Foundation Installation at South Fork Wind Farm

Animal Exposure Modelling

Submitted to:
Jeff Nield
Jacobs Engineering Group Inc.
Agreement number: 10381-7-120889

Authors:
Samuel Denes
Michelle Weirathmueller
David Zeddies

10 July 2020

P001383-002
Document 01726
Version 2.0

JASCO Applied Sciences (USA) Inc.
8630 Fenton Street, Suite 218
Silver Spring, MD 20910 USA
Tel: +1-301-565-3500
www.jasco.com

Suggested citation:

Denes, S.L., M.M. Weirathmueller, and D.G. Zeddies. 2019. *Foundation Installation at South Fork Wind Farm: Animal Exposure Modelling*. Document 01726, Version 2.0. Technical report by JASCO Applied Sciences for Jacobs Engineering Group Inc.

Disclaimer:

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

Executive Summary

Deepwater Wind South Fork LLC (DWSF) is proposing to install an offshore wind energy facility, the South Fork Wind Farm (SFWF), in its lease area on the Atlantic Outer Continental Shelf. The SFWF will consist of up to 15 wind turbine generators (WTG) and an offshore substation, each of which will be supported by a monopile foundation with a maximum diameter of 10.97 meter (m) (36 feet [ft]).

Underwater noise will be generated during impact pile driving for installing the monopile foundations. The objective of this modeling study was to generate predictions of the mean number of animals that may be exposed to sound levels resulting in injury to or behavioral disruption of marine mammals and sea turtles in the SFWF project area. Acoustic fields produced during impact pile driving of the monopile foundations were modeled (see Denes et al (2018) for acoustic modeling details). The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to integrate the sound fields with species-typical behavior. JASMINE results provide an estimate of the probability of sound exposure, which can be compared to acoustic thresholds and then scaled to predict the mean number of animals expected to receive sound levels that may cause injury or behavioral disruption.

The acoustic thresholds used in this study represented the best available science. For potential injury (Level A) to marine mammal species, the Technical Guidance issued by NOAA (NMFS 2018) was used. For potential behavioral disruption (Level B) of marine mammals, the threshold values currently considered by NMFS were used along with an approach suggested by Wood et al. (2012) that accounts for the hearing range of the animals. For potential effects of sound on sea turtles, the guidelines established by Popper et al. (2014), representing the consensus efforts of a scientific working group, were used as well as those developed by Blackstock et al. (2017).

Cetacean exposure probabilities were scaled using the Duke University Marine Geospatial Ecological Laboratory density models (Roberts et al. 2016), including an updated unpublished model for the North Atlantic right whale (Roberts et al. 2017, Roberts et al. 2018) that incorporates additional sighting data. Sea turtle densities were obtained from the U.S. Navy Operating Area Density Estimate (NODE) database on the Strategic Environmental Research and Development Program Spatial Decision Support System (SERDP-SDSS) portal (DoN 2007, 2012). These numbers were adjusted by the Sea Mammal Research Unit (SMRU 2013), available in the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (Halpin et al. 2009). The density models for scaling the exposure results for marine mammals and sea turtles represent the best available data for the SFWF project area.

The mean number of animals that may be exposed to sounds exceeding acoustic thresholds were calculated for a Maximum Design scenario, sixteen foundations installed in twenty days (one pile installed each day), and a Most Likely scenario, sixteen foundations installed in thirty days (one pile installed every other day). Estimates were generated assuming one monopile foundation is driven in a day and that no concurrent pile driving would occur. Noise mitigation was considered by reducing the predicted sound fields by six and twelve decibels to evaluate the effects of using noise reduction systems such as bubble curtains.

The exposure estimates for the Maximum Design scenario and the Most Likely scenario were found to be similar, indicating little difference in expected impacts if one monopile foundation is installed each day or every other day. The case where one of the foundation piles is difficult to install generally resulted in a small increase in exposure estimates of less than a few percent. The behavioral response of animals avoiding loud sounds (aversion) produced during pile driving was also investigated for North Atlantic right whales, harbor porpoises, and humpback whales. It was found that aversive behavior could result in substantial decreases in the exposure estimates, particularly for Level A exposures (injury). Aversion is thought to be common in marine mammals (Ellison et al. 2012), so the exposure estimates that do not include aversion are likely conservative.

Contents

EXECUTIVE SUMMARY II

1. INTRODUCTION 1

2. ACOUSTIC IMPACTS MODELING 2

2.1. Pile Driving as a Source of Sound 2
2.2. Exposure Estimate Calculation Overview 3
2.3. Acoustic Modeling: Scope and Assumptions 3

3. ACOUSTIC EXPOSURE ESTIMATION–MARINE MAMMALS 5

3.1. Species that May be Present near the SFWF 5
3.1.1. Density Estimates 6
3.2. Acoustic Criteria–Injury and Behavioral Disruption 9
3.2.1. Marine mammal hearing groups 10
3.2.2. Marine mammal auditory weighting functions 10
3.2.3. Level A exposure criteria 11
3.2.4. Behavioral disruption exposure criteria 11
3.3. Predicted Sound Fields 12
3.3.1. Ranges to exposure thresholds 13
3.4. Animal Movement and Exposure Modeling 14
3.4.1. Exposure Estimates: Maximum Design Scenario (6 piles per week) 15
3.4.2. Exposure Estimates: Most Likely Scenario (Piling every other day) 32

4. ACOUSTIC EXPOSURE ESTIMATION–SEA TURTLES 50

4.1. Species that May be Present in the SFWF 50
4.1.1. Density Estimates 50
4.2. Acoustic Criteria–Injury and Behavior 51
4.3. Predicted Sound Fields 51
4.4. Animal Movement and Exposure Modeling 52
4.4.1. Maximum Design Scenario (six piles per week) 52
4.4.2. Most Likely Scenario (piling every other day) 60

5. DISCUSSION 68

LITERATURE CITED 69

APPENDIX A. ANIMAL MOVEMENT AND EXPOSURE MODELING A-1

Figures

Figure 1. Sound propagation paths associated with pile driving........ 2
Figure 2. Decidecade band spectral source levels for monopile 4
Figure 3. North Atlantic right whale density map 7
Figure 4. Graphic of animats in a moving sound field........ 15

Figure A-1. Map of fin whale animat seeding range with density from Roberts et al. (2016) for July A-49
Figure A-2. Map of humpback whale animat seeding range with density from Roberts et al. (2016) for September A-50
Figure A-3. Map of minke whale animat seeding range with density from Roberts et al. (2016) for May A-51
Figure A-4. Map of North Atlantic right whale animat seeding range with density from Roberts et al. (2016) for May........A-52
Figure A-5. Map of sei whale animat seeding range with density from Roberts et al. (2016) for May A-53
Figure A-6. Map of Atlantic spotted dolphin animat seeding range with density from Roberts et al. (2016) for October........A-54
Figure A-7. Map of Atlantic white-sided dolphin animat seeding range with density from Roberts et al. (2016) for May........A-55
Figure A-8. Map of bottlenose dolphin animat seeding range with density from Roberts et al. (2016) for September A-56
Figure A-9. Map of pilot whale animat seeding range with annual density from Roberts et al. (2016). ..A-57
Figure A-10. Map of Risso's dolphin animat seeding range with density from Roberts et al. (2016) for August........A-58
Figure A-11. Map of short-beaked common dolphin animat seeding range with density from Roberts et al. (2016) for October........A-59
Figure A-12. Map of sperm whale animat seeding range with density from Roberts et al. (2016) for July........A-60
Figure A-13. Map of harbor porpoise animat seeding range with density from Roberts et al. (2016) for May A-61
Figure A-14. Map of gray and harbor seal animat seeding range with density from Roberts et al. (2015) for May........A-62
Figure A-15. Map of Kemp's ridley turtle animat seeding range with density from DoN (2017) for summer A-63
Figure A-16. Map of leatherback sea turtle animat seeding range with density from DoN (2017) for summer A-64
Figure A-17. Map of loggerhead sea turtle animat seeding range with density from DoN (2017) for summer A-65

Tables

Table 1. Hammer energy schedule for monopile installation. 3
Table 2. Modeling scenarios 4
Table 3. Summary of marine mammal species considered in the acoustic exposure analysis 5
Table 4. Mean monthly marine mammal density estimates for the South Fork Work Area (SFWF) 8
Table 5. Summary of relevant acoustic terminology used in this report 9
Table 6. Marine mammal hearing groups 10
Table 7. Summary of relevant Level A onset acoustic thresholds 11
Table 8. Level B exposure criteria used in this analysis. 12
Table 9. Sites used in propagation modeling. 12
Table 10. Average radial distances ($R_{95\%}$, in meters) to Level A thresholds (NMFS 2018) 13
Table 11. Average radial distances ($R_{95\%}$, in meters) to Level A thresholds (NMFS 2018) 13
Table 12. Average radial distances ($R_{95\%}$ in meters) to Level B thresholds in summer 14
Table 13. Average radial distances ($R_{95\%}$ in meters) to Level B thresholds in winter 14
Table 14. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with no attenuation. 16
Table 15. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation. 17
Table 16. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation. 18
Table 17. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation. 19
Table 18. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with no attenuation. 20
Table 19. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 6 dB of attenuation. 21
Table 20. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 10 dB of attenuation. 22
Table 21. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 12 dB of attenuation. 23
Table 22. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with no attenuation. 24
Table 23. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation. 25
Table 24. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation. 26

Table 25. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation. 27
Table 26. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with no attenuation. 28
Table 27. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 6 dB of attenuation. 29
Table 28. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 10 dB of attenuation. 30
Table 29. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 12 dB of attenuation. 31
Table 30. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with no attenuation. 33
Table 31. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 6 dB of attenuation. 34
Table 32. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 10 dB of attenuation. 35
Table 33. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 12 dB of attenuation. 36
Table 34. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with no attenuation. 37
Table 35. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 6 dB of attenuation. 38
Table 36. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 10 dB of attenuation. 39
Table 37. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 12 dB of attenuation. 40
Table 38. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with no attenuation. 41
Table 39. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 6 dB of attenuation. 42
Table 40. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 10 dB of attenuation. 43
Table 41. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 12 dB of attenuation. 44

Table 42. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation. 45
Table 43. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation. 46
Table 44. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation. 47
Table 45. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation. 48
Table 46. Comparison of exposure estimates for humpback whale (September), North Atlantic right whale (May), and harbor porpoise (May) 49
Table 47. Sea turtle density estimates 50
Table 48. Ranges ($R_{95\%}$ in meters) to thresholds for sea turtles in summer 51
Table 49. Ranges ($R_{95\%}$ in meters) to thresholds for sea turtles in winter 52
Table 50. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with no attenuation. 53
Table 51. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation. 53
Table 52. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation. 54
Table 53. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation. 54
Table 54. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with no attenuation. 55
Table 55. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 6 dB of attenuation. 55
Table 56. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 10 dB of attenuation. 56
Table 57. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 12 dB of attenuation. 56
Table 58. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with no attenuation. 57
Table 59. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation. 57
Table 60. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation. 57

Table 61. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation. 58
Table 62. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with no attenuation. 58
Table 63. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 6 dB of attenuation. 58
Table 64. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 10 dB of attenuation. 59
Table 65. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 12 dB of attenuation. 59
Table 66. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with no attenuation. 61
Table 67. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 6 dB of attenuation. 61
Table 68. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 10 dB of attenuation. 62
Table 69. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 12 dB of attenuation. 62
Table 70. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation. 63
Table 71. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation. 63
Table 72. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation. 64
Table 73. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation. 64
Table 74. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with no attenuation. 65
Table 75. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 6 dB of attenuation. 65
Table 76. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 10 dB of attenuation. 65
Table 77. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 12 dB of attenuation. 66

Table 78. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation. 66

Table 79. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation. 66

Table 80. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation. 67

Table 81. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation. 67

Table A-1. Aversion parameters for the animal movement simulation based on Southall et al. (2016) behavioral response criteria. A-4

Table A-2. *Blue whales*: Data values and references input in JASMINE to create diving behavior A-5

Table A-3. *Fin whales*: Data values and references input in JASMINE to create diving behavior A-7

Table A-4. *Humpback whales*: Data values and references input in JASMINE to create diving behavior A-9

Table A-5. *Minke whales:* Data values and references input in JASMINE to create diving behavior A-10

Table A-6. *North Atlantic right whales*: Data values and references input in JASMINE to create diving behavior A-13

Table A-7. *Atlantic spotted dolphins*: Data values and references input in JASMINE to create diving behavior A-17

Table A-8. *Atlantic white-sided dolphins*: Data values and references input in JASMINE to create diving behavior A-18

Table A-9. *Bottlenose dolphins*: Data values and references input in JASMINE to create diving behavior A-20

Table A-10. *Cuvier's beaked whales*: Data values and references input in JASMINE to create diving behavior A-22

Table A-11. *Killer whales*: Data values and references input in JASMINE to create diving behavior A-24

Table A-12. *Mesoplodont beaked whales*: Data values and references input in JASMINE to create diving behavior A-26

Table A-13. *Long-finned pilot whales*: Data values and references input in JASMINE to create diving behavior A-28

Table A-14. *Risso's dolphins:* Data values and references input in JASMINE to create diving behavior A-30

Table A-15. *Short-beaked common dolphins*: Data values and references input in JASMINE to create diving behavior A-32

Table A-16. *Sperm whales*: Data values and references input in JASMINE to create diving behavior A-33

Table A-17. *Harbor porpoises*: Data values and references input in JASMINE to create diving behavior A-36

Table A-18. *Gray seals:* Data values and references input in JASMINE to create diving behavior A-38

Table A-19. *Harbor seals*: Data values and references input in JASMINE to create diving behavior A-41

Table A-20*. Leatherback sea turtle*: Data values and references for inputs in JASMINE Software to create diving behavior A-44

Table A-21. *Loggerhead turtle*: Data values and references for inputs in JASMINE Software to create diving behavior A-46

1. Introduction

Deepwater Wind South Fork LLC (DWSF) is proposing to install fifteen wind turbine generators (WTGs) and one offshore substation in the South Fork Wind Farm (SFWF) area, each supported by a monopile foundation. Underwater noise will be generated during impact pile driving when installing the monopile foundations (see *Underwater Acoustic Modeling of Construction Noise Report,* Denes et al. 2018). The objective of the present modeling study was to predict the number of marine mammals and sea turtles that may be exposed to sound levels resulting in injury to or behavioral disruption.

