.55	12.68	8.92	6.76	4.55	59.81	46.82	39.14	32.03
	Sei whale[c] (migrating)	13.04	9.21	7.01	4.79	34.13	25.93	21.88	16.90	70.65	51.43	41.15	32.73
MF	Atlantic white-sided dolphin	12.27	8.62	6.64	4.43	5.14	3.25	2.47	1.28	60.59	44.84	38.50	31.32
	Atlantic spotted dolphin	13.11	9.25	6.90	4.57	5.40	3.50	2.44	1.23	65.52	47.73	40.92	33.08
	Common dolphin	12.50	8.75	6.74	4.55	5.22	3.20	2.31	1.42	69.13	50.68	40.99	32.89
	Bottlenose dolphin, offshore	11.68	8.20	5.46	3.92	4.84	3.19	2.26	1.22	61.37	42.74	34.63	27.97
	Risso's dolphin	12.80	9.13	6.97	4.60	5.34	3.50	2.50	1.33	71.77	52.01	41.86	33.27
	Long-finned pilot whale	12.59	8.76	6.70	4.58	5.23	3.40	2.47	1.39	68.67	49.87	40.42	32.36
	Short-finned pilot whale	12.81	8.83	6.82	4.65	5.19	3.43	2.35	1.40	70.60	51.26	41.45	33.11
	Sperm whale[c]	12.78	8.99	6.83	4.75	5.39	3.51	2.29	1.25	71.81	50.91	40.64	32.70
HF	Harbor porpoise (sensitive)	12.61	8.80	6.68	4.52	47.30	33.34	26.46	20.50	56.07	42.96	37.31	30.56
PW	Gray seal	13.61	9.66	7.49	4.89	9.00	5.98	4.31	2.96	68.75	50.11	40.66	32.92
	Harbor seal	12.70	8.90	6.81	4.73	8.50	5.67	4.01	2.78	66.93	48.63	39.66	32.09
	Harp seal	13.21	9.29	7.02	4.73	8.79	5.66	4.15	2.84	72.72	52.34	41.89	33.52

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

Table H-44. Injury: WTG monopile foundation (16 m diameter, winter, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_E				L_{pk}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	9.94	6.11	4.45	2.44	0.07	0.03	0	0	1.43	0.44	0	0
	Minke whale (migrating)	6.88	4.28	3.02	1.13	0.06	0	0	0	0.92	0.17	0	0
	Humpback whale	8.69	5.33	3.66	2.21	0.04	0.02	0	0	0.99	0.35	0	0
	North Atlantic right whale[a]	8.04	4.67	3.20	1.86	0.01	0.01	0	0	1.15	0.26	0	0
	Sei whale[a] (migrating)	8.11	4.93	3.39	2.10	0.08	<0.01	<0.01	<0.01	0.91	0.15	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
	Common dolphin	0	0	0	0	<0.01	<0.01	0	0	0	0	0	0
	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0
	Risso's dolphin	0	0	0	0	<0.01	0	0	0	0	0	0	0
	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
	Short-finned pilot whale	0	0	0	0	<0.01	0	0	0	0	0	0	0
	Sperm whale[a]	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0.35	0	0	0	0.75	0.37	0.18	0.05	0	0	0	0
PW	Gray seal	1.57	0.53	0.34	0	0	0	0	0	0	0	0	0
	Harbor seal	1.34	0.24	0.01	0	0.11	<0.01	0.01	0.01	0	0	0	0
	Harp seal	1.37	0.22	0.04	0	0.11	0.03	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-45. Behavior: WTG monopile foundation (16 m diameter, winter, one pile per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	16.79	11.44	8.38	5.24	16.75	11.29	8.35	5.18	85.44	84.60	83.42	74.85
LF	Minke whale (migrating)	15.86	10.79	7.63	4.95	77.79	44.16	31.30	21.66	84.51	82.80	79.52	69.06
LF	Humpback whale	16.36	11.10	7.96	5.12	16.30	11.08	8.04	5.06	85.23	84.33	83.28	72.09
LF	North Atlantic right whale[c]	16.03	10.75	7.69	5.01	16.07	10.68	7.68	5.01	82.51	80.96	76.20	63.11
LF	Sei whale[c] (migrating)	16.42	11.26	8.13	5.18	84.08	46.08	32.52	22.59	85.39	84.59	83.15	72.99
MF	Atlantic white-sided dolphin	15.66	10.18	7.50	4.89	5.75	3.39	2.50	1.35	85.12	84.19	82.91	69.68
MF	Atlantic spotted dolphin	16.51	11.53	8.13	5.05	5.78	3.58	2.47	1.23	86.34	85.67	84.75	73.84
MF	Common dolphin	15.70	10.43	7.60	4.99	5.86	3.47	2.51	1.43	85.16	84.11	82.80	72.24
MF	Bottlenose dolphin, offshore	14.36	9.91	6.42	4.20	5.24	3.25	2.32	1.34	85.03	82.49	79.58	69.12
MF	Risso's dolphin	16.11	10.94	7.88	5.10	5.93	3.66	2.52	1.36	85.49	84.80	83.57	74.81
MF	Long-finned pilot whale	15.78	10.69	7.58	4.99	5.88	3.51	2.56	1.37	85.48	84.15	83.08	70.08
MF	Short-finned pilot whale	15.99	10.65	7.64	5.01	5.96	3.66	2.42	1.42	85.24	84.49	83.29	74.13
MF	Sperm whale[c]	16.10	11.20	7.91	5.18	6.05	3.65	2.41	1.30	85.13	84.36	83.05	73.88
HF	Harbor porpoise (sensitive)	15.96	10.81	7.61	5.01	85.92	84.17	79.85	37.78	84.99	83.93	82.84	67.42
PW	Gray seal	16.87	11.79	8.56	5.56	11.50	6.92	4.69	2.96	85.12	84.63	83.53	73.41
PW	Harbor seal	16.36	10.87	7.83	5.04	10.64	6.38	4.42	2.76	84.28	81.77	79.50	70.26
PW	Harp seal	16.53	11.15	8.21	5.11	10.92	6.47	4.58	2.85	85.35	84.66	83.32	75.37

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

Table H-46. Injury: Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_E				L_{PK}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	6.30	3.79	2.25	1.32	0.05	<0.01	<0.01	0	0	0	0	0
LF	Minke whale (migrating)	3.60	2.06	1.13	0.49	<0.01	0	0	0	0	0	0	0
LF	Humpback whale	5.14	2.93	1.84	1.01	0.02	0	0	0	0	0	0	0
LF	North Atlantic right whale[a]	4.49	2.44	1.57	0.59	<0.01	0	0	0	0	0	0	0
LF	Sei whale[a] (migrating)	5.04	2.90	1.84	0.72	0.04	<0.01	<0.01	0	0	0	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	0	0	0	0
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0
MF	Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
MF	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
MF	Sperm whale[a]	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0	0	0	0	0.36	0.18	0.02	0	0	0	0	0
PW	Gray seal	1.36	0.52	0	0	<0.01	0	0	0	0	0	0	0
PW	Harbor seal	0.46	0.01	0	0	0.03	0.01	0.01	0	0	0	0	0
PW	Harp seal	0.60	0	0	0	0.03	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-47. Behavior: Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	9.15	5.48	3.90	2.38	9.16	5.48	3.75	2.38	25.46	19.12	15.75	12.09
	Minke whale (migrating)	8.32	5.06	3.53	2.17	31.06	21.76	17.00	12.15	23.97	18.32	14.99	11.73
	Humpback whale	8.73	5.23	3.74	2.21	8.73	5.24	3.71	2.21	24.96	18.67	15.47	11.89
	North Atlantic right whale[c]	8.56	5.12	3.67	2.21	8.56	5.14	3.62	2.21	24.08	18.31	15.21	11.78
	Sei whale[c] (migrating)	9.03	5.35	3.85	2.17	33.90	23.30	18.23	12.97	25.22	18.83	15.43	11.98
MF	Atlantic white-sided dolphin	8.13	5.03	3.54	2.22	3.81	2.25	1.38	0.83	23.58	17.94	14.67	11.50
	Atlantic spotted dolphin	8.89	5.35	3.83	2.21	4.03	2.25	1.47	0.65	25.52	19.37	15.72	12.26
	Common dolphin	8.15	5.17	3.63	2.23	3.89	2.24	1.52	0.84	24.47	18.27	15.11	11.74
	Bottlenose dolphin, offshore	7.04	4.31	3.24	1.92	3.77	2.11	1.37	0.69	20.77	15.83	13.22	10.29
	Risso's dolphin	8.79	5.26	3.69	2.28	3.91	2.31	1.52	0.69	25.15	18.97	15.45	11.95
	Long-finned pilot whale	8.21	5.12	3.61	2.26	3.94	2.30	1.52	0.90	24.48	18.46	15.22	11.82
	Short-finned pilot whale	8.47	5.07	3.62	2.16	3.90	2.21	1.46	0.86	24.72	18.45	15.18	11.86
	Sperm whale[c]	8.68	5.32	3.72	2.25	3.92	2.28	1.47	0.82	24.66	18.40	15.27	11.85
HF	Harbor porpoise (sensitive)	8.26	5.16	3.62	2.13	67.09	41.26	31.62	22.44	23.75	18.00	14.85	11.70
PW	Gray seal	9.17	5.54	4.02	2.35	6.55	3.89	2.70	1.54	25.45	19.03	15.68	12.25
	Harbor seal	8.65	5.11	3.68	2.24	6.00	3.61	2.42	1.45	24.28	18.44	14.91	11.90
	Harp seal	9.00	5.42	3.89	2.31	6.25	3.72	2.50	1.51	25.28	18.96	15.67	12.09

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

Table H-48. Injury: Pre-piled jacket foundation (4.5 m diameter, winter, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_E				L_{pk}				L_E			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[a]	7.59	4.29	2.56	1.34	0.03	<0.01	<0.01	0	0	0	0	0
LF	Minke whale (migrating)	4.38	2.44	1.32	0.60	<0.01	0	0	0	0	0	0	0
LF	Humpback whale	6.33	3.34	1.95	0.96	0.02	0	0	0	0	0	0	0
LF	North Atlantic right whale[a]	5.35	2.75	1.78	0.68	<0.01	0	0	0	0	0	0	0
LF	Sei whale[a] (migrating)	6.09	3.30	2.07	0.75	0.01	<0.01	<0.01	0	0	0	0	0
MF	Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Atlantic spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Common dolphin	0	0	0	0	<0.01	0	0	0	0	0	0	0
MF	Bottlenose dolphin, offshore	0	0	0	0	0	0	0	0	0	0	0	0
MF	Risso's dolphin	0	0	0	0	0	0	0	0	0	0	0	0
MF	Long-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
MF	Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0
MF	Sperm whale[a]	0	0	0	0	0	0	0	0	0	0	0	0
HF	Harbor porpoise (sensitive)	0	0	0	0	0.35	0.18	0.02	0	0	0	0	0
PW	Gray seal	1.43	0.65	0	0	<0.01	0	0	0	0	0	0	0
PW	Harbor seal	0.57	0.01	0	0	0.03	0.01	0.01	0	0	0	0	0
PW	Harp seal	0.60	0	0	0	0.03	0	0	0	0	0	0	0

[a] Listed as Endangered under the ESA.