To obtain the mean number of animals expected to receive sound levels resulting in injury or behavioral disruption, the previously modeled acoustic fields (Denes et al. 2018) were integrated with animal movement using JASCO's Animal Simulation Model Including Noise Exposure (JASMINE) to estimate the probability of sound exposures. The sound exposure probabilities were then compared to acoustic thresholds and scaled using models of species density near the SFWF project area. The mean number of animals expected to be exposed to sound levels that exceed the thresholds for each species were determined for a Maximum Design scenario and a Most Likely scenario. The mean number of animals expected to be exposed to sound levels exceeding the thresholds where also determined when broadband attenuation of 6 dB, 10 dB, and 12 dB were applied to the predicted sound fields so that potential noise attenuation systems could be evaluated.

2. Acoustic Impacts Modeling

2.1. Pile Driving as a Source of Sound

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 1). Sound transmission depends on many environmental parameters, such as the sound speeds in water and substrates; sound production parameters of the pile and how it is driven, including the pile material, size (length, diameter, and thickness) and the type and energy of the hammer. These parameters were considered in the acoustic modeling study detailed in Denes et al. (2018). Mitigation was considered in this study by attenuating the sound fields by 6 dB, 10 dB, and 12 dB. These reductions may be achieved with various proven technologies.

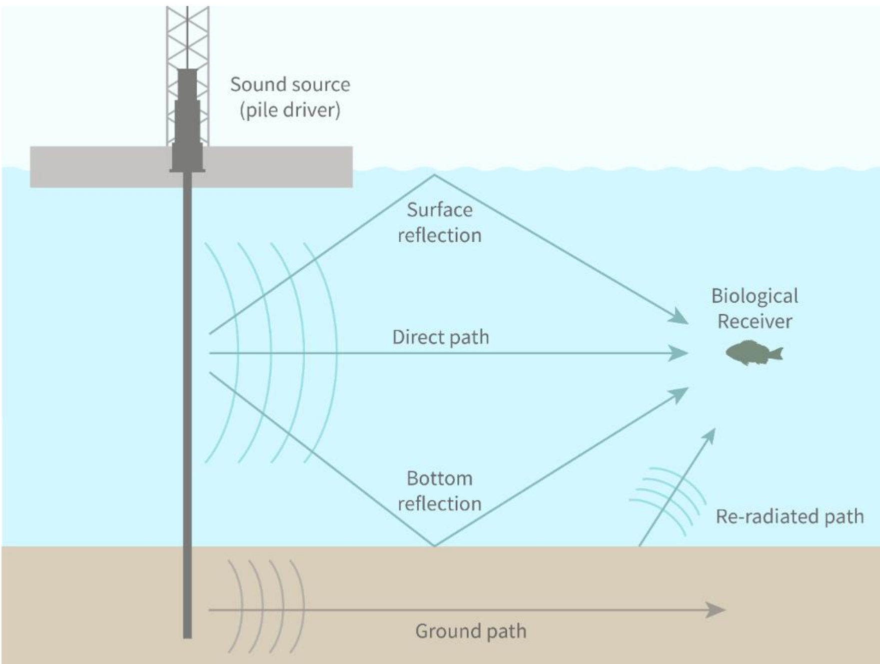

Figure 1. Sound propagation paths associated with pile driving (adapted from Buehler et al. 2015).

2.2. Exposure Estimate Calculation Overview

To estimate potential effects to marine fauna (i.e., injury, behavioral disturbance) from noise generated during the SFWF project, JASCO performed the following steps:

1. Modeling the spectral and temporal characteristics of the sound output from the proposed pile driving activities using the industry-standard GRLWEAP (wave equation analysis of pile driving) model and JASCO's Pile Driving Source Model (PDSM). Source model set-up and initialization data was based on pile-driving operational parameters provided by DWSF (Denes et al. 2018).
2. Acoustic propagation modeling using JASCO's Marine Operations Noise (MONM) and Full Wave Range Dependent Acoustic (FWRAM) models that combined the outputs of the source model with the spatial and temporal environmental context (e.g., location, oceanographic conditions, and seabed type) to estimate sound fields (converted to exposure radii for monitoring and mitigation). The lower frequency bands were modeled using MONM-RAM, which is based on the parabolic equation method of acoustic propagation modeling. The higher frequencies were modeled using MONM-Bellhop, which is a Gaussian-beam ray-theoretic acoustic propagation model (Denes et al. 2018).
3. Animal movement modeling using the JASMINE model that integrated the predicted sound fields with species-typical behavior (e.g., dive patterns and aversion) to obtain estimated received sound levels for species that may occur near the SFWF.
4. Estimating the number of potential Level A and Level B exposures based on pre-defined acoustic thresholds/criteria (NOAA 2005, Wood et al. 2012, Popper et al. 2014, Blackstock et al. 2017, NMFS 2018).

2.3. Acoustic Modeling: Scope and Assumptions

DWSF is proposing to install 15 WTGs and 1 offshore substation in the SFWF, both using monopile foundations with a maximum diameter of 10.97 meters (m) (36 feet [ft]). The monopiles for the foundations are all 97 m (318.2 ft) in length and will be driven to a penetration depth of 40–45 m (141.2–147.6 ft). An IHC S-4000 hammer was assumed for driving the piles, and representative hammering schedules (supplied by DWSF) of increasing hammer energy with increasing penetration depth were modeled (Table 1). The total number of strikes to drive each monopile foundation is ~4,500. At full energy, the strike rate is ~36 strikes per minute (strikes/min). The soft start schedule has an increasing strike rate over the first 20 minutes, so assuming a slower overall strike rate of ~32 strikes/min, ~140 minutes (min) (2.3 hours [hr]) of continuous pile driving is required to install a foundation. The dominant acoustic energy for all hammer energies is <100 Hz (Figure 2); see acoustic modelling report (Denes et al. 2018) for greater detail on the acoustic modelling process and results.

Table 1. Hammer energy schedule for monopile installation.

Energy level (kilojoule [kJ])	Strike count (4,500 total)	Strike count (8,000 total)	Pile penetration (m)	Modeled strike rate (min^{-1})
1,000	500	800	0–6	32
1,500	1,000	1,200	6–23.5	
2,500	1,500	3,000	23.5–41	
4,000	1,500	3,000	41–45	

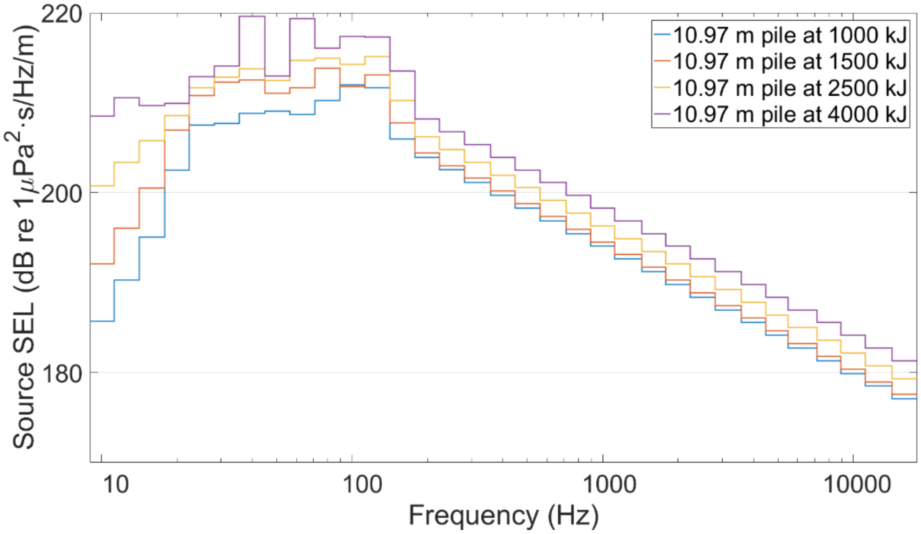

Figure 2. Decidecade band spectral source levels for monopile (10.97 m [36 ft]) installation using an IHC S-4000 hammer operating at 1000 to 4000 kilojoule [kJ].

Two installation scenarios were considered for the 16 monopile foundations: a Maximum Design scenario in which 16, 10.97 m (36 ft) monopile foundations are installed over 20 consecutive days, and a Most Likely scenario where the 16, 10.97 m (36 ft) WTG monopile foundations are installed over 30 days (Table 2). Both scenarios were modeled assuming the installation of one monopile per day, and it was also assumed that no concurrent pile driving was performed. The mean number of animals estimated to exceed exposure thresholds were obtained by scaling the animal movement modeling exposure results by the month with the highest density for each species during the proposed construction period from May through December.

Table 2. Modeling scenarios

Scenario	Foundation monopiles (10.97 m [36 ft] piles)	Piling days
Maximum Design	16	6 piles every 7 days
Most Likely		1 pile every other day

3. Acoustic Exposure Estimation–Marine Mammals

Scientific knowledge of how anthropogenic sound sources may or may not affect marine mammals is advancing, though much remains unknown. In 2016, NOAA released Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2016). The guidance has since been reviewed and found to represent the best available science, and no changes to the methods were suggested. The Technical Guidance (NMFS 2018) provides methods for assessing the potential for sounds to injure the animals by damaging their hearing but does not provide guidance for assessing the potential of sound to harass marine mammals by disrupting their behavior. For potential behavioral disruption, NMFS relies on earlier criteria (NOAA 2005), though refinements to the current NMFS criteria have been suggested (e.g., Wood et al. 2012).

The following sections describe the approach and procedures for estimating the potential of pile driving sound to injure or disrupt the behavior of marine mammals. The analysis employs robust acoustic impact assessment methods that consider pile-specific parameters, environmental conditions relevant to the location and affecting sound propagation, local animal densities, and biological behaviors of the species present near the SFWF.

3.1. Species that May be Present near the SFWF

Table 3 lists the 20 species considered in this study that are known to occur at least occasionally near the SFWF. Their expected occurrence is shown in the area population status, and their hearing range is indicated by hearing groups as discussed in Section 3.2.1.

Table 3. Summary of marine mammal species considered in the acoustic exposure analysis

Species of interest		Area population status†	Hearing group
Common name	Latin binomial		
Blue whale	*Balaenoptera musculus*	Rare	Low frequency
Fin whale*	*Balaenoptera physalus*	Common	
Humpback whale	*Megaptera novaeangliae*	Common	
Minke whale	*Balaenoptera acutorostrata*	Common	
North Atlantic right whale*	*Eubalaena glacialis*	Common	
Sei whale*	*Balaenoptera borealis*	Common	
Atlantic spotted dolphin	*Stenella frontalis*	Uncommon	Mid frequency
Atlantic white sided dolphin	*Lagenorhynchus acutus*	Common	
Bottlenose dolphin	*Tursiops truncatus*	Common	
Cuvier's beaked whale	*Ziphius cavirostris*	Common	
Killer whale	*Orcinus orca*	Uncommon	
Mesoplodont beaked whale	*Mesoplodon spp.*	Rare	
Long-finned pilot whale	*Globicephala melas*	Common	
Short-finned pilot whale	*Globicephala macrorhynchus*	Uncommon	
Risso's dolphin	*Grampus griseus*	Rare	
Short beaked common dolphin	*Delphinus delphis*	Common	
Sperm whale*	*Physeter macrocephalus*	Common	
Harbor porpoise	*Phocoena*	Uncommon	High frequency
Gray seal	*Halichoerus grypus*	Common	Pinnipeds underwater
Harbor seal	*Phoca vitulina*	Common	

† Area population status categories are: Common–abundant wherever it occurs in the region; Uncommon–may or may not be widely distributed but does not occur in large numbers; Rare–present in such small numbers throughout the region that it is seldom seen
* Indicates a species listed as endangered.

3.1.1. Density Estimates

Quantifying the number of animals or the percentage of a population that is at risk of acoustic exposure requires an estimate of the number of animals in that area. Occurrence and abundance estimates are determined from visual and/or acoustic surveys that identify, count, and log the position of species in various waters. From these data, models can be created to estimate the occurrence likelihood (surface density) along transect lines and between lines.

Marine mammal density estimates (animals/km^2) used in this assessment were obtained using the Duke University Marine Geospatial Ecological Laboratory model results (Roberts et al. 2016). Jason Roberts supplied an unpublished updated model for North Atlantic right whale densities (Roberts et al. 2017, Roberts et al. 2018) that incorporates more sighting data than Roberts et al. (2016), including sightings from the Atlantic Marine Assessment Program for Protected Species (AMAPPS) 2010–2014 (NEFSC and SEFSC, 2011b, NEFSC and SEFSC, 2011c, NEFSC and SEFSC, 2011a, NEFSC and SEFSC, 2012, NEFSC and SEFSC, 2013, NEFSC and SEFSC, 2014, NEFSC and SEFSC, 2015, NEFSC and SEFSC, 2016).

Mean monthly densities for all animals were calculated using a 60 km (37.3 mile) square centered on the SFWF and overlaying it on the abundance maps from Roberts et al. (2015, 2016, 2017), Roberts et al. (2018), e.g., Figure 3. The 60 km (37.3 mile) area exceeds the maximum range around the SFWF with the potential to result in behavioral disturbance from the 10.97 m (36 ft) monopile installation using Wood et al. (2012) thresholds with 6 dB attenuation (Table 12). This buffer encompasses and extends well beyond the range of behavioral disturbance for all hearing groups using the NOAA (2005) unweighted thresholds.

The mean density for each month was calculated using the mean of all 10 x 10 km (6.2 × 6.2 mile) grid cells partially or fully within the buffer zone polygon. Mean values from the density maps were converted from units of abundance (animals/100 km^2 [38.6 miles^2]) to units of density (animals/km^2). Densities were computed for May to December to coincide with planned pile driving activities. In cases where monthly densities were unavailable (e.g., for pilot whales), annual mean densities were used instead. Table 4 shows the monthly marine mammal density estimates for each species evaluated in the acoustic analysis. To obtain conservative exposure risks, the maximum of the mean monthly (May to December) densities for each species was used to estimate the number of individuals of each species exposed above the thresholds.

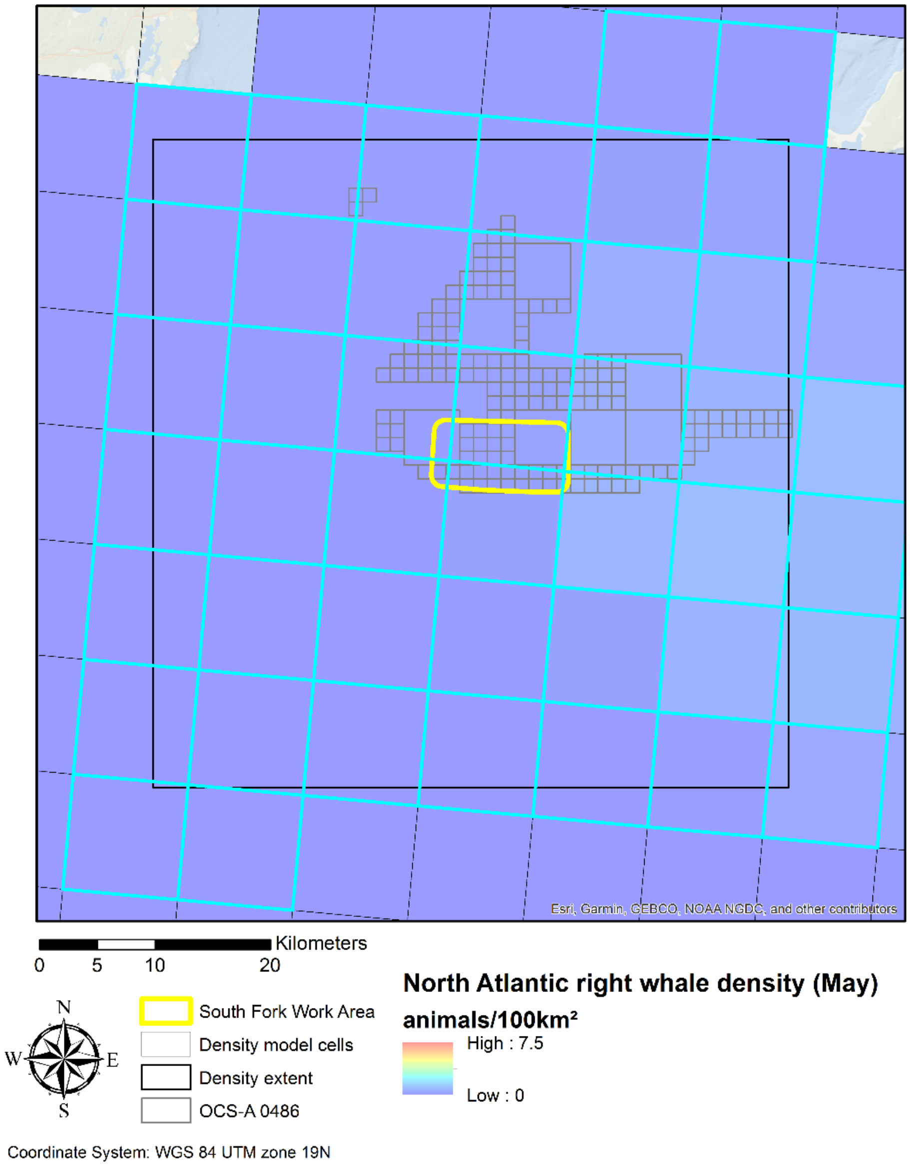

Figure 3. North Atlantic right whale density map showing Roberts et al. (2018) grid cells. Highlighted cells indicate those used to calculate mean monthly species estimates in the vicinity of the SFWF.

Table 4. Mean monthly marine mammal density estimates for the South Fork Work Area (SFWF) (Roberts et al. 2018). The density value in the month with the highest density for each species is indicated in bold typeface.

Species of interest	Density (animals/km² [0.386 miles²])							
	May	June	July	August	September	October	November	December
Blue whale	**9.18E-06**							
Fin whale	2.01E-03	2.19E-03	**2.64E-03**	2.51E-03	2.17E-03	1.45E-03	1.02E-03	1.05E-03
Humpback whale	1.33E-03	1.48E-03	6.93E-04	9.36E-04	**3.17E-03**	1.56E-03	4.21E-04	6.07E-04
Minke whale	**1.63E-03**	1.43E-03	4.65E-04	2.63E-04	2.72E-04	4.88E-04	2.24E-04	3.17E-04
North Atlantic right whale	**2.36E-03**	1.85E-03	5.39E-05	3.45E-05	2.39E-04	6.46E-06	7.38E-06	8.23E-04
Sei whale	**1.99E-04**	1.32E-04	3.19E-05	1.95E-05	3.47E-05	4.61E-06	7.79E-06	8.20E-06
Atlantic spotted dolphin	1.17E-04	1.55E-04	3.38E-04	4.08E-04	5.08E-04	**5.82E-04**	3.66E-04	6.82E-05
Atlantic white sided dolphin	**0.039**	0.036	0.025	0.013	0.015	0.022	0.021	0.028
Beaked whales (Mesoplodon spp.)	**0**							
Bottlenose dolphin	4.96E-03	0.018	0.037	0.038	**0.040**	0.020	9.62E-03	8.46E-03
Cuvier's beaked whale	**3.78E-05**							
Killer whale	**8.95E-06**							
Pilot whale†	**5.96E-03**							
Risso's dolphin	4.95E-05	5.30E-05	1.76E-04	**2.60E-04**	1.54E-04	5.29E-05	8.98E-05	1.89E-04
Short-beaked common dolphin	0.044	0.046	0.043	0.062	0.102	0.128	0.098	**0.204**
Sperm whale	1.91E-05	8.14E-05	**3.06E-04**	2.37E-04	1.04E-04	7.41E-05	6.65E-05	1.27E-05
Striped dolphin	**1.76E-05**							
Harbor porpoise	**0.038**	2.36E-03	1.60E-03	1.72E-03	1.61E-03	3.99E-03	0.024	.023
Gray seal	**0.039**	0.026	8.74E-03	3.57E-03	5.29E-03	9.55E-03	6.30E-03	0.034
Harbor seal	**0.039**	0.026	8.74E-03	3.57E-03	5.29E-03	9.55E-03	6.30E-03	0.034

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

3.2. Acoustic Criteria–Injury and Behavioral Disruption

The Marine Mammal Protection Act (MMPA; 16 U.S.C. 1362) defines the term “take” as “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal”. The MMPA prohibits taking marine mammals. MMPA regulations define the following two categories of harassment relevant to pile driving 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 that has the potential to disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but that does not have the potential to injure a marine mammal or marine mammal stock in the wild.

To assess the potential impacts of the SFWF-associated pile driving noise, it is necessary to first establish acoustic exposure criteria for which takes could result. In 2016, the National Marine Fisheries Service (NMFS) issued a Technical Guidance document that provided acoustic thresholds for onset of permanent threshold shift (PTS) in marine mammal hearing for most sound sources, that was then updated in 2018 (NMFS 2016, 2018). The NMFS also provided guidance on using weighting functions when applying Level A criteria. The NMFS Technical Guidance recommends using a dual criterion for assessing exposures, including a peak (unweighted/flat) sound level metric (PK) and a cumulative sound exposure level (SEL) metric with frequency weighting. Both acoustic criteria and weighting function application are divided into functional hearing groups (low-frequency (LF), mid-frequency (MF), and high frequency (HF)) that species are assigned to, based on their respective hearing ranges.

The publication of ISO 18405 Underwater Acoustics–Terminology (ISO 2017) provided a dictionary of underwater bioacoustics (the previous standard was ANSI S1.1-2013 R2013). In the remainder of this report, we follow the definitions and conventions of ISO (2017) except where stated otherwise (Table 5).

Table 5. Summary of relevant acoustic terminology used in this report and by Bureau of Ocean Energy Management (BOEM) and National Oceanic and Atmospheric Administration (NOAA).

Metric	NOAA (NMFS 2018)	This report (ISO 2017)	
		Main text	Tables/ Equations
Sound pressure level	n/a	SPL	L_p
Peak pressure level	PK	PK	L_{pk}
Cumulative sound exposure level	SEL_{cum}	SEL	L_E

The SEL_{cum} metric as used by the NMFS describes the sound energy received by a receptor over a period of 24 hours. 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.

3.2.1. Marine mammal hearing groups

Current data and predictions show that marine mammal species differ in their hearing capabilities, in absolute hearing sensitivity as well as frequency band of hearing (Richardson et al. 1995, Wartzok and Ketten 1999, Southall et al. 2007, Au and Hastings 2008). While hearing measurements are available for a small number of species based on captive animal studies, there are no direct measurements of many odontocetes or any mysticetes. As a result, hearing ranges for many odontocetes are grouped with similar species, and predictions for mysticetes are based on other methods including: anatomical studies and modeling (Houser et al. 2001, Parks et al. 2007, Tubelli et al. 2012, Cranford and Krysl 2015); vocalizations (see reviews in Richardson et al. 1995, Wartzok and Ketten 1999, Au and Hastings 2008); taxonomy; and behavioral responses to sound (Dahlheim and Ljungblad 1990, see review in Reichmuth et al. 2007). In 2007, Southall et al. proposed that marine mammals be divided into hearing groups. This division was updated in 2016 and 2018 by the NMFS using more recent best available science (Table 6).

Table 6. Marine mammal hearing groups (NMFS Sills et al. 2014, 2018).

Hearing group	Generalized hearing range*
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 39 kHz

* The generalized hearing range for all species within a group. Individual hearing will vary.

3.2.2. Marine mammal auditory weighting functions

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

Applying marine mammal auditory weighting functions emphasizes the importance of making 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 of interest or concern for completing the sound-producing activity (i.e., context of sound source; NMFS 2018).