Table H-49. Behavior: Pre-piled jacket foundation (4.5 m diameter, winter, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to marine mammal threshold criteria with sound attenuation.

	Species	Impact								Vibratory			
		L_p [a]				L_p [b]				L_p [a]			
		Attenuation (dB)								Attenuation (dB)			
		0	6	10	15	0	6	10	15	0	6	10	15
LF	Fin whale[c]	10.57	5.89	4.19	2.44	10.59	5.86	4.15	2.42	48.83	29.53	22.01	15.22
LF	Minke whale (migrating)	9.92	5.45	3.71	2.28	76.72	40.49	26.67	15.86	47.88	28.74	21.35	14.72
LF	Humpback whale	10.33	5.77	3.94	2.28	10.37	5.71	3.91	2.22	48.25	29.41	21.79	15.14
LF	North Atlantic right whale[c]	10.04	5.60	3.78	2.33	10.05	5.53	3.77	2.28	46.60	28.35	21.03	14.84
LF	Sei whale[c] (migrating)	10.32	5.83	4.02	2.22	84.08	41.90	27.83	16.50	48.44	29.26	21.96	15.05
MF	Atlantic white-sided dolphin	9.48	5.48	3.68	2.28	3.94	2.29	1.37	0.84	46.84	28.51	20.93	14.53
MF	Atlantic spotted dolphin	10.23	5.65	3.84	2.23	4.06	2.25	1.39	0.65	48.82	30.28	22.18	15.43
MF	Common dolphin	9.64	5.49	3.82	2.26	3.99	2.29	1.52	0.84	47.67	28.48	21.24	14.83
MF	Bottlenose dolphin, offshore	8.59	4.69	3.38	2.07	3.82	2.13	1.38	0.66	40.10	24.26	18.37	13.23
MF	Risso's dolphin	10.28	5.70	3.86	2.31	4.11	2.35	1.55	0.68	48.34	29.17	21.90	15.07
MF	Long-finned pilot whale	9.74	5.53	3.75	2.36	4.12	2.37	1.54	0.86	47.50	28.71	21.54	14.83
MF	Short-finned pilot whale	9.76	5.56	3.87	2.27	4.05	2.27	1.49	0.81	48.20	28.79	21.68	14.83
MF	Sperm whale[c]	10.25	5.62	3.95	2.31	4.11	2.31	1.51	0.87	47.80	28.68	21.61	14.97
HF	Harbor porpoise (sensitive)	9.89	5.54	3.79	2.21	87.25	86.54	84.62	62.28	47.09	28.50	21.08	14.77
PW	Gray seal	10.82	6.07	4.27	2.63	7.05	3.92	2.70	1.64	48.68	29.39	21.89	15.25
PW	Harbor seal	10.29	5.60	3.82	2.30	6.54	3.64	2.46	1.43	47.38	28.81	21.55	14.68
PW	Harp seal	10.40	5.73	3.97	2.43	6.74	3.80	2.56	1.60	48.67	29.43	21.96	15.20

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

H.2.3.2. Sea Turtles

This section contains sea turtle exposure ranges for each of the modeled cases and seasons assuming 0, 6, 10, and 15 dB broadband attenuation.

Sequential Pile Driving

Table H-50. WTG monopile foundation (16 m diameter, summer, two piles per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	2.02	0.69	0.39	0.02	0	0	0	0	4.15	2.46	1.70	0.84
Leatherback turtle[a]	3.28	1.72	0.89	0.34	0	0	0	0	4.99	3.03	2.01	1.23
Loggerhead turtle	1.60	0.45	0.13	0.02	0	0	0	0	3.94	2.34	1.46	0.76
Green turtle	2.88	1.18	0.55	0.05	0	0	0	0	4.65	2.92	1.95	1.04

[a] Listed as Endangered under the ESA.

Table H-51. WTG monopile foundation (16 m diameter, summer, one pile per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.93	0.74	0.18	0.03	0	0	0	0	4.36	2.54	1.78	0.96
Leatherback turtle[a]	3.27	1.51	1.00	0.29	0	0	0	0	5.03	3.11	2.11	1.03
Loggerhead turtle	1.48	0.54	0.01	0	0	0	0	0	3.86	2.40	1.50	0.75
Green turtle	2.64	1.15	0.48	0.03	<0.01	0	0	0	4.67	2.80	1.70	1.06

[a] Listed as Endangered under the ESA.

Table H-52. WTG monopile foundation (16 m diameter, winter, one pile per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	2.13	0.80	0.31	0.03	0	0	0	0	4.56	2.67	1.83	0.95
Leatherback turtle[a]	3.39	1.52	1.00	0.29	0	0	0	0	5.60	3.26	2.16	1.02
Loggerhead turtle	1.55	0.62	0.01	0	0	0	0	0	4.50	2.41	1.51	0.85
Green turtle	2.85	1.24	0.68	0.03	<0.01	0	0	0	5.12	2.90	1.85	1.06

[a] Listed as Endangered under the ESA.

Table H-53. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{PK}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.81	0.16	0	0	0	0	0	0	2.19	1.01	0.61	0.20
Leatherback turtle[a]	1.80	0.86	0.37	0	0	0	0	0	2.53	1.23	0.65	0.22
Loggerhead turtle	0.52	0.04	0	0	0	0	0	0	1.95	1.00	0.50	0.20
Green turtle	0.99	0.14	0.15	0	0	0	0	0	2.31	1.17	0.68	0.18

[a] Listed as Endangered under the ESA.

Table H-54. Pre-piled jacket foundation (4.5 m diameter, winter, four piles per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{PK}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.83	0.16	0	0	0	0	0	0	2.27	1.13	0.61	0.20
Leatherback turtle[a]	2.10	0.86	0.37	0	0	0	0	0	2.69	1.28	0.71	0.22
Loggerhead turtle	0.60	0.18	0	0	0	0	0	0	2.06	1.04	0.50	0.20
Green turtle	1.02	0.23	0.15	0	0	0	0	0	2.39	1.27	0.71	0.18

[a] Listed as Endangered under the ESA.

Table H-55. Post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.00	0.25	0.13	0	0	0	0	0	2.65	1.36	0.86	0.38
Leatherback turtle[a]	2.53	1.10	0.57	0.22	0	0	0	0	3.21	1.70	0.99	0.41
Loggerhead turtle	0.78	0.28	0	0	0	0	0	0	2.45	1.18	0.86	0.31
Green turtle	1.34	0.55	0.15	0	0	0	0	0	2.81	1.46	0.87	0.31

[a] Listed as Endangered under the ESA.

Table H-56. Post-piled jacket foundation (4.5 m diameter, winter, four piles per day) impact pile driving exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.06	0.25	0.13	0	0	0	0	0	2.79	1.29	0.85	0.38
Leatherback turtle[a]	2.58	1.10	0.57	0.22	0	0	0	0	3.34	1.69	0.99	0.50
Loggerhead turtle	0.88	0.28	0	0	0	0	0	0	2.61	1.16	0.77	0.30
Green turtle	1.36	0.55	0.15	0	0	0	0	0	3.00	1.47	0.87	0.31

[a] Listed as Endangered under the ESA.

Concurrent Pile Driving

Table H-57. WTG monopile foundation (16 m diameter, summer, one pile per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{pk}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.89	0.76	0.35	0	0	0	0	0	4.33	2.54	1.68	0.91
Leatherback turtle[a]	3.46	1.64	0.99	0	0	0	0	0	5.40	3.23	1.66	1.30
Loggerhead turtle	1.37	0.46	0.22	0	0	0	0	0	3.60	2.14	1.39	0.74
Green turtle	2.65	1.27	0.60	0.07	0	0	0	0	4.75	2.75	1.89	0.87

[a] Listed as Endangered under the ESA.

Table H-58. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) and post-piled jacket foundation (4.5 m diameter, summer, four piles per day) impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury								Behavior			
	L_E				L_{PK}				L_p			
	Attenuation (dB)								Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.04	0.29	0.03	0	0	0	0	0	2.76	1.44	0.78	0.30
Leatherback turtle[a]	2.73	1.26	0.45	0	0	0	0	0	3.41	1.59	0.99	0
Loggerhead turtle	0.82	0.14	0	0	0	0	0	0	2.38	1.26	0.70	0.30
Green turtle	1.58	0.37	0.20	0	0	0	0	0	3.05	1.39	0.78	0.33

[a] Listed as Endangered under the ESA.

Vibratory and Impact

Table H-59. WTG monopile foundation (16 m diameter, summer, two piles per day) vibratory and impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{pk}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	2.04	0.63	0.39	0.02	0	0	0	0	0	0	0	0	4.18	2.44	1.72	0.87
Leatherback turtle[a]	3.27	1.72	0.89	0.34	0	0	0	0	0	0	0	0	4.99	3.02	2.01	1.23
Loggerhead turtle	1.37	0.45	0.02	0.02	0	0	0	0	0	0	0	0	3.91	2.34	1.33	0.76
Green turtle	2.91	1.16	0.55	0.05	0	0	0	0	0.10	0	0	0	4.65	2.94	1.93	1.10

[a] Listed as Endangered under the ESA.

Table H-60. WTG monopile foundation (16 m diameter, winter, two piles per day) vibratory and impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{pk}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	2.10	0.83	0.39	0.02	0	0	0	0	0	0	0	0	4.67	2.58	1.77	0.99
Leatherback turtle[a]	3.61	1.74	0.96	0.34	0	0	0	0	0	0	0	0	5.48	3.04	2.08	1.23
Loggerhead turtle	1.69	0.49	0.14	0.02	0	0	0	0	0	0	0	0	4.14	2.39	1.57	0.80
Green turtle	3.12	1.36	0.60	0.05	0	0	0	0	0.10	0	0	0	5.11	2.95	2.04	1.10

[a] Listed as Endangered under the ESA.