3.2.3. Level A exposure criteria

Injury to the hearing apparatus of a marine mammal may result from a fatiguing stimulus measured in terms of SEL, which considers the sound level and duration of the exposure signal. Intense sounds may also damage hearing independent of duration, so an additional metric of peak pressure (PK) is also used to assess acoustic exposure injury risk. A PTS in hearing may be considered injurious, but there are no published data on the sound levels that cause PTS in marine mammals. There are data that indicate the received sound levels at which temporary threshold shift (TTS) occurs, and PTS onset may be extrapolated from 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 sound energy accumulated over 24 hours (SEL), or very loud, instantaneous peak sound pressure levels. These dual threshold criteria of SEL and PK are used to calculate marine mammal exposures (Table 7).

Table 7. Summary of relevant Level A onset acoustic thresholds (NMFS 2018).

Hearing group	PTS onset thresholds* (received level) Impulsive
Low-frequency (LF) cetaceans	L_{pk}, flat: 219 dB $L_{E,\,LF}$, 24h: 183 dB
Mid-frequency (MF) cetaceans	L_{pk}, flat: 230 dB $L_{E,\,MF}$, 24h: 185 dB
High-frequency (HF) cetaceans	L_{pk}, flat: 202 dB $L_{E,\,HF}$, 24h: 155 dB
Phocid seals in water (PW)	L_{pk}, flat: 218 dB $L_{E,\,PW}$, 24h: 185 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s
The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting.

3.2.4. Behavioral disruption exposure criteria

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

An extensive review of behavioral responses to sound was undertaken by Southall et al. (2007, their Appendix B). Southall et al. (2007) found varying responses for most marine mammals between an SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions. In 2012, Wood et al. proposed a graded probability of response for impulsive sounds using a frequency weighted SPL metric. Wood et al. (2012) also designated behavioral response categories for sensitive species (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 8).

Table 8. Level B exposure criteria used in this analysis. Probability of behavioral response frequency-weighted sound pressure level (SPL dB re 1 µPa). Probabilities are not additive. Adapted from Wood et al. (2012).

Marine mammal group	Probability of response to frequency-weighted L_p (dB re 1 µPa)			
	120	140	160	180
Beaked whales and harbor porpoises	50%	90%		
Migrating mysticete whales	10%	50%	90%	
All other species		10%	50%	90%

3.3. Predicted Sound Fields

The sound a source produces is characterized in time, spectral content, and space. As the sound travels away from the source, it is also shaped by interactions with the environment in which it propagates (see Appendix A). For this reason, the sound field produced by a source is specific to the source and the location. Understanding the potential for sound exposure to impact animals requires an understanding of the sound field to which they could be exposed.

Sound fields produced during pile driving were modeled by first characterizing the sound signal produced during pile driving using the industry-standard GRLWEAP (wave equation analysis of pile driving) model and JASCO's PDSM. The source signal was then propagated along radial planes using JASCO's parabolic equation models MONM and FWRAM, and radial planes were assembled into three-dimensional (3-D) sound fields (Denes et al. 2018). These 3-D, per-strike sound fields were then used with animal movement modeling (see below) to obtain estimates of animal exposure probability.

Two sites were selected to provide representative propagation and sound fields for the SFWF area (Table 9). Source locations were selected to span the region from shallow to deep water and varying distances to dominant bathymetric features (i.e., slope and shelf break). Water depth and environmental characteristics (e.g., bottom type) are similar throughout the SFWF area, and therefore minimal difference was found in sound propagation results for the two sites (Denes et al. 2018).

Table 9. Sites used in propagation modeling.

Site	Location (UTM Zone 19N)		Water depth (m)*	Sound source	Source type
	Easting	Northing			
P1	317803	4553388	34	Monopile	Impulsive
P2	318822	4549318	36		

* Vertical datum for water depth is Earth Gravitational Model 1996 (EGM96).

3.3.1. Ranges to exposure thresholds

Though not used for exposure estimates, ranges to exposure criteria thresholds are often reported for monitoring and mitigation purposes. For each sound level threshold, the maximum range (R_{max}) and the 95% range ($R_{95\%}$) were calculated. R_{max} is the distance to the farthest occurrence of the threshold level, at any depth. $R_{95\%}$ for a sound level is the radius of a circle, centered on the source, encompassing 95% of the sound at levels above threshold. Using $R_{95\%}$ reduces the sensitivity to extreme outlying values (the farthest 5% of ranges). A more detailed description is found in Denes et al (2018).

3.3.1.1. Injury criteria radii

Tables 10 and 11 list the radial distances to SEL, using the NMFS (2018) frequency weighting for marine mammals and PK, in summer and winter propagation conditions respectively. The greatest distances to PK typically occurred at the highest hammer energy levels. The distances to SEL were calculated using the hammer energy schedule for driving one monopile (Table 1) and the most conservative hammer size and energy combination. Tables 10 and 11 shows the average distance from two modeling sites for the summer sound speed profile. Results for each site are in Denes et al (2018).

Table 10. Average radial distances ($R_{95\%,}$ in meters) to Level A thresholds (NMFS 2018) for marine mammal functional hearing groups estimated for 4500 strikes in summer. $R_{95\%}$ is shown with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation.

Foundation type	Hearing group	Level A (L_{pk})				Level A ($L_{E,24hr}$)			
		No attenuation	6 dB	10 dB	12 dB	No attenuation	6 dB	10 dB	12 dB
10.97 m (36 ft) monopile	LF	87	22	9	7	12,831	7,773	5,626	4,660
	MF	8	2	1	1	103	46	33	33
	HF	1,545	541	243	183	7,800	3,587	2,017	1,508
	PW	101	26	12	8	3,085	1,350	712	445

Table 11. Average radial distances ($R_{95\%,}$ in meters) to Level A thresholds (NMFS 2018) for marine mammal functional hearing groups estimated for 4500 strikes in winter. $R_{95\%}$ is shown with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation.

Foundation type	Hearing group	Level A (L_{pk})				Level A ($L_{E,24hr}$)			
		No attenuation	6 dB	10 dB	12 dB	No attenuation	6 dB	10 dB	12 dB
10.97 m (36 ft) monopile	LF	87	22	9	7	20,001	10,003	6,542	5,370
	MF	8	2	1	1	111	40	20	20
	HF	1,545	541	243	183	10,779	4,437	2,330	1,637
	PW	101	26	12	8	3,363	1,400	633	428

3.3.1.2. Level B criteria radii

The NMFS (NOAA 2005) behavioral threshold for all hearing groups is an unweighted SPL of 160 dB re 1µPa. For comparison, the Wood et al. (2012) criteria are also included. Wood et al. (2012) uses Southall et al. (2007) auditory weighting applied to the SPL with a probability of response step function (Table 8). Tables 12 and 13 show the average range for both criteria using the hammer energy schedule to drive one monopile (Table 1) and the most conservative hammer size and energy combination in summer and winter respectively. The average range to the 50% response probability threshold are shown for Wood et al. (2012).

Table 12. Average radial distances ($R_{95\%}$ in meters) to Level B thresholds in summer for marine mammals based on NMFS (NOAA 2005) and Wood et al. (2012). $R_{95\%}$ is shown with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation for the marine mammal functional hearing groups.

Foundation type	Hearing group	Level B unweighted (NOAA 2005)				Level B frequency-weighted mean 50% probability of response (Wood et al. 2012)			
		No attenuation	6 dB	10 dB	12 dB	No attenuation	6 dB	10 dB	12 dB
10.97 m (36 ft) monopile	LF*	10,150	6,275	4,535	4,045	10,105	6,205	4,517	4,021
	MF					4,845	3,161	2,520	2,157
	HF**					>100,000	70,733	48,876	42,128
	PW					7,648	4,514	3,362	2,976

* Mysticetes near the SFWF area during planned operations are likely foraging even if they are migrating (Leiter et al. 2017), so the migrating mysticete category in Wood et al. (2012) was not used to select ranges included in this table.

** Harbor porpoise are the only high-frequency species near the SFWF. Wood et al. (2012) applies a lower threshold for this species to account for their known behavioral sensitivity.

Table 13. Average radial distances ($R_{95\%}$ in meters) to Level B thresholds in winter for marine mammals based on NMFS (NOAA 2005) and Wood et al. (2012). $R_{95\%}$ is shown with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation for the marine mammal functional hearing groups.

Foundation type	Hearing group	Level B unweighted (NOAA 2005)				Level B frequency-weighted mean 50% probability of response (Wood et al. 2012)			
		No attenuation	6 dB	10 dB	12 dB	No attenuation	6 dB	10 dB	12 dB
10.97 m (36 ft) monopile	LF*	12,614	7,493	4,832	4,282	12,587	7,451	4,809	4,261
	MF					5,590	3,313	2,562	2,225
	HF**					>100,000	>100,000	>100,000	>100,000
	PW					9,636	4,835	3,582	3,085

* Mysticetes near the SFWF area during planned operations are likely foraging even if they are migrating (Leiter et al. 2017), so the migrating mysticete category in Wood et al. (2012) was not used to select ranges included in this table.

** Harbor porpoise are the only high-frequency species near the SFWF. Wood et al. (2012) applies a lower threshold for this species to account for their known behavioral sensitivity.

3.4. Animal Movement and Exposure Modeling

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the probability of exposure of animals to sound arising from the SFWF's pile driving operations. Sound exposure models such as JASMINE use simulated animals (animats) to sample the predicted 3-D sound fields with movement rules derived from animal observations (Appendix A). The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, and surface times) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species (Appendix A). With animats programmed to behave like marine species that may be present near the SFWF area, the predicted sound fields are sampled in a way that real animals are expected to (Figure 4). 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 hr (Appendix A.1.1), to determine its total received acoustic energy (SEL) and maximum received PK and SPL. These received levels are then compared to the threshold criteria described in Sections 3.2.3 and 3.2.4. The number of animats predicted to receive sound levels exceeding the thresholds indicates the probability of such exposures, which is then scaled by the real-world density estimates for each species (Section 3.1.1) to obtain the mean number of real-world animals expected to receive above-threshold sound levels. Appendix A provides fuller description of animal movement modeling and the parameters used in the JASMINE simulations.

The following sections show the marine mammal exposure estimates for the Maximum Design Scenario (Section 3.4.1) and the Most Likely Scenario (Section 3.4.2).

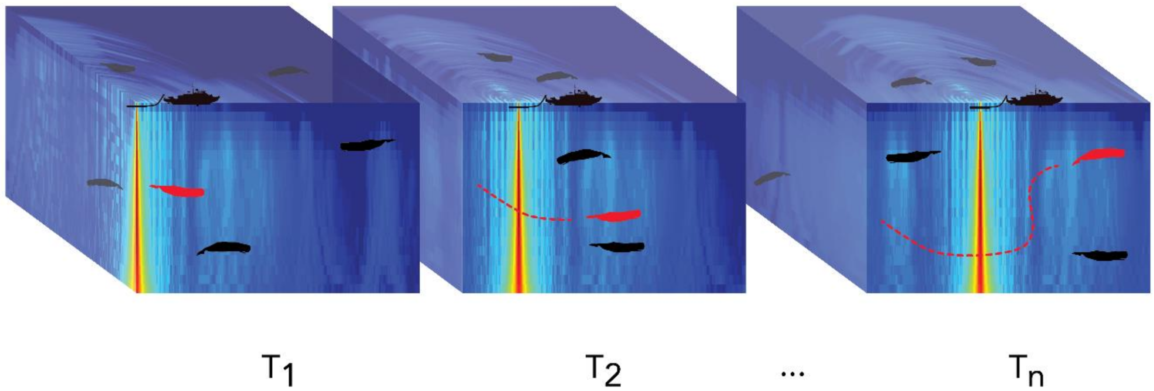

Figure 4. Graphic of animats in a moving sound field. Example animat (red) shown moving with each time step. The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

3.4.1. Exposure Estimates: Maximum Design Scenario (6 piles per week)

Table 14 shows the mean number of individual marine mammals expected to receive sound levels exceeding the Level A exposure criteria (NMFS 2018) for the entire project (construction period May to December) for the Maximum Design scenario (Table 2). The mean number of individual marine mammals predicted to receive sound levels exceeding the Level A criteria were estimated with no attenuation (Table 14), and then with the sound fields attenuated by 6 (Table 15), 10 (Table 16), and 12 dB (Table 17). Table 18 shows the similar results for the Maximum Design scenario, except it includes one difficult-to-drive pile that requires a total of 8,000 hammer strikes instead of 4,500 (Table 1) with no attenuation. Table 19 (6 dB attenuation), Table 20 (10 dB attenuation), and Table 21 (12 dB attenuation) show the results for the Maximum Design scenario with one difficult-to-drive pile with attenuation.

Tables 22–25 show the mean number of individual marine mammals expected to receive sound levels exceeding the Level B exposure criteria (NMFS, referenced as NOAA 2005; and Wood et al. 2012) for the entire project (May to December) for the Maximum Design scenario with no attenuation, 6 dB, 10 dB, and 12 dB of attenuation. In addition to the mean number of animals expected to receive sound levels exceeding the Level B exposure criteria, the total time, in minutes, above the NMFS threshold of SPL 160 dB re 1 µPa was calculated for all animats and scaled using the real-world density for the month with the highest density. Tables 26–29 show the Level B results for the Maximum Design scenario including one difficult-to-drive pile with varying levels of attenuation.

Table 14. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with no attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	0.11	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	0.04	0.07	0.04
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	5.61	0.07	6.1	0.08	7.35	0.09	7	0.09	6.06	0.08	4.03	0.05	2.81	0.01	2.89	0.01
Gray seal	5.34	0.49	3.58	0.33	1.21	0.11	0.49	0.04	0.73	0.07	1.32	0.12	0.58	0.05	3.16	0.29
Harbor porpoise	26.67	20.46	1.67	1.28	1.14	0.87	1.22	0.94	1.14	0.88	2.83	2.17	18.28	12.73	17.69	12.32
Harbor seal	8.1	0.9	5.42	0.6	1.83	0.2	0.75	0.08	1.11	0.12	2	0.22	1.03	0.1	5.59	0.53
Humpback whale*	8.64	0.05	9.58	0.06	4.49	0.03	6.06	0.04	20.52	0.12	10.13	0.06	2.78	0.02	4.01	0.03
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	8.74	0.2	7.64	0.18	2.49	0.06	1.41	0.03	1.46	0.03	2.61	0.06	1.31	0.01	1.85	0.02
North Atlantic right whale*	5.16	0.09	4.06	0.07	0.12	<0.01	0.08	<0.01	0.52	0.01	0.01	<0.01	0.02	<0.01	1.83	0.02
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.58	0.01	0.38	0.01	0.09	<0.01	0.06	<0.01	0.1	<0.01	0.01	<0.01	0.02	<0.01	0.03	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 15. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	0.11	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier’s beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	2.21	0.01	2.4	0.01	2.89	0.01	2.75	0.01	2.38	0.01	1.58	0.01	1.01	<0.01	1.04	<0.01
Gray seal	0.65	0.16	0.43	0.11	0.15	0.04	0.06	0.01	0.09	0.02	0.16	0.04	0.03	<0.01	0.14	<0.01
Harbor porpoise	3.11	5.31	0.2	0.33	0.13	0.23	0.14	0.24	0.13	0.23	0.33	0.56	2.37	3.83	2.29	3.71
Harbor seal	1.65	0.45	1.11	0.3	0.37	0.1	0.15	0.04	0.23	0.06	0.41	0.11	0.15	<0.01	0.8	<0.01
Humpback whale*	3.51	0.01	3.89	0.01	1.82	<0.01	2.46	<0.01	8.33	0.01	4.11	0.01	1.11	<0.01	1.61	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	3.42	0.01	2.98	0.01	0.97	<0.01	0.55	<0.01	0.57	<0.01	1.02	<0.01	0.5	<0.01	0.71	<0.01
North Atlantic right whale*	1.75	0.01	1.38	0.01	0.04	<0.01	0.03	<0.01	0.18	<0.01	<0.01	<0.01	0.01	<0.01	0.67	0.01
Risso’s dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.23	<0.01	0.15	<0.01	0.04	<0.01	0.02	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 16. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	1.01	<0.01	1.1	<0.01	1.33	<0.01	1.27	<0.01	1.1	<0.01	0.73	<0.01	0.38	<0.01	0.39	<0.01
Gray seal	0.16	<0.01	0.11	<0.01	0.04	<0.01	0.01	<0.01	0.02	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.65	2.33	0.04	0.15	0.03	0.1	0.03	0.11	0.03	0.1	0.07	0.25	0.16	0.9	0.16	0.87
Harbor seal	0.45	0.3	0.3	0.2	0.1	0.07	0.04	0.03	0.06	0.04	0.11	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.8	<0.01	1.99	<0.01	0.93	<0.01	1.26	<0.01	4.27	<0.01	2.11	<0.01	0.58	<0.01	0.83	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	1.47	<0.01	1.28	<0.01	0.42	<0.01	0.24	<0.01	0.24	<0.01	0.44	<0.01	0.2	<0.01	0.29	<0.01
North Atlantic right whale*	0.65	<0.01	0.51	<0.01	0.01	<0.01	0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	0.23	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.11	<0.01	0.07	<0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 17. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier’s beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.6	<0.01	0.65	<0.01	0.78	<0.01	0.74	<0.01	0.64	<0.01	0.43	<0.01	0.19	<0.01	0.2	<0.01
Gray seal	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.52	2.33	0.03	0.15	0.02	0.1	0.02	0.11	0.02	0.1	0.05	0.25	0.08	0.9	0.08	0.87
Harbor seal	0.45	0.3	0.3	0.2	0.1	0.07	0.04	0.03	0.06	0.04	0.11	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.25	<0.01	1.39	<0.01	0.65	<0.01	0.88	<0.01	2.98	<0.01	1.47	<0.01	0.4	<0.01	0.57	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	0.65	<0.01	0.57	<0.01	0.18	<0.01	0.1	<0.01	0.11	<0.01	0.19	<0.01	0.09	<0.01	0.13	<0.01
North Atlantic right whale*	0.34	<0.01	0.27	<0.01	0.01	<0.01	0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.13	<0.01
Risso’s dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.07	<0.01	0.05	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 18. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with no attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.09	0.01	0.11	0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	0.04	0.07	0.04
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier’s beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	5.87	0.08	6.37	0.08	7.68	0.1	7.32	0.1	6.34	0.08	4.21	0.05	2.92	0.01	3	0.01
Gray seal	5.72	0.55	3.83	0.37	1.29	0.12	0.53	0.05	0.78	0.07	1.41	0.13	0.65	0.05	3.56	0.28
Harbor porpoise	33.25	23.35	2.09	1.47	1.42	1	1.52	1.07	1.42	1	3.52	2.48	19.39	12.96	18.77	12.55
Harbor seal	8.45	0.96	5.66	0.64	1.91	0.22	0.78	0.09	1.15	0.13	2.08	0.24	1.11	0.11	6.07	0.57
Humpback whale*	8.95	0.05	9.92	0.06	4.65	0.03	6.28	0.04	21.25	0.13	10.49	0.06	2.88	0.02	4.15	0.03
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	7.04	0.11	5.54	0.09	0.16	0	0.1	0	0.71	0.01	0.02	0	0.02	0	2.17	0.03
North Atlantic right whale*	5.39	0.09	4.24	0.07	0.12	<0.01	0.08	<0.01	0.55	0.01	0.01	<0.01	0.02	<0.01	1.91	0.03
Risso’s dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.6	0.01	0.4	0.01	0.1	<0.01	0.06	<0.01	0.1	<0.01	0.01	<0.01	0.02	<0.01	0.03	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 19. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	0.11	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	2.3	0.01	2.5	0.01	3.01	0.01	2.87	0.01	2.48	0.01	1.65	0.01	1.06	<0.01	1.09	<0.01
Gray seal	0.74	0.2	0.5	0.13	0.17	0.04	0.07	0.02	0.1	0.03	0.18	0.05	0.03	<0.01	0.18	<0.01
Harbor porpoise	4.44	6.59	0.28	0.41	0.19	0.28	0.2	0.3	0.19	0.28	0.47	0.7	2.61	3.99	2.52	3.86
Harbor seal	1.79	0.44	1.2	0.29	0.4	0.1	0.16	0.04	0.24	0.06	0.44	0.11	0.16	<0.01	0.9	0.01
Humpback whale*	3.66	0.01	4.05	0.01	1.9	<0.01	2.57	<0.01	8.68	0.02	4.29	0.01	1.16	<0.01	1.67	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	3.49	0.01	3.04	0.01	0.99	<0.01	0.56	<0.01	0.58	<0.01	1.04	<0.01	0.53	<0.01	0.75	<0.01
North Atlantic right whale*	1.86	0.01	1.46	0.01	0.04	<0.01	0.03	<0.01	0.19	<0.01	0.01	<0.01	0.01	<0.01	0.71	0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.24	<0.01	0.16	<0.01	0.04	<0.01	0.02	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 20. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	1.06	<0.01	1.15	<0.01	1.38	<0.01	1.32	<0.01	1.14	<0.01	0.76	<0.01	0.41	<0.01	0.42	<0.01
Gray seal	0.21	<0.01	0.14	<0.01	0.05	<0.01	0.02	<0.01	0.03	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.7	2.59	0.04	0.16	0.03	0.11	0.03	0.12	0.03	0.11	0.07	0.27	0.2	0.96	0.19	0.93
Harbor seal	0.42	0.28	0.28	0.19	0.1	0.06	0.04	0.03	0.06	0.04	0.1	0.07	<0.01	<0.01	0.02	<0.01
Humpback whale*	1.89	<0.01	2.09	<0.01	0.98	<0.01	1.32	<0.01	4.48	<0.01	2.21	<0.01	0.61	<0.01	0.87	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	1.49	<0.01	1.3	<0.01	0.42	<0.01	0.24	<0.01	0.25	<0.01	0.44	<0.01	0.21	<0.01	0.3	<0.01
North Atlantic right whale*	0.71	<0.01	0.55	<0.01	0.02	<0.01	0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	0.26	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.11	<0.01	0.08	<0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 21. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.63	<0.01	0.68	<0.01	0.82	<0.01	0.79	<0.01	0.68	<0.01	0.45	<0.01	0.22	<0.01	0.22	<0.01
Gray seal	0.03	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.51	2.59	0.03	0.16	0.02	0.11	0.02	0.12	0.02	0.11	0.05	0.27	0.1	0.96	0.1	0.93
Harbor seal	0.42	0.28	0.28	0.19	0.1	0.06	0.04	0.03	0.06	0.04	0.1	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.32	<0.01	1.46	<0.01	0.69	<0.01	0.93	<0.01	3.13	<0.01	1.55	<0.01	0.42	<0.01	0.6	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	0.66	<0.01	0.58	<0.01	0.19	<0.01	0.11	<0.01	0.11	<0.01	0.2	<0.01	0.1	<0.01	0.14	<0.01
North Atlantic right whale*	0.38	<0.01	0.3	<0.01	0.01	<0.01	0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.07	<0.01	0.05	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 22. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with no attenuation.