Table H-61. WTG monopile foundation (16 m diameter, summer, one pile per day) vibratory and impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{pk}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	1.91	0.78	0.20	0.03	0	0	0	0	0	0	0	0	4.32	2.59	1.75	0.88
Leatherback turtle[a]	3.25	1.50	1.00	0.29	0	0	0	0	0	0	0	0	5.04	3.11	2.11	1.03
Loggerhead turtle	1.47	0.49	0.01	0	0	0	0	0	0	0	0	0	3.99	2.27	1.48	0.66
Green turtle	2.61	1.05	0.49	0.03	<0.01	0	0	0	0	0	0	0	4.61	2.84	1.70	1.05

[a] Listed as Endangered under the ESA.

Table H-62. WTG monopile foundation (16 m diameter, winter, one pile per day) vibratory and impact piling exposure ranges ($ER_{95\%}$) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{pk}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	2.12	0.80	0.20	0.03	0	0	0	0	0	0	0	0	4.50	2.70	1.79	0.93
Leatherback turtle[a]	3.37	1.50	0.99	0.29	0	0	0	0	0	0	0	0	5.58	3.26	2.16	1.02
Loggerhead turtle	1.51	0.56	0.01	0	0	0	0	0	0	0	0	0	4.55	2.37	1.51	0.87
Green turtle	2.95	1.14	0.47	0.03	<0.01	0	0	0	0	0	0	0	5.11	2.91	2.06	1.05

[a] Listed as Endangered under the ESA.

Table H-63. Pre-piled jacket foundation (4.5 m diameter, summer, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{PK}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.81	0.19	0	0	0	0	0	0	0	0	0	0	1.94	1.13	0.63	0.23
Leatherback turtle[a]	1.80	0.87	0.39	0	0	0	0	0	0	0	0	0	2.55	1.17	0.65	0.22
Loggerhead turtle	0.53	0.04	0	0	0	0	0	0	0	0	0	0	1.97	0.90	0.56	0.26
Green turtle	0.98	0.14	<0.01	0	0	0	0	0	0	0	0	0	2.19	1.03	0.64	0.26

[a] Listed as Endangered under the ESA.

Table H-64. Pre-piled jacket foundation (4.5 m diameter, winter, four piles per day) vibratory and impact exposure ranges ($ER_{95\%}$)) in km to sea turtle threshold criteria with sound attenuation.

Species	Injury												Behavior			
	Impact								Vibratory				Vibratory and Impact			
	L_E				L_{pk}				L_E				L_p			
	Attenuation (dB)												Attenuation (dB)			
	0	6	10	15	0	6	10	15	0	6	10	15	0	6	10	15
Kemp's ridley turtle[a]	0.80	0.19	0	0	0	0	0	0	0	0	0	0	2.09	1.14	0.63	0.23
Leatherback turtle[a]	1.91	0.87	0.39	0	0	0	0	0	0	0	0	0	2.67	1.24	0.71	0.22
Loggerhead turtle	0.64	0.04	0	0	0	0	0	0	0	0	0	0	2.01	0.90	0.56	0.29
Green turtle	1.04	0.14	<0.01	0	0	0	0	0	0	0	0	0	2.32	1.10	0.65	0.26

[a] Listed as Endangered under the ESA.

H.3. Animat Seeding Areas

Exposure modeling seeding areas are set using each species' preferred depth range. The following maps show seeding areas for each species, overlaid on a density map, when available, displaying the highest density month for that species. If density surfaces are unavailable for a particular species, a surrogate may be used, and for some species, the density data source shown in the image may not coincide with the data source used in predicting exposures. Please refer to Sections 3.2 and 3.4 for detailed descriptions of density sources and calculations for marine mammals and sea turtles.

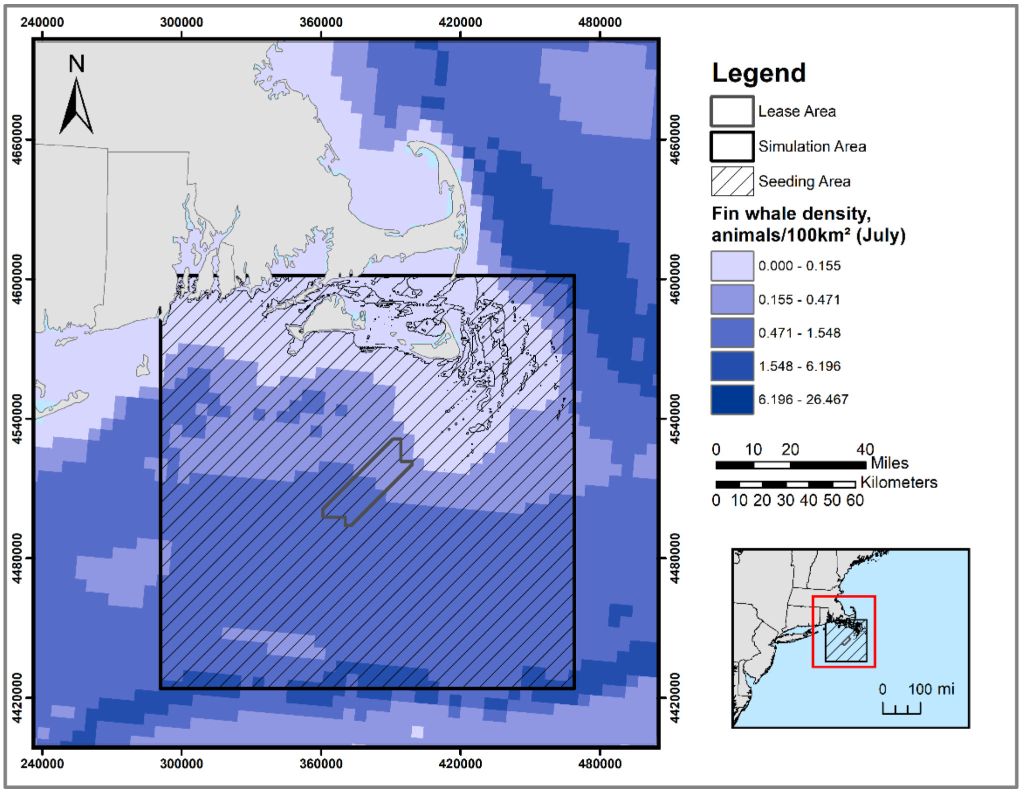

Figure H-1. Map of fin whale animat seeding range.

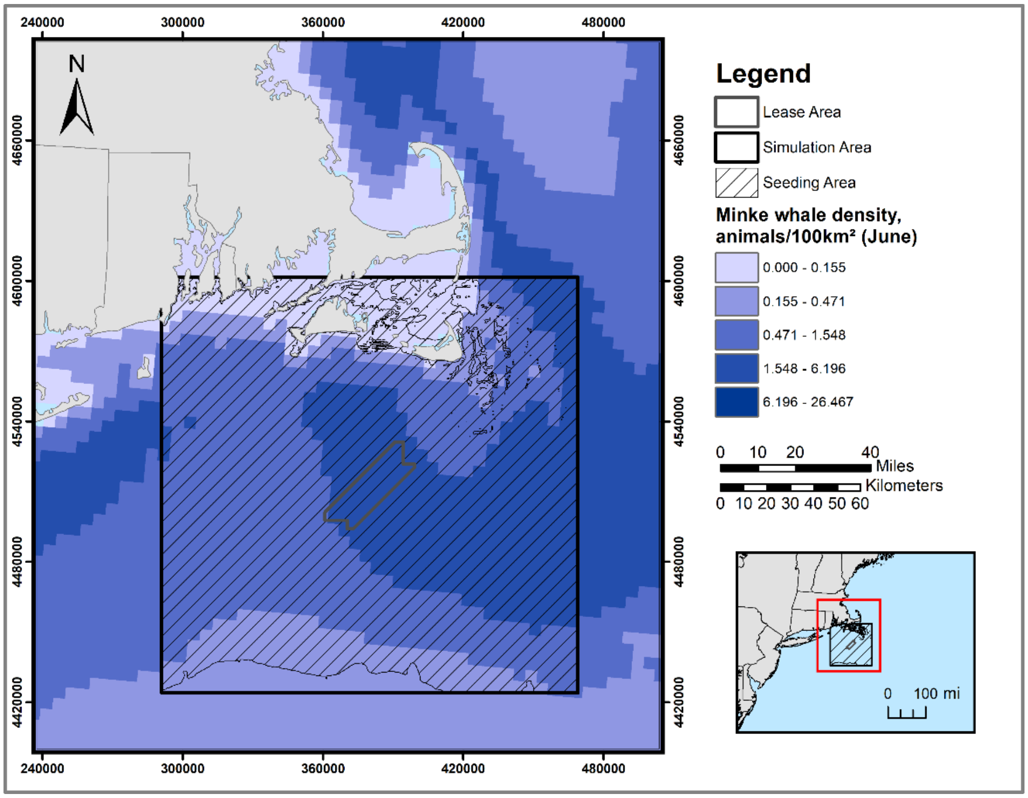

Figure H-2. Map of minke whale animat seeding range.