Species	May		June		July		August		September		October		November		December		*t*>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	1.3	0.7	1.7	1	3.7	2.1	4.5	2.5	5.5	3.1	6.4	3.6	5.4	11.7	1	2.2	502.5
Atlantic white sided dolphin	313.2	198.2	291.7	184.6	199.5	126.2	108.7	68.8	119.6	75.7	179.5	113.6	242.9	623.1	320.5	822.1	25040.8
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	26.1	18.1	92.6	64.1	196.9	136.3	198	137.1	210.9	146	104.9	72.6	82.9	228.4	72.9	200.8	35397.9
Short beaked common dolphin	183.9	103	195.6	109.6	182.9	102.5	259.9	145.6	429	240.3	539.6	302.3	636	1541.3	1321.4	3202.3	164758.4
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	15.6	20.5	17	22.2	20.5	26.8	19.5	25.5	16.9	22.1	11.2	14.7	10.6	40.2	10.9	41.3	1295.6
Gray seal	252	253.7	168.8	169.9	56.9	57.3	23.2	23.4	34.4	34.6	62.2	62.6	59	214.7	321.7	1170.7	51297.7
Harbor porpoise	249.7	5468.6	15.7	343.3	10.6	233	11.4	250.6	10.7	234.2	26.5	579.7	236.4	7093.1	228.8	6865.1	46145.6
Harbor seal	217.9	231.4	146	155	49.2	52.2	20.1	21.3	29.8	31.6	53.7	57.1	56.9	213.6	310	1164.6	51552.3
Humpback whale*	10.6	13.3	11.7	14.8	5.5	6.9	7.4	9.4	25.1	31.7	12.4	15.6	4.6	12.4	6.7	17.9	5611.9
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.1	<0.1	8.1	0
Minke whale	28.5	32.2	24.9	28.2	8.1	9.2	4.6	5.2	4.7	5.4	8.5	9.6	6.4	16.2	9	22.9	405.8
North Atlantic right whale*	17.6	23.2	13.8	18.2	0.4	0.5	0.3	0.3	1.8	2.4	<0.1	0.1	0.1	0.3	8.8	32	867.3
Risso's dolphin	0.4	0.3	0.4	0.3	1.4	0.9	2.1	1.3	1.2	0.8	0.4	0.3	1.1	2.8	2.3	5.9	458.9
Sei whale*	1.6	2.1	1	1.4	0.3	0.3	0.2	0.2	0.3	0.4	<0.1	<0.1	0.1	0.3	0.1	0.3	101.3
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 23. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December		*t*>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.7	0.4	0.9	0.5	2	1.1	2.4	1.4	3	1.7	3.4	1.9	2.7	2.6	0.5	0.5	186.6
Atlantic white sided dolphin	157.1	99.3	146.3	92.5	100.1	63.2	54.5	34.5	60	37.9	90.1	56.9	105.1	129.8	138.7	171.2	9457.5
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	10.6	7.8	37.4	27.6	79.5	58.7	80	59.1	85.2	62.9	42.4	31.3	30.9	46	27.1	40.4	14004.3
Short beaked common dolphin	69.4	51.8	73.8	55.2	69	51.6	98.1	73.3	161.9	120.9	203.6	152.1	221.6	279.6	460.5	580.9	50390.0
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	7.5	10.8	8.1	11.7	9.8	14.2	9.3	13.5	8.1	11.7	5.4	7.8	4.6	15.3	4.7	15.7	486.8
Gray seal	106.7	122.6	71.5	82.1	24.1	27.7	9.8	11.3	14.6	16.7	26.3	30.2	21.9	60.9	119.6	332.1	16087.5
Harbor porpoise	117	3053.2	7.3	191.7	5	130.1	5.4	139.9	5	130.8	12.4	323.7	95.9	5481.5	92.9	5305.3	17862.9
Harbor seal	95.5	112.7	64	75.5	21.6	25.4	8.8	10.4	13	15.4	23.6	27.8	21.7	59	118.1	321.9	15883.4
Humpback whale*	5.4	7.2	6	8	2.8	3.7	3.8	5	12.8	17.1	6.3	8.4	2.1	5.9	3	8.5	2031.4
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0
Minke whale	15.6	18.2	13.6	15.9	4.4	5.2	2.5	2.9	2.6	3	4.7	5.4	2.9	9.3	4.2	13.1	156.0
North Atlantic right whale*	8.7	12.3	6.8	9.6	0.2	0.3	0.1	0.2	0.9	1.2	<0.1	<0.1	<0.1	0.1	3.7	12.2	319.6
Risso's dolphin	0.2	0.1	0.2	0.1	0.7	0.5	1	0.7	0.6	0.4	0.2	0.1	0.5	0.6	1	1.3	170.1
Sei whale*	0.8	1.1	0.5	0.7	0.1	0.2	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	0.1	38.8
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 24. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.5	0.3	0.6	0.4	1.4	0.8	1.6	0.9	2	1.2	2.3	1.3	1.6	1.3	0.3	0.2	107.4
Atlantic white sided dolphin	107.4	64.5	100	60.1	68.4	41.1	37.3	22.4	41	24.6	61.5	37	60.4	59.3	79.7	78.2	5634.3
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	5.8	4.6	20.7	16.3	43.9	34.7	44.2	34.9	47.1	37.1	23.4	18.5	14.1	20	12.4	17.6	8156.8
Short beaked common dolphin	37	30.7	39.4	32.7	36.8	30.5	52.3	43.4	86.3	71.6	108.5	90.1	98.1	134.8	203.9	280	25648.7
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.9	7.1	5.3	7.7	6.4	9.3	6.1	8.8	5.3	7.6	3.5	5.1	2.7	7.1	2.8	7.3	289.5
Gray seal	58.3	72.4	39	48.5	13.2	16.4	5.4	6.7	8	9.9	14.4	17.9	10.1	26.5	55.3	144.4	9884.7
Harbor porpoise	70.7	1896.1	4.4	119	3	80.8	3.2	86.9	3	81.2	7.5	201	51.2	5217.8	49.5	5050	10091.1
Harbor seal	52.6	65	35.3	43.6	11.9	14.7	4.9	6	7.2	8.9	13	16	9.4	25.8	51.1	140.9	9678.9
Humpback whale*	3.5	4.7	3.9	5.2	1.8	2.4	2.5	3.3	8.4	11.1	4.2	5.5	1.2	2.9	1.8	4.1	1169.5
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	10.2	12.3	8.9	10.7	2.9	3.5	1.6	2	1.7	2	3	3.7	1.8	4.1	2.6	5.8	85.7
North Atlantic right whale*	5.6	7.9	4.4	6.2	0.1	0.2	0.1	0.1	0.6	0.8	<0.1	<0.1	<0.1	0.1	2.1	5.7	181.4
Risso's dolphin	0.1	0.1	0.1	0.1	0.5	0.3	0.7	0.4	0.4	0.3	0.1	0.1	0.3	0.3	0.6	0.6	101.9
Sei whale*	0.5	0.7	0.3	0.5	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	22.8
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 25. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.4	0.2	0.5	0.3	1.2	0.6	1.4	0.8	1.8	0.9	2	1.1	1.4	0.9	0.3	0.4	83.0
Atlantic white sided dolphin	91	51.6	84.7	48	57.9	32.8	31.6	17.9	34.7	19.7	52.2	29.6	49.6	37.1	65.4	91	4464.9
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	4.6	3.4	16.4	12.2	34.8	26	35	26.1	37.3	27.8	18.5	13.8	11.3	10.9	9.9	4.6	6353.4
Short beaked common dolphin	30	22.6	31.9	24	29.8	22.4	42.4	31.9	70	52.6	88	66.2	77.3	81.5	160.6	30	18907.1
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.1	5.6	4.5	6.1	5.4	7.3	5.2	7	4.5	6.1	3	4	2.3	5.2	2.4	4.1	228.2
Gray seal	50.2	55.5	33.6	37.2	11.3	12.5	4.6	5.1	6.9	7.6	12.4	13.7	8.3	18.7	45.3	50.2	7627.6
Harbor porpoise	58.9	1505.4	3.7	94.5	2.5	64.1	2.7	69	2.5	64.5	6.2	159.6	42.5	5148.9	41.1	58.9	7763.9
Harbor seal	44.4	50	29.7	33.5	10	11.3	4.1	4.6	6.1	6.8	10.9	12.3	7	18.5	38.4	44.4	7792.6
Humpback whale*	3	3.8	3.3	4.2	1.6	2	2.1	2.7	7.1	9	3.5	4.5	1.1	2.1	1.5	3	902.7
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	8.8	10.2	7.6	8.9	2.5	2.9	1.4	1.6	1.5	1.7	2.6	3	1.4	2.9	2	4.1	65.8
North Atlantic right whale*	4.8	6.3	3.8	5	0.1	0.1	0.1	0.1	0.5	0.6	<0.1	<0.1	<0.1	<0.1	1.8	4.8	140.0
Risso's dolphin	0.1	0.1	0.1	0.1	0.4	0.2	0.6	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.5	0.1	80.1
Sei whale*	0.4	0.6	0.3	0.4	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	17.9
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 26. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with no attenuation.

Species	May		June		July		August		September		October		November		December		$t_{>NMFS}$ (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	1.3	0.7	1.7	1	3.8	2.1	4.5	2.5	5.7	3.2	6.5	3.6	5.4	11.7	1	2.2	524.7
Atlantic white sided dolphin	318.6	200.7	296.7	186.9	202.9	127.8	110.6	69.7	121.7	76.7	182.6	115.1	246	625	324.6	824.5	26218.7
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	26.3	18.1	93.3	64.1	198.2	136.2	199.4	137	212.4	146	105.6	72.6	83.2	228.9	73.1	201.2	37599.4
Short beaked common dolphin	186.1	103.7	198	110.3	185.1	103.1	263	146.5	434.1	241.8	546.2	304.2	640.6	1540.3	1331	3200.1	171038.6
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	15.9	20.6	17.2	22.4	20.8	27	19.8	25.7	17.1	22.3	11.4	14.8	10.7	40.3	11	41.4	1362.6
Gray seal	251.7	253.9	168.6	170.1	56.8	57.3	23.2	23.4	34.4	34.7	62.1	62.6	59.1	214.9	322.2	1172.1	53836.4
Harbor porpoise	273.1	5828.5	17.1	365.9	11.6	248.4	12.5	267.1	11.7	249.6	29	617.9	238.2	7098.5	230.6	6870.3	48999.3
Harbor seal	220.8	232.8	147.9	156	49.8	52.6	20.3	21.5	30.1	31.8	54.4	57.4	57.2	214	311.6	1166.7	54599.8
Humpback whale*	10.8	13.5	11.9	14.9	5.6	7	7.6	9.4	25.6	32	12.6	15.8	4.7	12.5	6.8	18	5891.4
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.1	<0.1	8.1	0
Minke whale	28.5	32	24.9	28	8.1	9.1	4.6	5.1	4.7	5.3	8.5	9.5	6.5	16.2	9.2	23	428.5
North Atlantic right whale*	17.9	23.3	14	18.4	0.4	0.5	0.3	0.3	1.8	2.4	<0.1	0.1	0.1	0.3	8.8	32.1	914.3
Risso's dolphin	0.4	0.3	0.4	0.3	1.4	0.9	2.1	1.4	1.3	0.8	0.4	0.3	1.1	2.8	2.3	5.9	482.6
Sei whale*	1.6	2.1	1.1	1.4	0.3	0.3	0.2	0.2	0.3	0.4	<0.1	<0.1	0.1	0.3	0.1	0.3	105.8
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 27. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.7	0.4	0.9	0.5	2	1.1	2.5	1.4	3.1	1.7	3.5	2	2.7	2.7	0.5	0.5	194.9
Atlantic white sided dolphin	161.1	100.8	150.1	93.9	102.6	64.2	55.9	35	61.5	38.5	92.4	57.8	106.9	130.9	141	172.7	9933.8
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	10.6	7.8	37.7	27.7	80.2	58.9	80.7	59.2	85.9	63.1	42.7	31.4	31	46.1	27.3	40.5	14744.7
Short beaked common dolphin	70.4	52.2	74.9	55.5	70	51.9	99.5	73.8	164.2	121.8	206.6	153.2	223.2	280.1	463.8	581.9	52618.2
Cuvier’s beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	7.6	10.9	8.3	11.9	10	14.3	9.5	13.6	8.3	11.8	5.5	7.9	4.7	15.3	4.8	15.8	509.4
Gray seal	107	122.9	71.7	82.3	24.2	27.7	9.9	11.3	14.6	16.8	26.4	30.3	22	61.1	119.9	332.9	16790.0
Harbor porpoise	128.8	3264.6	8.1	204.9	5.5	139.1	5.9	149.6	5.5	139.8	13.7	346.1	96.9	5483.5	93.8	5307.2	18960.6
Harbor seal	97.3	113.8	65.2	76.2	22	25.7	9	10.5	13.3	15.5	24	28.1	21.9	59.3	119.4	323.1	16838.3
Humpback whale*	5.5	7.3	6.1	8.1	2.9	3.8	3.9	5.1	13	17.3	6.4	8.5	2.2	5.9	3.1	8.5	2133.5
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0
Minke whale	15.7	18.2	13.7	15.9	4.5	5.2	2.5	2.9	2.6	3	4.7	5.4	3	9.3	4.3	13.2	164.6
North Atlantic right whale*	8.8	12.4	6.9	9.7	0.2	0.3	0.1	0.2	0.9	1.3	<0.1	<0.1	<0.1	0.1	3.8	12.3	336.6
Risso’s dolphin	0.2	0.1	0.2	0.1	0.7	0.5	1.1	0.7	0.6	0.4	0.2	0.1	0.5	0.6	1	1.3	177.8
Sei whale*	0.8	1.1	0.5	0.7	0.1	0.2	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	0.1	40.3
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 28. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.5	0.3	0.6	0.4	1.4	0.8	1.7	0.9	2.1	1.2	2.4	1.3	1.7	1.3	0.3	0.2	112.2
Atlantic white sided dolphin	110.4	65.8	102.8	61.3	70.3	41.9	38.3	22.8	42.2	25.1	63.3	37.7	61.6	60	81.2	79.1	5904.7
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	5.9	4.6	20.8	16.4	44.3	34.8	44.5	35	47.4	37.3	23.6	18.6	14.1	20.1	12.4	17.6	8544.2
Short beaked common dolphin	37.8	31.1	40.2	33.1	37.6	30.9	53.4	43.9	88.1	72.5	110.8	91.2	99.8	135.3	207.3	281.2	26989.8
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	5	7.2	5.5	7.8	6.6	9.4	6.3	8.9	5.4	7.7	3.6	5.1	2.8	7.2	2.9	7.3	301.9
Gray seal	58.6	72.6	39.2	48.7	13.2	16.4	5.4	6.7	8	9.9	14.4	17.9	10.2	26.6	55.5	144.9	10226.3
Harbor porpoise	78.4	2028.4	4.9	127.3	3.3	86.4	3.6	93	3.4	86.9	8.3	215	51.9	5219.4	50.2	5051.5	10806.6
Harbor seal	53.7	65.8	36	44.1	12.1	14.8	4.9	6.1	7.3	9	13.2	16.2	9.5	26	51.9	141.6	10196.3
Humpback whale*	3.6	4.8	4	5.3	1.9	2.5	2.6	3.3	8.6	11.3	4.3	5.6	1.3	2.9	1.8	4.2	1229.3
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	10.2	12.2	8.9	10.7	2.9	3.5	1.6	2	1.7	2	3.1	3.6	1.9	4.1	2.6	5.9	89.9
North Atlantic right whale*	5.7	8	4.5	6.3	0.1	0.2	0.1	0.1	0.6	0.8	<0.1	<0.1	<0.1	0.1	2.2	5.8	191.2
Risso's dolphin	0.1	0.1	0.1	0.1	0.5	0.3	0.7	0.4	0.4	0.3	0.1	0.1	0.3	0.3	0.6	0.6	106.5
Sei whale*	0.5	0.7	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	23.7
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 29. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Maximum Design scenario, with one difficult-to-drive pile with 12 dB of attenuation.

Species	**May**		**June**		**July**		**August**		**September**		**October**		**November**		**December**		*t*>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.4	0.2	0.6	0.3	1.2	0.6	1.5	0.8	1.8	1	2.1	1.1	1.4	0.9	0.3	0.2	86.7
Atlantic white sided dolphin	93.9	52.7	87.5	49.1	59.8	33.5	32.6	18.3	35.9	20.1	53.8	30.2	50.7	37.8	67	49.8	4664.7
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	4.6	3.5	16.4	12.3	34.9	26.1	35.1	26.3	37.4	28	18.6	13.9	11.3	11	9.9	9.6	6638.5
Short beaked common dolphin	30.5	22.9	32.4	24.4	30.3	22.8	43.1	32.4	71.1	53.4	89.5	67.2	78.9	82.3	164	171	19993.3
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.3	5.7	4.6	6.2	5.6	7.4	5.3	7.1	4.6	6.1	3.1	4.1	2.3	5.2	2.4	5.3	237.3
Gray seal	50.3	55.6	33.7	37.3	11.4	12.6	4.6	5.1	6.9	7.6	12.4	13.7	8.3	18.8	45.3	102.5	7886.2
Harbor porpoise	65.7	1612.1	4.1	101.2	2.8	68.7	3	73.9	2.8	69	7	170.9	43	5150.1	41.7	4984.5	8337.9
Harbor seal	45.1	50.6	30.2	33.9	10.2	11.4	4.2	4.7	6.2	6.9	11.1	12.5	7.2	18.6	39.2	101.6	8185.1
Humpback whale*	3.1	3.9	3.4	4.3	1.6	2	2.2	2.7	7.3	9.2	3.6	4.5	1.1	2.1	1.6	3.1	948.6
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	8.8	10.2	7.7	8.9	2.5	2.9	1.4	1.6	1.5	1.7	2.6	3	1.5	2.9	2.1	4.1	68.9
North Atlantic right whale*	4.9	6.4	3.9	5	0.1	0.1	0.1	0.1	0.5	0.6	<0.1	<0.1	<0.1	<0.1	1.8	4.2	147.5
Risso's dolphin	0.1	0.1	0.1	0.1	0.4	0.2	0.6	0.3	0.4	0.2	0.1	0.1	0.2	0.2	0.5	0.4	83.6
Sei whale*	0.5	0.6	0.3	0.4	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18.5
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

3.4.2. Exposure Estimates: Most Likely Scenario (Piling every other day)

Similar to the Maximum Design scenario, Tables 30–33 show the mean number of individual marine mammals expected to receive sound levels exceeding the Level A exposure criteria (NMFS 2018) for the entire project (construction period May to December) for the Most Likely scenario (Table 2). And, again, the mean number of individual marine mammals predicted to receive sound levels exceeding the Level A criteria were estimated with no attenuation, and then with the sound fields attenuated by 6 dB, 10 dB, and 12 dB. Tables 34–37 similar results for the Most Likely scenario, except it includes one difficult-to-drive pile that requires a total of 8,000 hammer strikes instead of 4,500 (Table 1). Each table presents results with different attenuation levels: no attenuation, 6 dB, 10 dB, and 12 dB of attenuation. Tables 38–41 show the mean number of individual marine mammals expected to receive sound levels exceeding the Level B exposure criteria (NMFS, referenced as NOAA 2005; and Wood et al. 2012) for the entire project (May to December) for the Most Likely scenario, and the total time, in minutes, above the NMFS threshold of SPL 160 dB re 1 µPa. Tables 42–45 show similar results with except they include one difficult-to-drive pile.

Table 30. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with no attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	0.07	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	5.54	0.11	6.02	0.12	7.26	0.14	6.92	0.14	5.99	0.12	3.98	0.08	2.74	0.02	2.81	0.02
Gray seal	6.8	0.32	4.55	0.22	1.53	0.07	0.63	0.03	0.93	0.04	1.68	0.08	0.63	0.11	3.45	0.57
Harbor porpoise	28.74	19.68	1.8	1.24	1.22	0.84	1.32	0.9	1.23	0.84	3.05	2.09	18.11	13.22	17.53	12.79
Harbor seal	9.9	1.2	6.63	0.8	2.23	0.27	0.91	0.11	1.35	0.16	2.44	0.3	1.42	0.1	7.72	0.53
Humpback whale*	8.95	0.05	9.92	0.06	4.65	0.03	6.28	0.04	21.25	0.12	10.49	0.06	2.75	0.02	3.97	0.03
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	8.63	0.21	7.54	0.19	2.46	0.06	1.39	0.03	1.44	0.04	2.57	0.06	1.3	0.01	1.84	0.02
North Atlantic right whale*	5.4	0.07	4.25	0.06	0.12	<0.01	0.08	<0.01	0.55	0.01	0.01	<0.01	0.02	<0.01	1.92	0.02
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.57	0.01	0.38	0.01	0.09	<0.01	0.06	<0.01	0.1	<0.01	0.01	<0.01	0.02	<0.01	0.02	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 31. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	2.11	0.02	2.29	0.02	2.76	0.02	2.63	0.02	2.27	0.02	1.51	0.01	1	<0.01	1.03	<0.01
Gray seal	0.97	0.32	0.65	0.22	0.22	0.07	0.09	0.03	0.13	0.04	0.24	0.08	0.05	<0.01	0.29	<0.01
Harbor porpoise	4.66	6.73	0.29	0.42	0.2	0.29	0.21	0.31	0.2	0.29	0.49	0.71	2.77	4.73	2.68	4.58
Harbor seal	3	0.3	2.01	0.2	0.68	0.07	0.28	0.03	0.41	0.04	0.74	0.07	0.2	<0.01	1.07	<0.01
Humpback whale*	3.52	<0.01	3.9	<0.01	1.83	<0.01	2.47	<0.01	8.35	<0.01	4.12	<0.01	1.13	<0.01	1.63	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	3.48	0.01	3.04	0.01	0.99	<0.01	0.56	<0.01	0.58	<0.01	1.04	<0.01	0.51	<0.01	0.72	<0.01
North Atlantic right whale*	1.77	<0.01	1.39	<0.01	0.04	<0.01	0.03	<0.01	0.18	<0.01	<0.01	<0.01	0.01	<0.01	0.7	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.23	<0.01	0.15	<0.01	0.04	<0.01	0.02	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 32. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.9	<0.01	0.98	<0.01	1.18	<0.01	1.12	<0.01	0.97	<0.01	0.65	<0.01	0.47	<0.01	0.48	<0.01
Gray seal	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	1.04	2.85	0.07	0.18	0.04	0.12	0.05	0.13	0.04	0.12	0.11	0.3	0.49	0.98	0.47	0.95
Harbor seal	0.3	0.3	0.2	0.2	0.07	0.07	0.03	0.03	0.04	0.04	0.07	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.81	<0.01	2	<0.01	0.94	<0.01	1.27	<0.01	4.29	<0.01	2.12	<0.01	0.59	<0.01	0.85	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	1.55	<0.01	1.35	<0.01	0.44	<0.01	0.25	<0.01	0.26	<0.01	0.46	<0.01	0.18	<0.01	0.25	<0.01
North Atlantic right whale*	0.84	<0.01	0.66	<0.01	0.02	<0.01	0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	0.25	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.11	<0.01	0.07	<0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 33. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the Most Likely Design scenario with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.56	<0.01	0.61	<0.01	0.73	<0.01	0.7	<0.01	0.6	<0.01	0.4	<0.01	0.23	<0.01	0.23	<0.01
Gray seal	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.52	2.85	0.03	0.18	0.02	0.12	0.02	0.13	0.02	0.12	0.05	0.3	0.33	0.98	0.32	0.95
Harbor seal	0.3	0.3	0.2	0.2	0.07	0.07	0.03	0.03	0.04	0.04	0.07	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.25	<0.01	1.39	<0.01	0.65	<0.01	0.88	<0.01	2.98	<0.01	1.47	<0.01	0.41	<0.01	0.59	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	0.78	<0.01	0.68	<0.01	0.22	<0.01	0.13	<0.01	0.13	<0.01	0.23	<0.01	0.08	<0.01	0.12	<0.01
North Atlantic right whale*	0.37	<0.01	0.29	<0.01	0.01	<0.01	0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.07	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 34. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with no attenuation.

Species	May		June		July		August		September		October		November		December	
	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}	L_{E}	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	0.01	0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	0.07	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	5.8	0.11	6.3	0.12	7.6	0.15	7.24	0.14	6.27	0.12	4.17	0.08	2.86	0.03	2.93	0.03
Gray seal	7.09	0.39	4.75	0.26	1.6	0.09	0.65	0.04	0.97	0.05	1.75	0.1	0.7	0.1	3.83	0.55
Harbor porpoise	35.19	22.62	2.21	1.42	1.5	0.96	1.61	1.04	1.51	0.97	3.73	2.4	19.24	13.42	18.62	12.99
Harbor seal	10.14	1.24	6.79	0.83	2.29	0.28	0.93	0.11	1.38	0.17	2.5	0.31	1.48	0.11	8.07	0.57
Humpback whale*	9.24	0.05	10.25	0.06	4.8	0.03	6.48	0.04	21.94	0.13	10.83	0.06	2.85	0.02	4.11	0.03
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	8.8	0.21	7.68	0.18	2.51	0.06	1.41	0.03	1.46	0.04	2.62	0.06	1.36	0.02	1.92	0.02
North Atlantic right whale*	5.62	0.07	4.42	0.06	0.13	<0.01	0.08	<0.01	0.57	0.01	0.02	<0.01	0.02	<0.01	1.99	0.03
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.59	0.01	0.39	0.01	0.09	<0.01	0.06	<0.01	0.1	<0.01	0.01	<0.01	0.02	<0.01	0.03	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 35. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier’s beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	2.21	0.02	2.4	0.02	2.89	0.02	2.75	0.02	2.38	0.02	1.58	0.01	1.06	<0.01	1.09	<0.01
Gray seal	1.05	0.35	0.7	0.23	0.24	0.08	0.1	0.03	0.14	0.05	0.26	0.09	0.06	<0.01	0.31	<0.01
Harbor porpoise	5.9	7.93	0.37	0.5	0.25	0.34	0.27	0.36	0.25	0.34	0.63	0.84	2.99	4.83	2.89	4.67
Harbor seal	3.05	0.3	2.04	0.2	0.69	0.07	0.28	0.03	0.42	0.04	0.75	0.07	0.21	<0.01	1.15	0.01
Humpback whale*	3.67	<0.01	4.06	<0.01	1.9	<0.01	2.57	<0.01	8.7	<0.01	4.3	<0.01	1.18	<0.01	1.7	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	3.54	0.01	3.1	0.01	1.01	<0.01	0.57	<0.01	0.59	<0.01	1.06	<0.01	0.54	<0.01	0.76	<0.01
North Atlantic right whale*	1.88	<0.01	1.48	<0.01	0.04	<0.01	0.03	<0.01	0.19	<0.01	0.01	<0.01	0.01	<0.01	0.74	0.01
Risso’s dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.23	<0.01	0.16	<0.01	0.04	<0.01	0.02	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 36. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.95	<0.01	1.03	<0.01	1.24	<0.01	1.18	<0.01	1.02	<0.01	0.68	<0.01	0.5	<0.01	0.51	<0.01
Gray seal	0.06	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	1.07	3.07	0.07	0.19	0.05	0.13	0.05	0.14	0.05	0.13	0.11	0.33	0.5	1.04	0.49	1.01
Harbor seal	0.28	0.28	0.19	0.19	0.06	0.06	0.03	0.03	0.04	0.04	0.07	0.07	<0.01	<0.01	0.02	<0.01
Humpback whale*	1.9	<0.01	2.1	<0.01	0.98	<0.01	1.33	<0.01	4.5	<0.01	2.22	<0.01	0.62	<0.01	0.89	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	1.56	<0.01	1.36	<0.01	0.44	<0.01	0.25	<0.01	0.26	<0.01	0.47	<0.01	0.19	<0.01	0.27	<0.01
North Atlantic right whale*	0.89	<0.01	0.7	<0.01	0.02	<0.01	0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	0.27	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.11	<0.01	0.07	<0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 37. The mean number of marine mammals estimated to experience sound levels above Level A exposure criteria (NMFS 2018) in the SFWF area for the most Likely scenario, with one difficult-to-drive pile with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December	
	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}	L_E	L_{pk}
Atlantic spotted dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atlantic white sided dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mesoplodont beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Blue whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Common bottlenose dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Short beaked common dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cuvier's beaked whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fin whale*	0.59	<0.01	0.64	<0.01	0.78	<0.01	0.74	<0.01	0.64	<0.01	0.43	<0.01	0.25	<0.01	0.26	<0.01
Gray seal	0.03	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harbor porpoise	0.51	3.07	0.03	0.19	0.02	0.13	0.02	0.14	0.02	0.13	0.05	0.33	0.33	1.04	0.32	1.01
Harbor seal	0.28	0.28	0.19	0.19	0.06	0.06	0.03	0.03	0.04	0.04	0.07	0.07	<0.01	<0.01	<0.01	<0.01
Humpback whale*	1.32	<0.01	1.46	<0.01	0.69	<0.01	0.93	<0.01	3.13	<0.01	1.55	<0.01	0.43	<0.01	0.61	<0.01
Killer whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pilot whale	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Minke whale	0.79	<0.01	0.69	<0.01	0.22	<0.01	0.13	<0.01	0.13	<0.01	0.23	<0.01	0.09	<0.01	0.13	<0.01
North Atlantic right whale*	0.41	<0.01	0.32	<0.01	0.01	<0.01	0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01
Risso's dolphin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sei whale*	0.07	<0.01	0.04	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sperm whale*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Endangered species

Table 38. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with no attenuation.