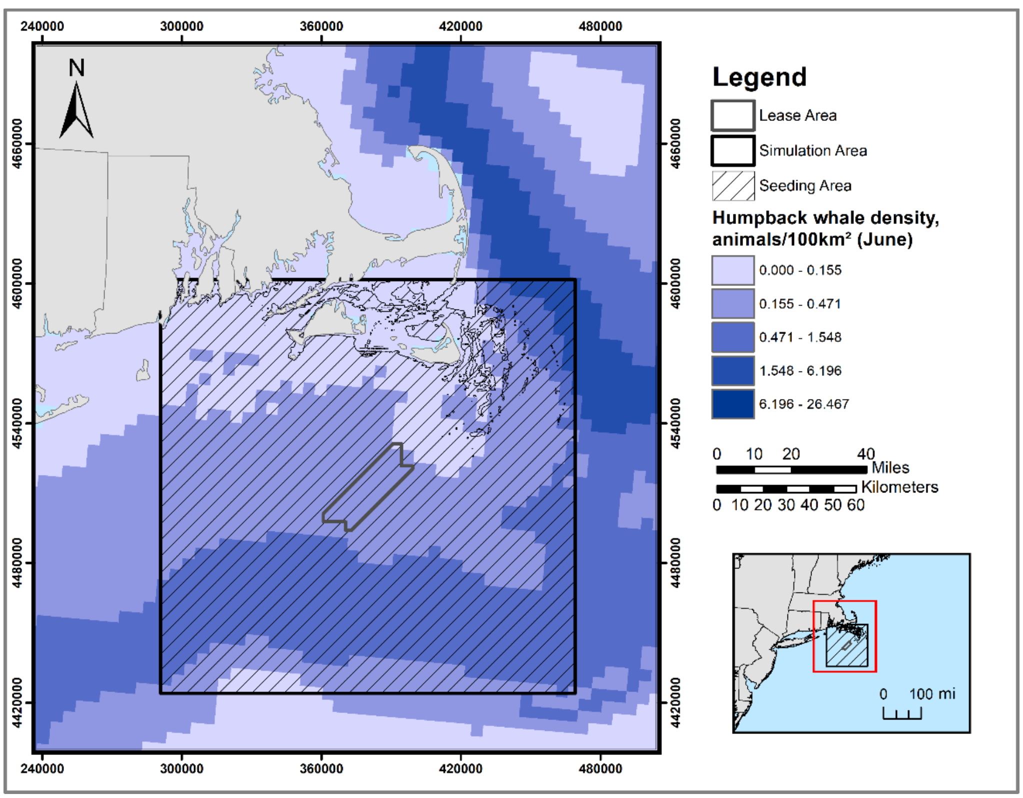

Figure H-3. Map of humpback whale animat seeding range.

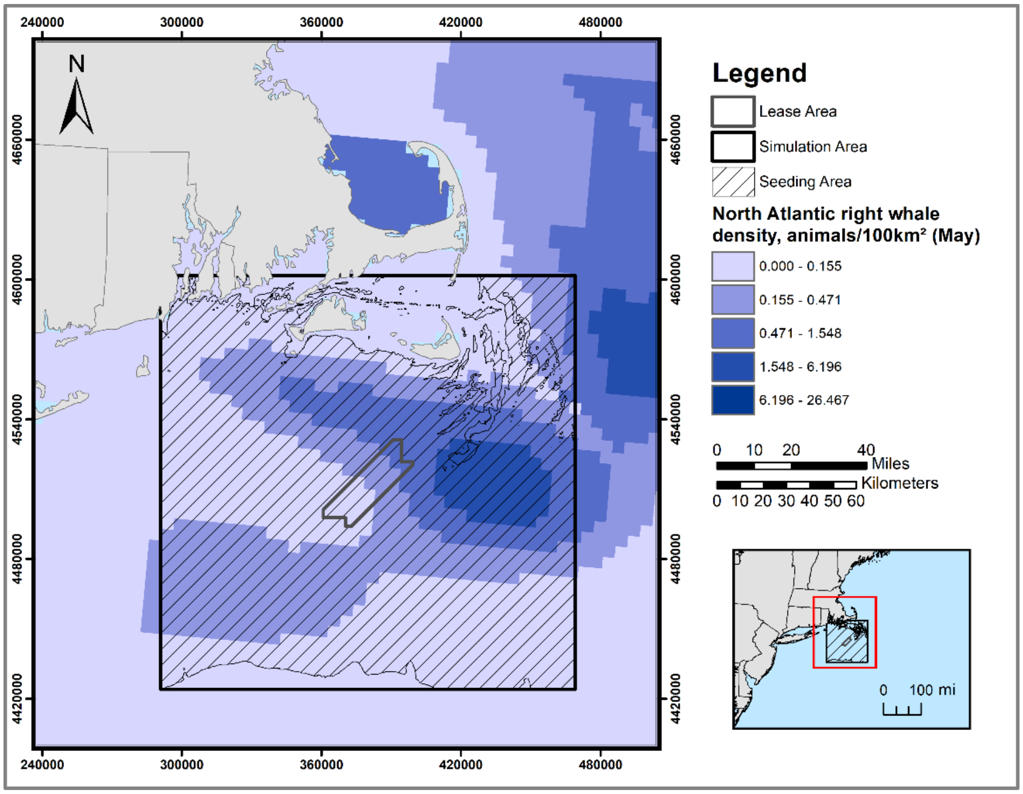

Figure H-4. Map of North Atlantic right whale animat seeding range.

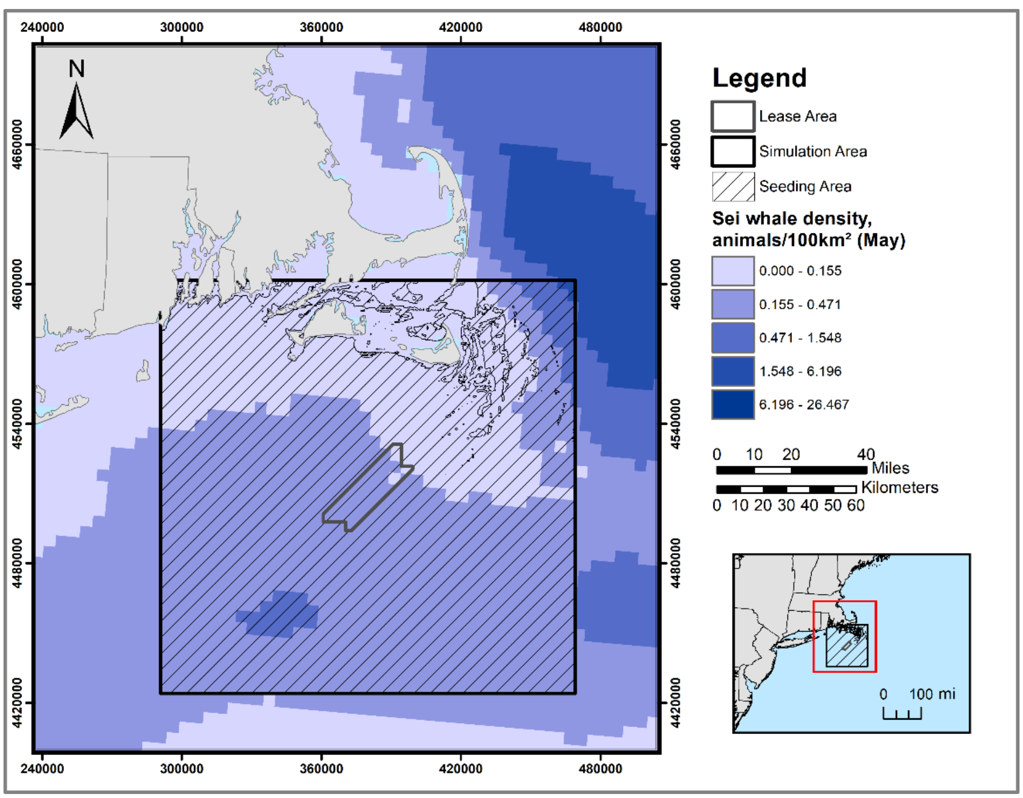

Figure H-5. Map of sei whale animat seeding range.

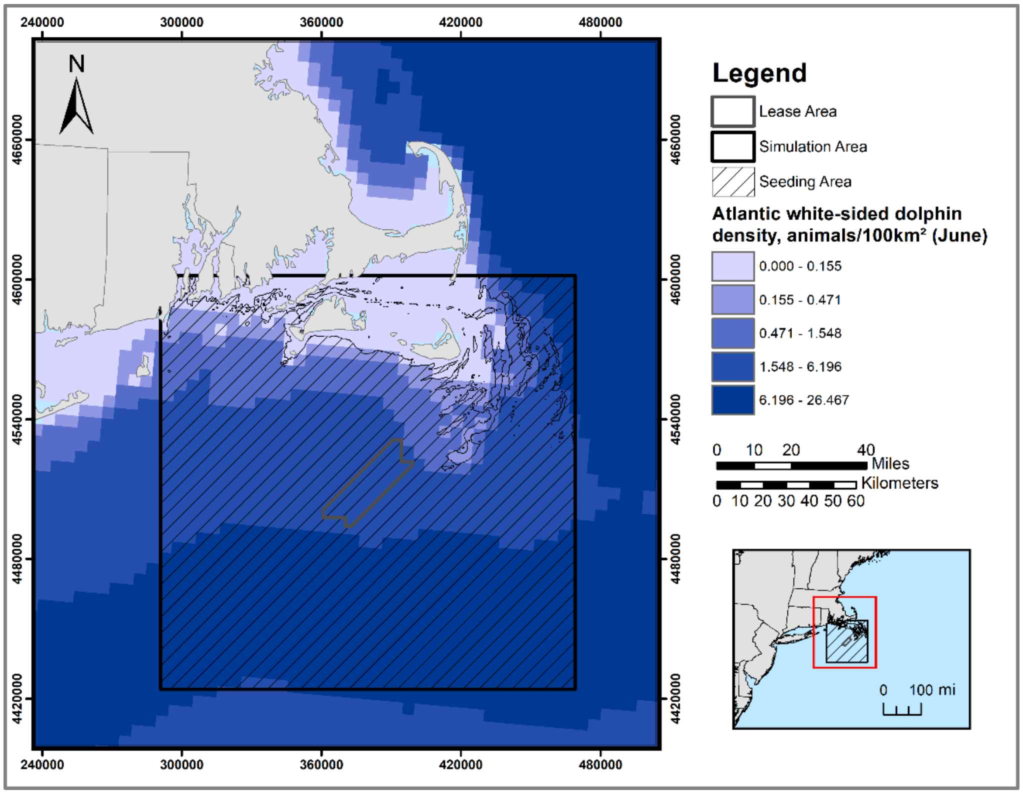

Figure H-6. Map of Atlantic white-sided dolphin animat seeding range.

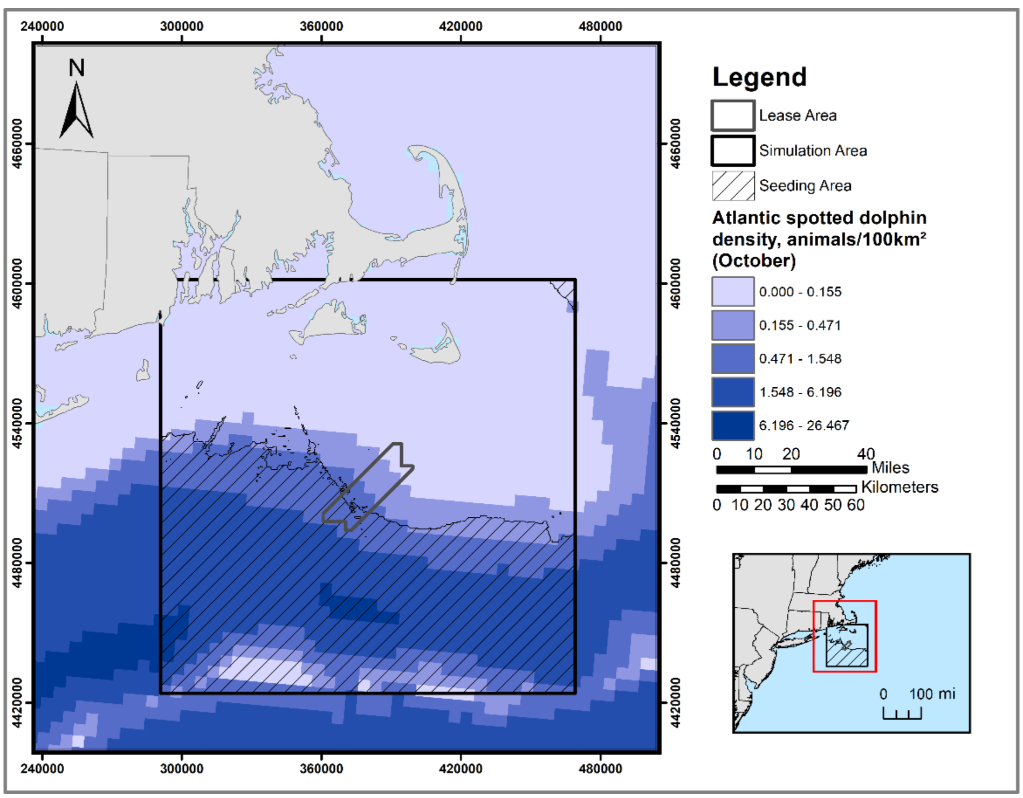

Figure H-7. Map of Atlantic spotted dolphin animat seeding range.

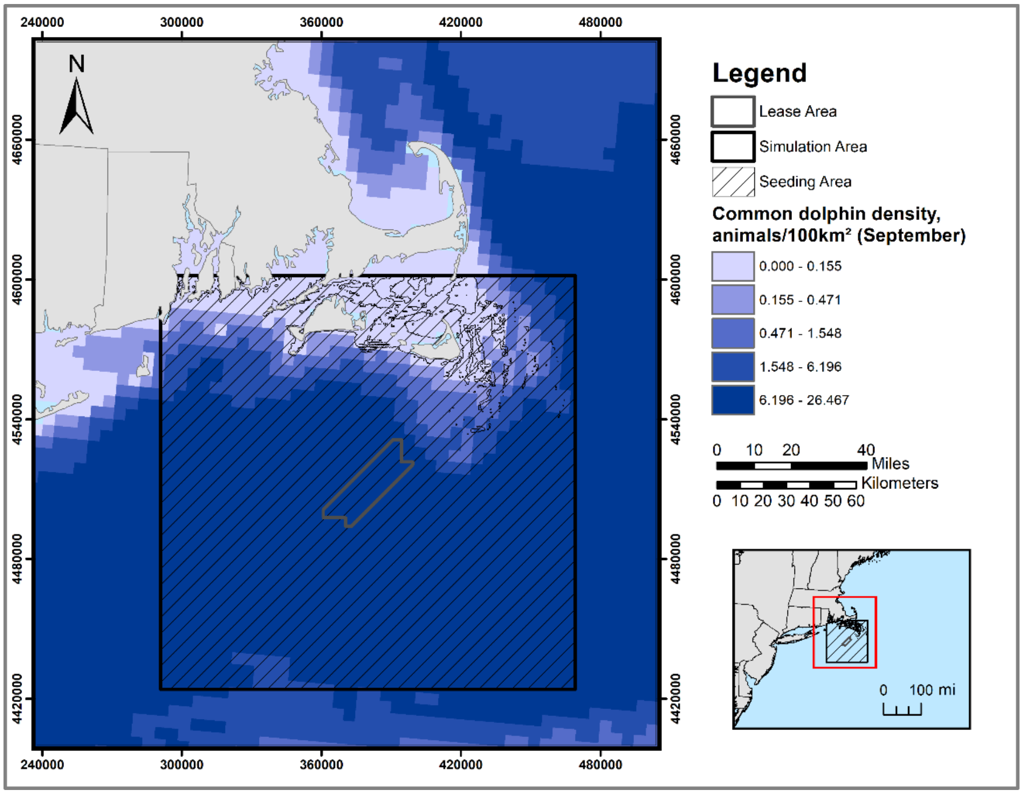

Figure H-8. Map of common dolphin animat seeding range.

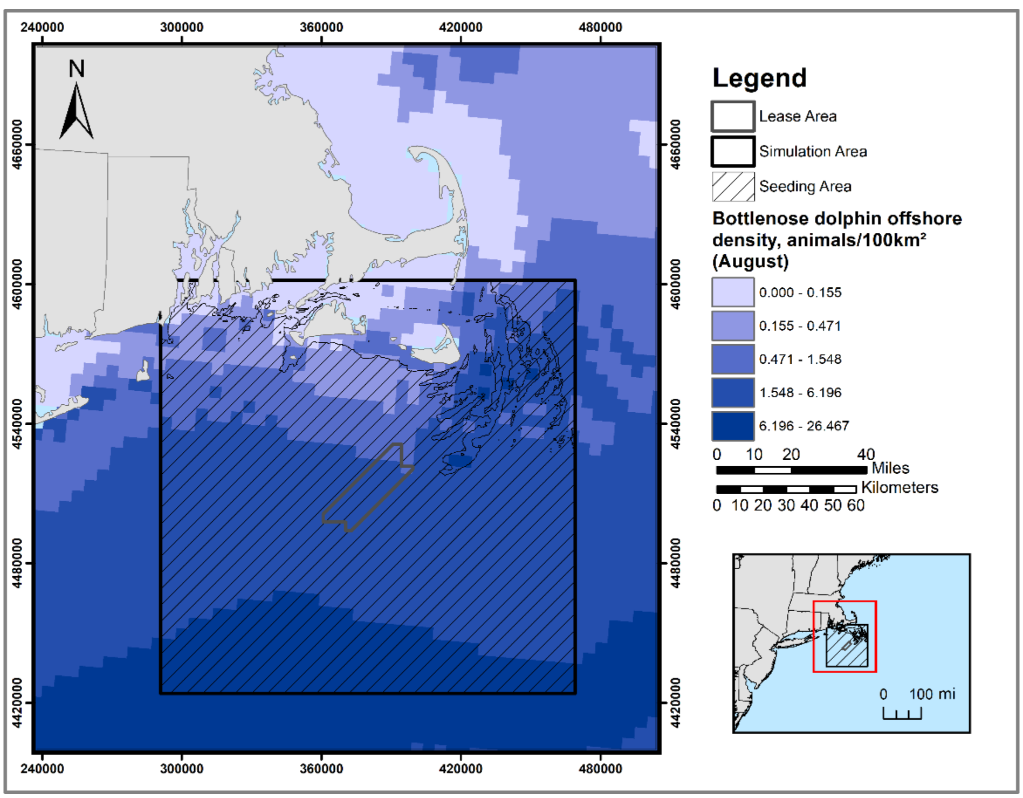

Figure H-9. Map of offshore bottlenose dolphin animat seeding range.

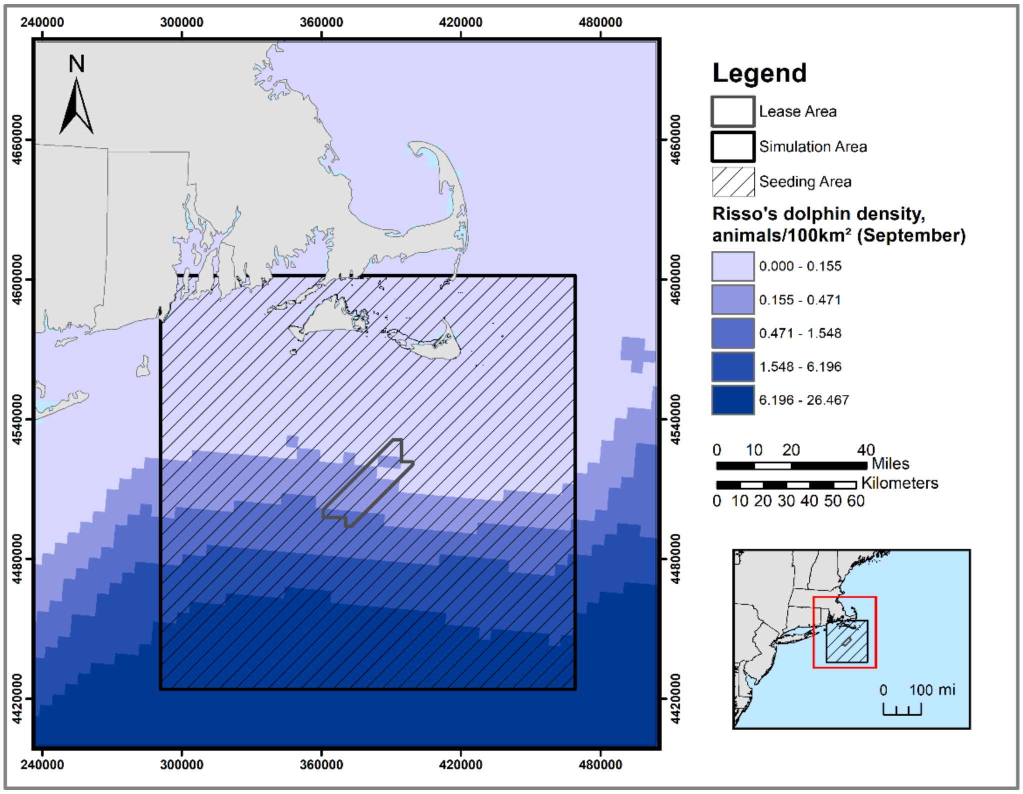

Figure H-10. Map of Risso's dolphin animat seeding range.

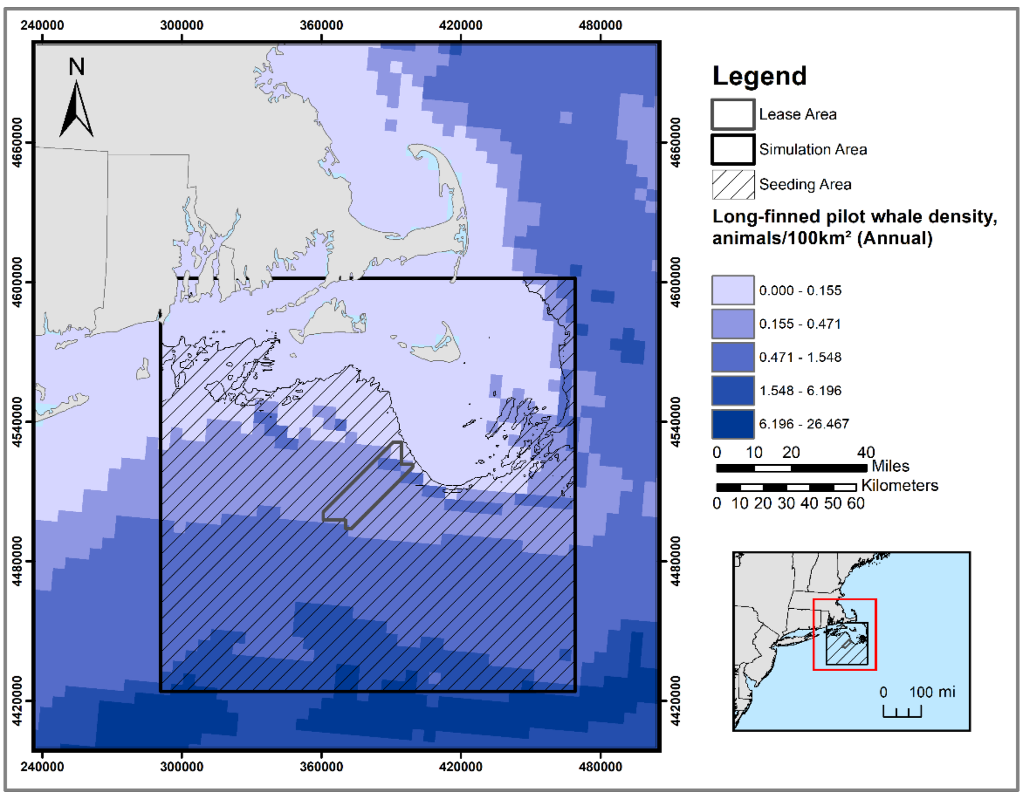

Figure H-11. Map of long-finned pilot whale animat seeding range. Density shown is for pilot whale guild.

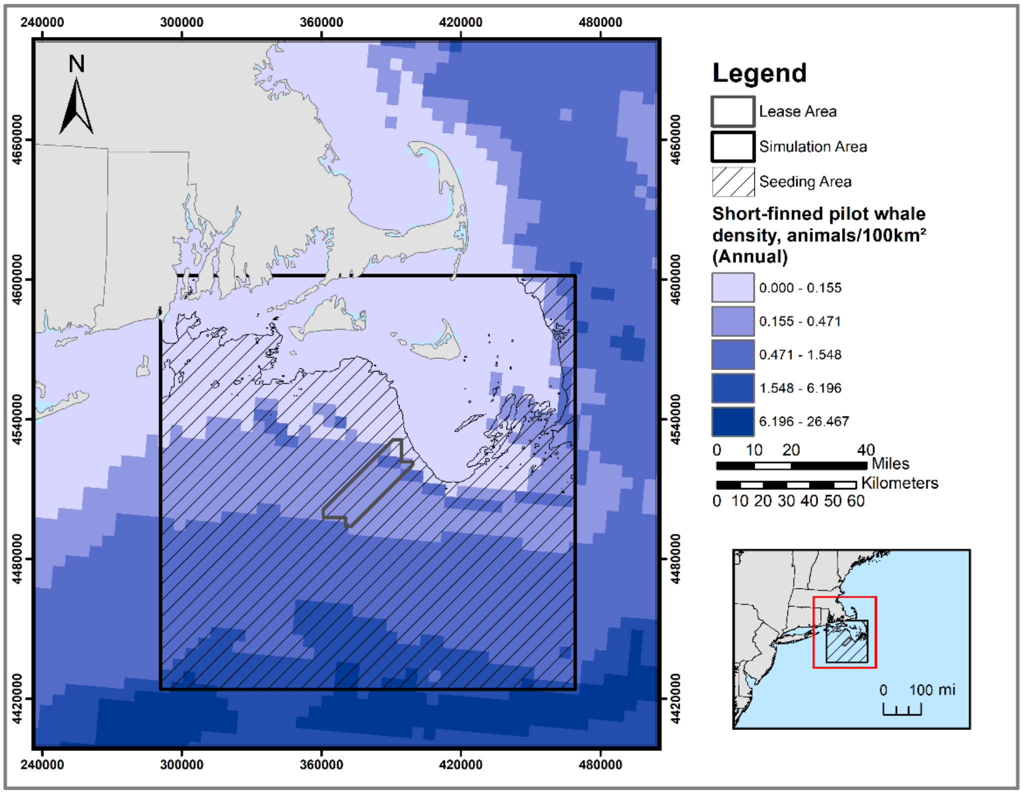

Figure H-12. Map of short-finned pilot whale animat seeding range. Density shown is for pilot whale guild.

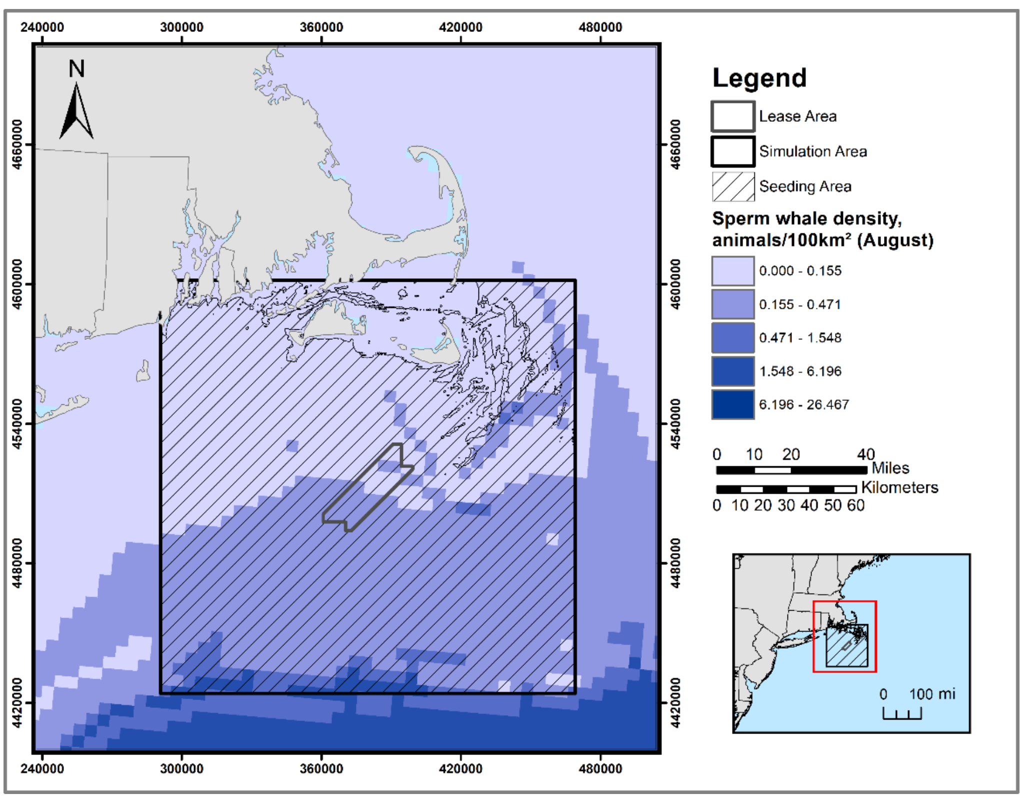

Figure H-13. Map of sperm whale animat seeding range.

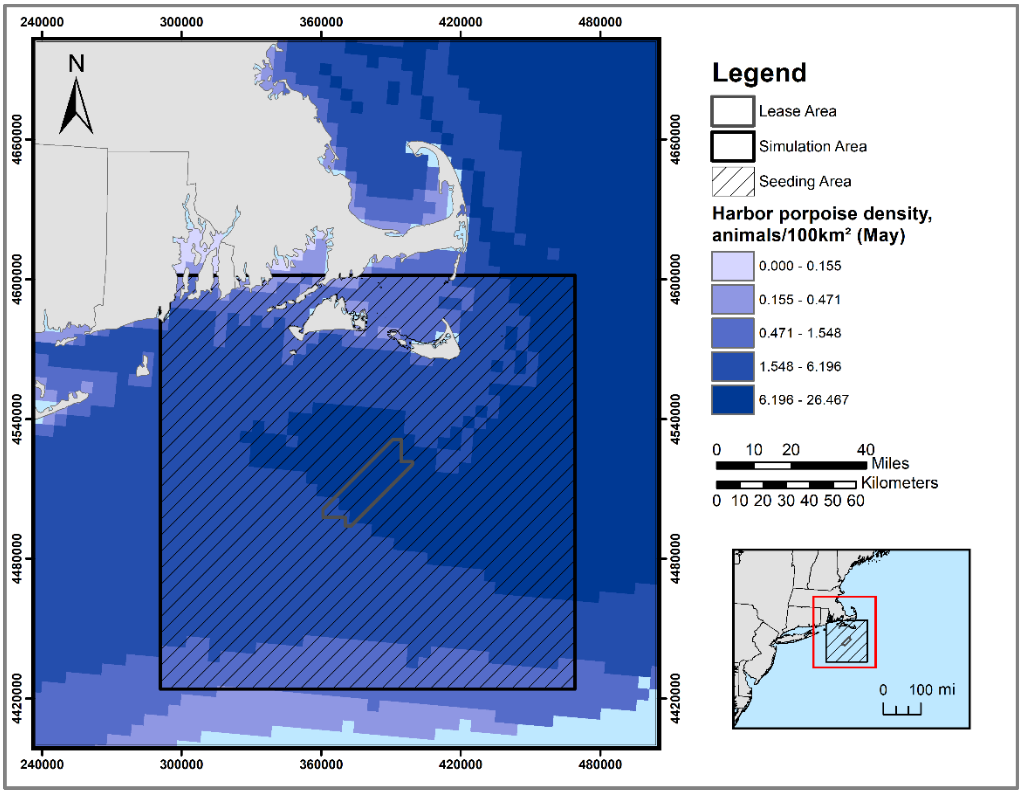

Figure H-14. Map of harbor porpoise animat seeding range.

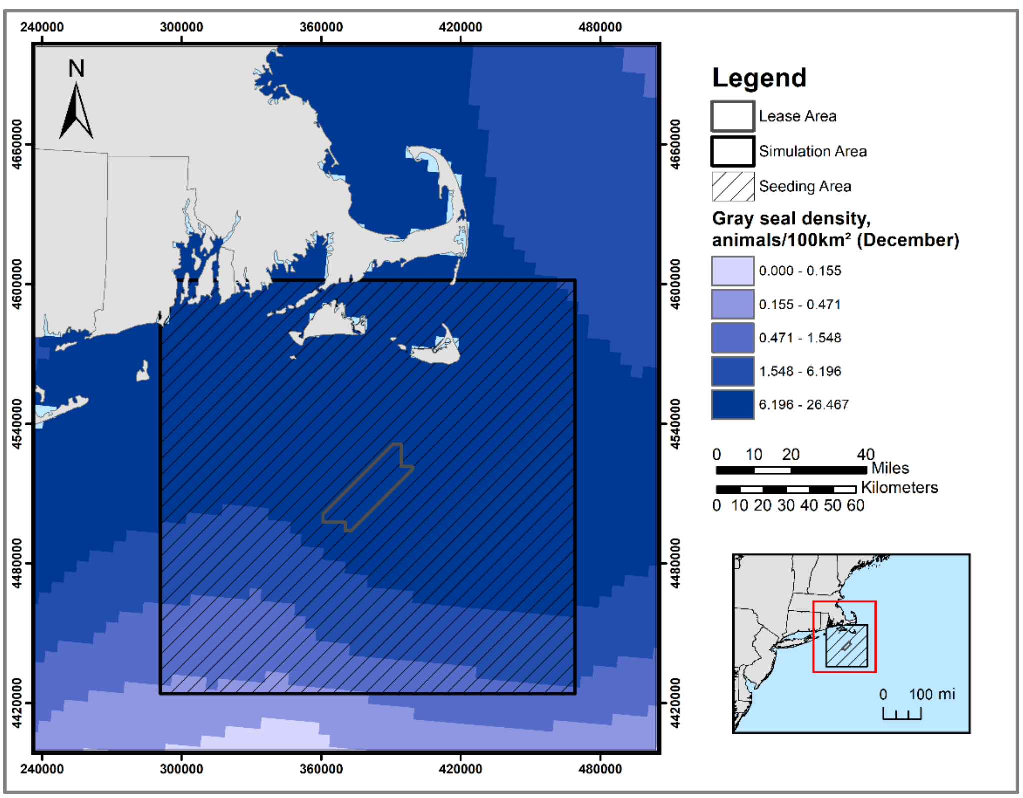

Figure H-15. Map of gray seal animat seeding range.

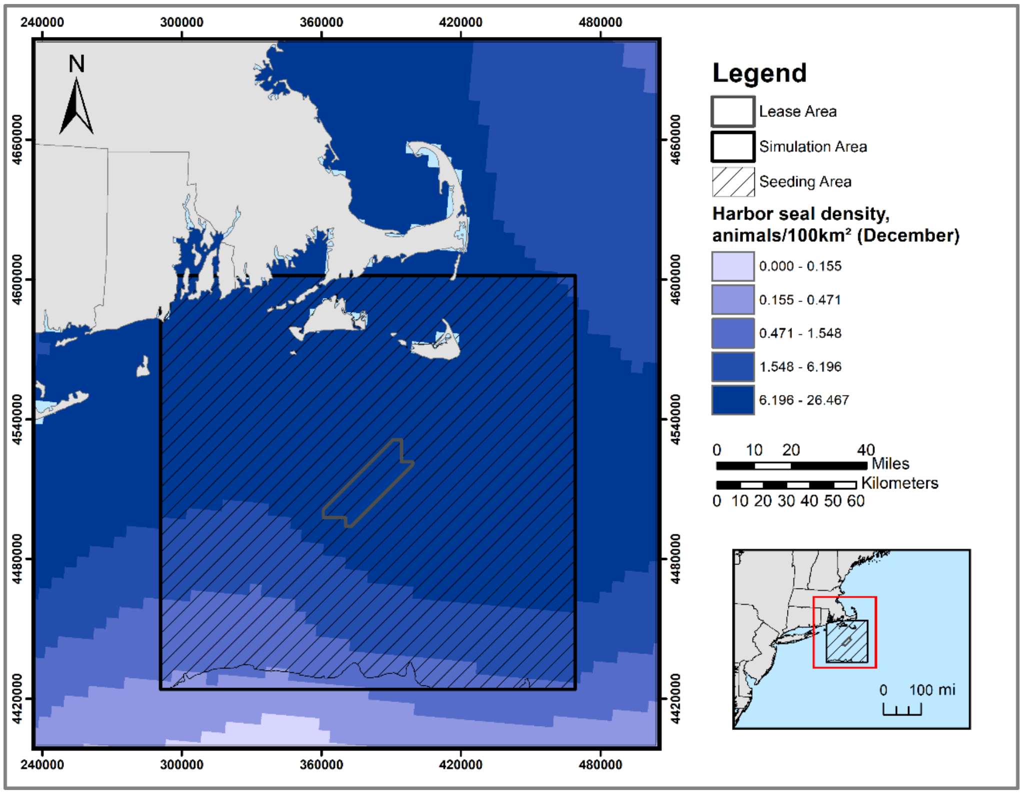

Figure H-16. Map of harbor seal animat seeding range.

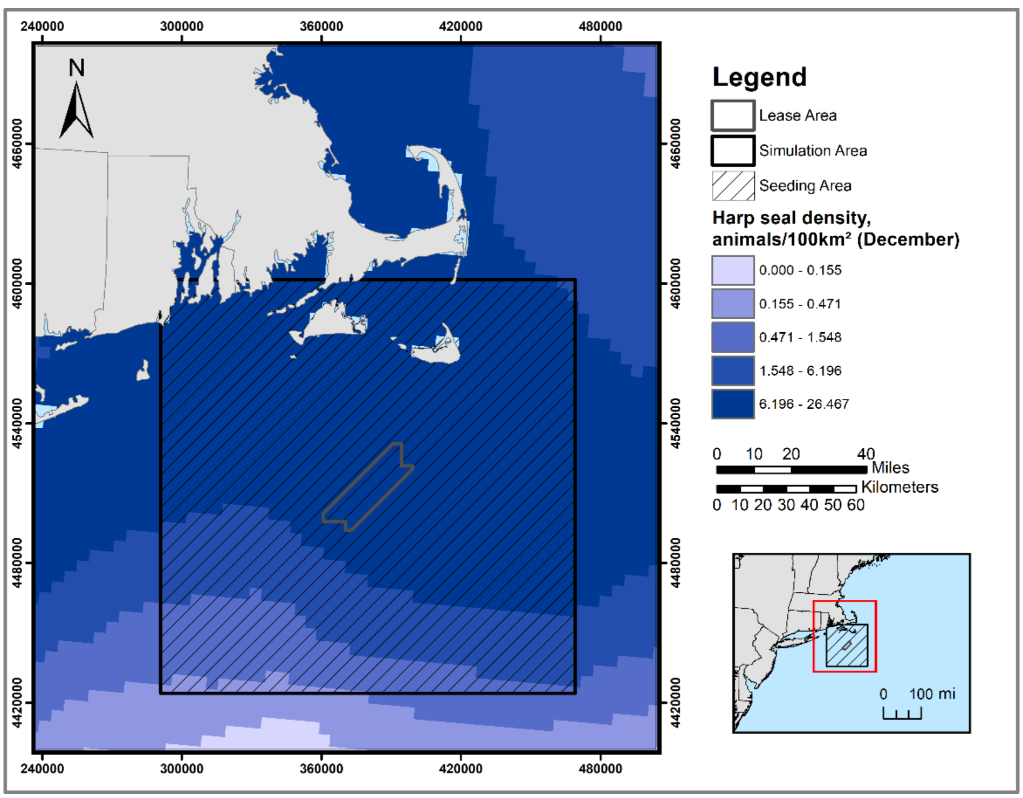

Figure H-17. Map of harp seal animat seeding range. Gray seal density used as a surrogate for harp seal.

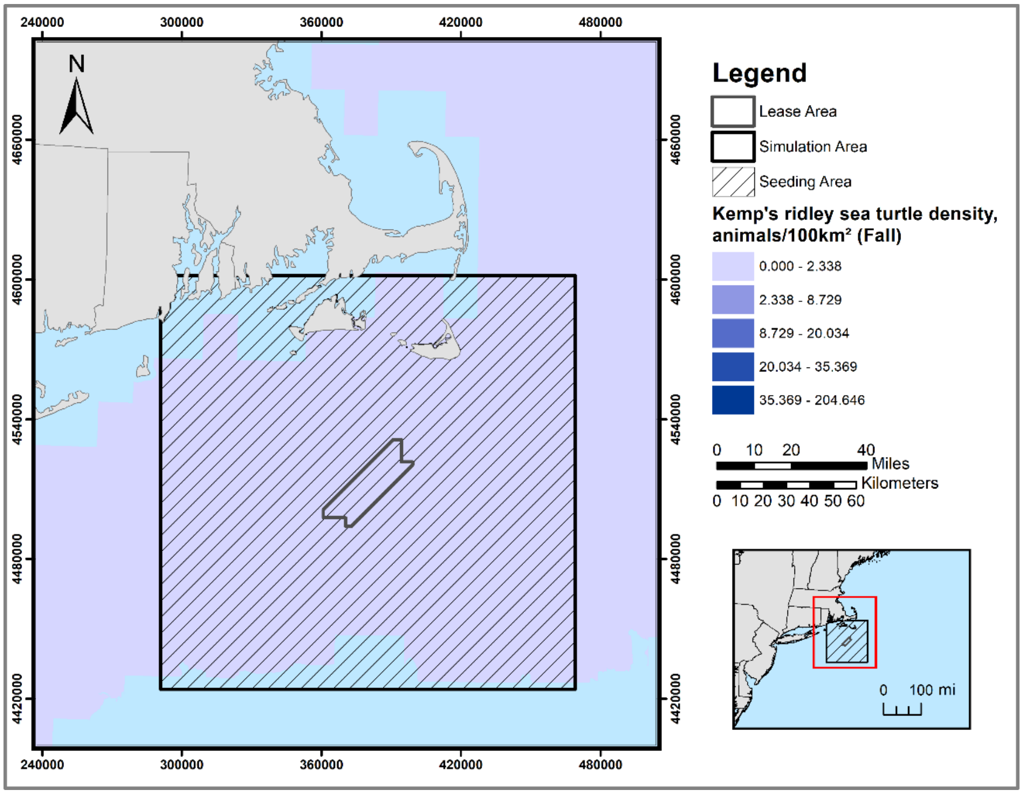

Figure H-18. Map of Kemp's ridley sea turtle animat seeding range.

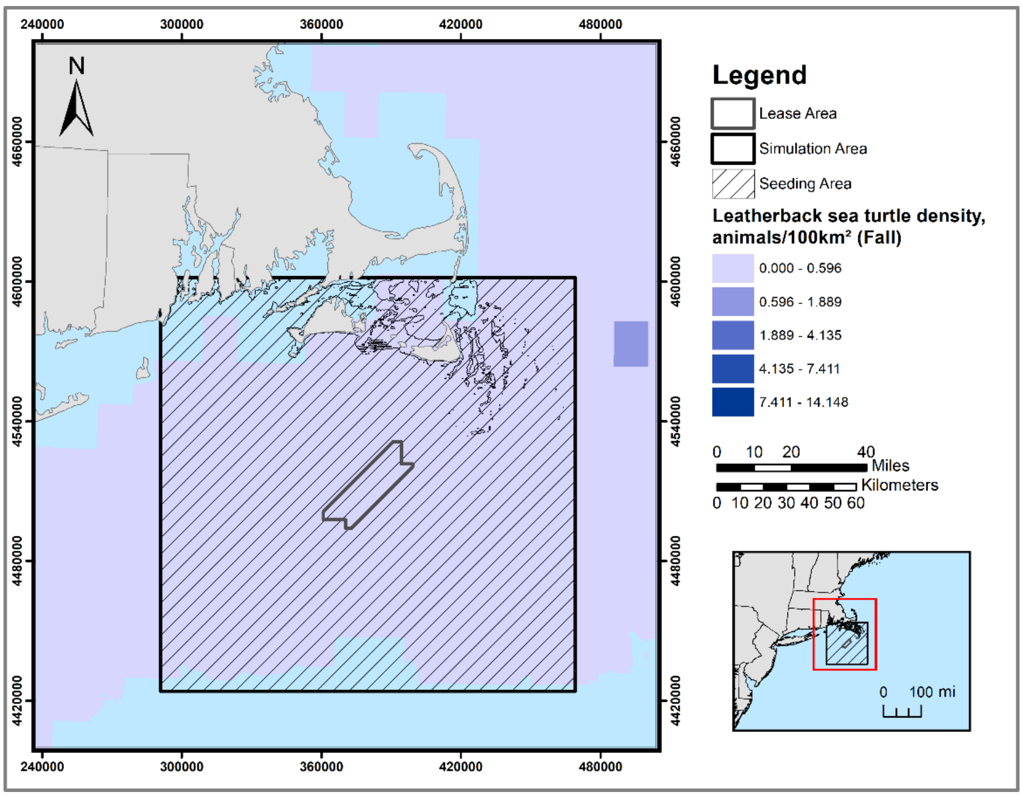

Figure H-19. Map of leatherback sea turtle animat seeding range.

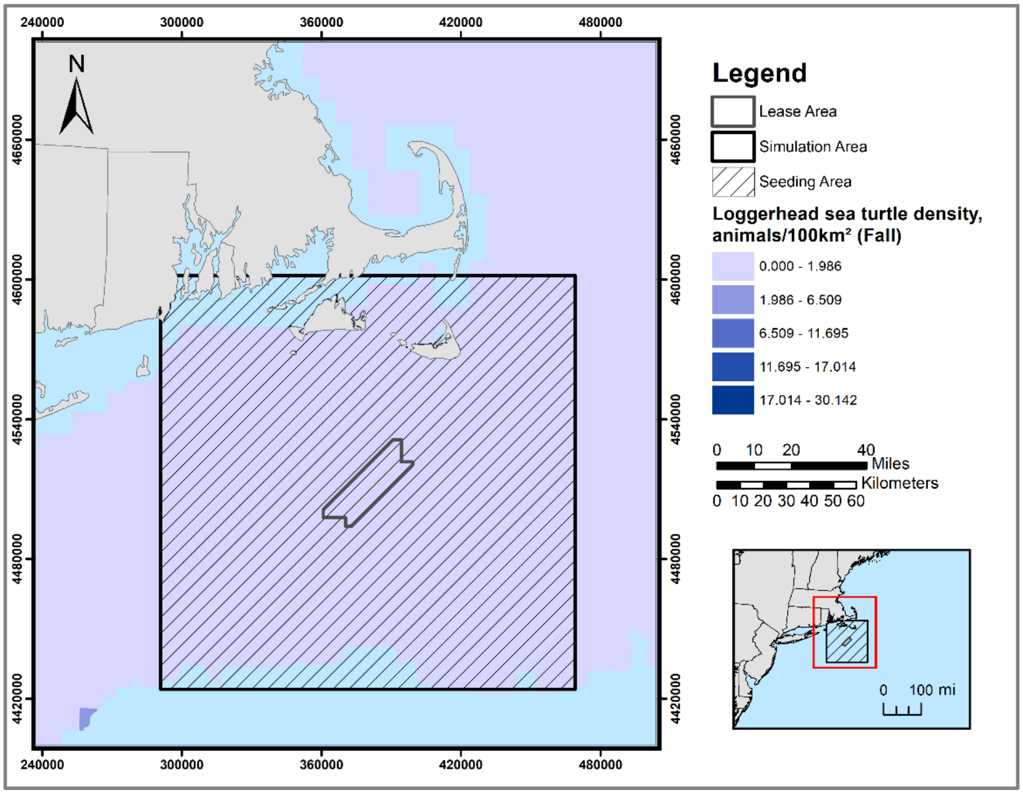

Figure H-20. Map of loggerhead sea turtle animat seeding range.

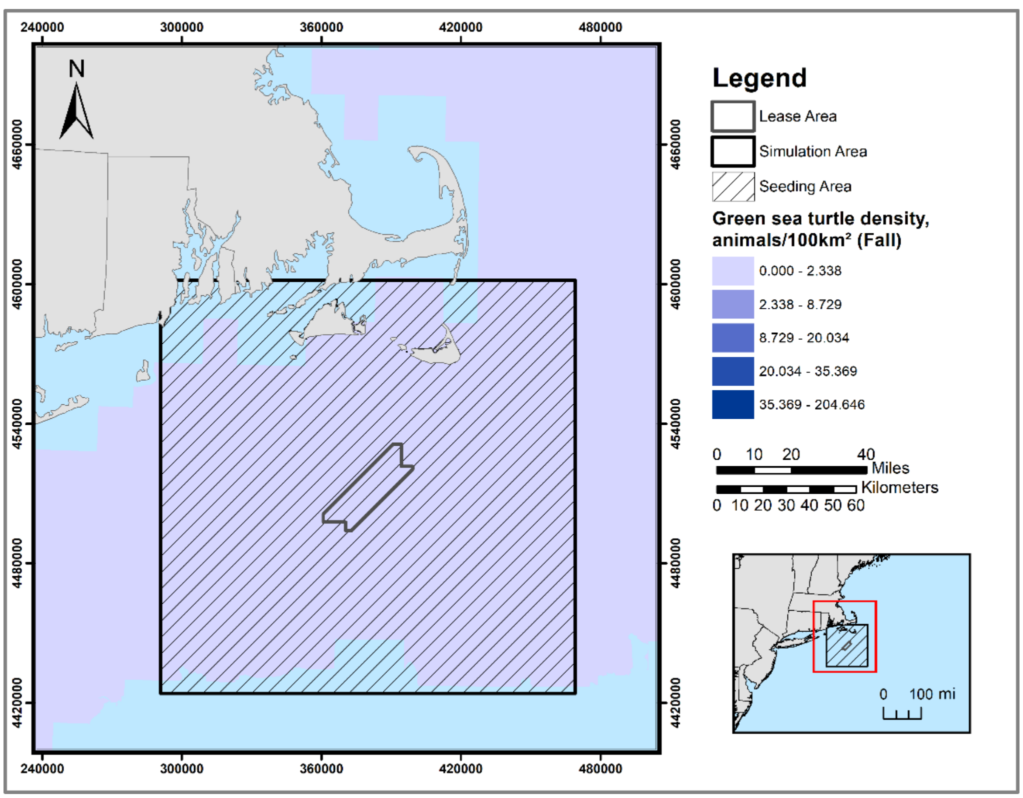

Figure H-21. Map of green sea turtle animat seeding range. Kemp's ridley sea turtle density was used as a surrogate.

SouthCoast Wind

Addendum to Additional Underwater Acoustic Modeling Scenarios

JASCO Applied Sciences (USA) Inc.

5 November 2024

Submitted to:

SouthCoast Wind

Authors:

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JASCO
APPLIED SCIENCES

G.2. Impact Pile Driving Single-Strike PK Acoustic Ranges

G.2.1. 16 m Monopile Foundation

G2.2. 4.5 m Diameter Pin Pile (post-piled, 2 dB shift)

Table G-1. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 0 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500 (c)
TUW	232	-	-	-
MF	230	-	-	-
LF	219	0.06	0.04	-
PPW	218	0.08	0.05	0.02
HF	202	0.55	0.44	0.33

Table G-2. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 6 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500 (c)
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.24	0.15	0.09

Table G-3. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 10 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500 (c)
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.15	0.10	0.06

Table G-4. Post-piled jacket foundation (4.5 m diameter, MHU 3500S) acoustic ranges to marine mammal and sea turtle injury thresholds ($R_{95\%}$ in km) during winter at location L01 with different energy levels at 15 dB.

Faunal group	Level (L_{pk})	Hammer energy (kJ)		
		3500 (a)	3500 (b)	3500 (c)
TUW	232	-	-	-
MF	230	-	-	-
LF	219	-	-	-
PPW	218	-	-	-
HF	202	0.09	0.06	0.03