Species	May		June		July		August		September		October		November		December		*t*>NMFS (min)
	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	NMFS $(L_{p,24hr})$	Wood $(L_{p,24hr})$	
Atlantic spotted dolphin	1.3	0.7	1.7	1	3.7	2.1	4.5	2.5	5.5	3.1	6.3	3.6	5.2	11.6	1	2.2	508.4
Atlantic white sided dolphin	316.7	193.2	295	180	201.7	123.1	109.9	67.1	121	73.8	181.6	110.8	241.4	626.9	318.5	827	25029.6
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	26.1	17.9	92.5	63.5	196.6	134.9	197.7	135.7	210.6	144.6	104.8	71.9	82	233.1	72	204.9	35272.4
Short beaked common dolphin	177.5	98.5	188.8	104.8	176.5	98	250.8	139.3	413.9	229.8	520.7	289.1	600.3	1506.1	1247.2	3129	159010.7
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	15.9	20.6	17.3	22.4	20.8	27	19.9	25.7	17.2	22.3	11.4	14.8	10.7	39.9	11	41	1310.4
Gray seal	255.4	257.1	171.1	172.2	57.7	58	23.5	23.7	34.9	35.1	63	63.4	56.1	217.2	305.9	1184.3	50892.5
Harbor porpoise	249.4	5368.3	15.7	337	10.6	228.7	11.4	246	10.7	229.9	26.4	569.1	234.3	7074.1	226.8	6846.6	47251.7
Harbor seal	223.4	236.4	149.7	158.4	50.4	53.4	20.6	21.8	30.5	32.3	55.1	58.3	58.4	216.3	318.3	1179.3	52827.3
Humpback whale*	10.9	13.6	12	15	5.6	7	7.6	9.5	25.8	32.2	12.7	15.9	4.6	12.4	6.6	17.9	5724.2
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.9	<0.1	8.9	0
Minke whale	27.6	31.7	24.1	27.7	7.9	9	4.4	5.1	4.6	5.3	8.2	9.5	6.3	15.9	8.9	22.5	404.2
North Atlantic right whale*	17.7	23.2	13.9	18.2	0.4	0.5	0.3	0.3	1.8	2.4	<0.1	0.1	0.1	0.3	8.5	31.8	907.1
Risso's dolphin	0.4	0.3	0.4	0.3	1.4	0.9	2	1.3	1.2	0.8	0.4	0.3	1.1	2.8	2.2	5.9	446.3
Sei whale*	1.6	2.1	1	1.4	0.3	0.3	0.2	0.2	0.3	0.4	<0.1	<0.1	0.1	0.3	0.1	0.3	101.4
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 39. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December		$t_{>NMFS}$ (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.7	0.4	0.9	0.5	2	1.1	2.4	1.4	3	1.7	3.5	2	2.6	2.6	0.5	0.5	182.4
Atlantic white sided dolphin	147.9	94.4	137.8	87.9	94.2	60.1	51.3	32.8	56.5	36.1	84.8	54.1	103.8	130.9	136.9	172.7	8414.3
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	10.5	7.8	37.3	27.6	79.2	58.7	79.6	59.1	84.8	62.9	42.2	31.3	31.9	46.3	28	40.6	12690.6
Short beaked common dolphin	75.5	49.2	80.3	52.4	75.1	49	106.7	69.6	176.1	114.8	221.5	144.4	219.6	260.4	456.3	540.9	46941.6
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	7.6	10.8	8.3	11.8	10	14.2	9.5	13.5	8.2	11.7	5.5	7.8	4.6	15.6	4.7	16	477.7
Gray seal	109.1	124.7	73.1	83.5	24.6	28.1	10.1	11.5	14.9	17	26.9	30.7	21.3	62	116.1	338.2	17016.4
Harbor porpoise	117.6	3075.7	7.4	193.1	5	131.1	5.4	141	5	131.7	12.5	326.1	95	5437.6	91.9	5262.7	18427.4
Harbor seal	96.6	114.1	64.7	76.4	21.8	25.7	8.9	10.5	13.2	15.6	23.8	28.1	21.6	60.5	118	330.1	17094.9
Humpback whale*	5.5	7.3	6.1	8.1	2.9	3.8	3.9	5.1	13.1	17.3	6.5	8.5	2.1	5.9	3	8.5	2052.8
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0
Minke whale	15.2	18	13.3	15.8	4.3	5.1	2.4	2.9	2.5	3	4.5	5.4	2.9	9.3	4.2	13.2	155.8
North Atlantic right whale*	8.7	12.3	6.8	9.6	0.2	0.3	0.1	0.2	0.9	1.2	<0.1	<0.1	<0.1	0.1	3.6	12.5	339.3
Risso's dolphin	0.2	0.1	0.2	0.1	0.7	0.4	1	0.7	0.6	0.4	0.2	0.1	0.5	0.6	1	1.3	163.0
Sei whale*	0.8	1.1	0.5	0.7	0.1	0.2	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	0.1	38.5
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 40. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.5	0.3	0.6	0.3	1.4	0.8	1.7	0.9	2.1	1.1	2.4	1.3	1.6	1.3	0.3	0.2	105.4
Atlantic white sided dolphin	103.8	61.2	96.7	57	66.1	39	36	21.2	39.7	23.4	59.5	35.1	60.6	57.7	79.9	76.2	4743.4
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	5.4	4.7	19	16.6	40.4	35.2	40.6	35.4	43.3	37.7	21.5	18.8	13.2	19.8	11.6	17.4	7697.9
Short beaked common dolphin	39.9	28.8	42.4	30.6	39.6	28.6	56.3	40.7	92.9	67.2	116.9	84.5	93.1	120.7	193.3	250.8	19395.6
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.9	7.1	5.3	7.7	6.4	9.3	6.1	8.8	5.3	7.6	3.5	5.1	2.7	7.1	2.8	7.3	279.5
Gray seal	59.9	72.7	40.1	48.7	13.5	16.4	5.5	6.7	8.2	9.9	14.8	17.9	9.5	26.7	51.7	145.5	10510.9
Harbor porpoise	71.2	1867.4	4.5	117.2	3	79.6	3.3	85.6	3	80	7.5	198	49.9	5175	48.3	5008.6	10951.6
Harbor seal	53.4	65.8	35.8	44.1	12.1	14.8	4.9	6.1	7.3	9	13.2	16.2	9.8	26.6	53.5	144.9	10739.3
Humpback whale*	3.6	4.7	4	5.2	1.9	2.5	2.5	3.3	8.5	11.2	4.2	5.5	1.2	2.9	1.8	4.2	1169.2
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	10.1	12.1	8.8	10.5	2.9	3.4	1.6	1.9	1.7	2	3	3.6	1.8	4.1	2.6	5.8	85.5
North Atlantic right whale*	5.7	8	4.5	6.3	0.1	0.2	0.1	0.1	0.6	0.8	<0.1	<0.1	<0.1	0.1	2.1	5.8	195.3
Risso's dolphin	0.1	0.1	0.1	0.1	0.4	0.3	0.7	0.4	0.4	0.2	0.1	0.1	0.3	0.3	0.6	0.6	95.8
Sei whale*	0.5	0.7	0.3	0.5	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	22.6
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 41. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario with 12 dB of attenuation.

Species	May		June		July		August		September		October		November		December		$t_{>NMFS}$ (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.4	0.2	0.5	0.3	1.2	0.6	1.4	0.8	1.8	0.9	2.1	1.1	1.4	0.9	0.3	0.2	81.7
Atlantic white sided dolphin	82.4	48.6	76.7	45.2	52.5	30.9	28.6	16.9	31.5	18.6	47.2	27.8	51.1	36.2	67.5	47.7	3706.0
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	4.3	3.5	15.2	12.4	32.3	26.5	32.5	26.6	34.6	28.3	17.2	14.1	10.6	11.1	9.3	9.8	6210.6
Short beaked common dolphin	32.5	21.1	34.6	22.5	32.3	21	45.9	29.9	75.8	49.3	95.3	62	69.4	74.3	144.1	154.3	12104.3
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.1	5.6	4.5	6.1	5.4	7.4	5.2	7	4.5	6.1	3	4	2.3	5.2	2.4	5.3	215.2
Gray seal	52.4	55.7	35.1	37.3	11.8	12.6	4.8	5.1	7.2	7.6	12.9	13.7	7.9	18.8	42.8	102.5	8173.1
Harbor porpoise	60.3	1475.7	3.8	92.6	2.6	62.9	2.8	67.6	2.6	63.2	6.4	156.4	41	5108.9	39.6	4944.7	8629.1
Harbor seal	44.4	51.3	29.7	34.4	10	11.6	4.1	4.7	6.1	7	10.9	12.7	7.7	18.9	42.1	102.8	8838.1
Humpback whale*	3	3.8	3.4	4.2	1.6	2	2.1	2.7	7.2	9.1	3.6	4.5	1.1	2.1	1.5	3.1	896.7
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	8.7	10.1	7.6	8.8	2.5	2.9	1.4	1.6	1.5	1.7	2.6	3	1.4	2.9	2	4	66.1
North Atlantic right whale*	4.9	6.3	3.9	5	0.1	0.1	0.1	0.1	0.5	0.6	<0.1	<0.1	<0.1	<0.1	1.8	4.1	150.1
Risso's dolphin	0.1	0.1	0.1	0.1	0.4	0.2	0.6	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.5	0.3	74.8
Sei whale*	0.4	0.6	0.3	0.4	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17.9
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 42. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation.

Species	May		June		July		August		September		October		November		December		*t*>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	1.3	0.7	1.7	1	3.8	2.1	4.5	2.5	5.6	3.2	6.5	3.6	5.3	11.7	1	2.2	530.2
Atlantic white sided dolphin	321.9	196.1	299.8	182.6	205	124.9	111.7	68	122.9	74.9	184.5	112.4	244.6	628.5	322.7	829.1	26208.3
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	26.3	17.9	93.1	63.5	197.9	134.9	199.1	135.7	212	144.6	105.5	71.9	82.3	233.3	72.3	205	37481.7
Short beaked common dolphin	180.1	99.5	191.6	105.8	179.1	98.9	254.5	140.6	420	232	528.4	291.8	607.1	1507.2	1261.4	3131.4	165650.1
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	16.1	20.8	17.5	22.6	21.1	27.2	20.1	25.9	17.4	22.4	11.6	14.9	10.8	40	11.1	41.1	1376.5
Gray seal	254.9	257.1	170.8	172.2	57.5	58	23.5	23.7	34.8	35.1	62.9	63.4	56.4	217.3	307.4	1184.8	53456.6
Harbor porpoise	272.8	5734.6	17.1	360	11.6	244.3	12.5	262.8	11.7	245.6	28.9	607.9	236.2	7080.6	228.6	6853	50036.3
Harbor seal	226	237.5	151.4	159.1	51	53.6	20.8	21.9	30.9	32.4	55.7	58.6	58.6	216.5	319.4	1180.5	55795.1
Humpback whale*	11	13.7	12.2	15.2	5.7	7.1	7.7	9.6	26.2	32.5	12.9	16	4.6	12.5	6.7	18	5996.7
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.9	<0.1	8.9	0
Minke whale	27.6	31.5	24.1	27.5	7.9	9	4.4	5.1	4.6	5.2	8.2	9.4	6.4	16	9	22.6	427.0
North Atlantic right whale*	17.9	23.3	14.1	18.3	0.4	0.5	0.3	0.3	1.8	2.4	<0.1	0.1	0.1	0.3	8.6	31.9	951.6
Risso's dolphin	0.4	0.3	0.4	0.3	1.4	0.9	2.1	1.3	1.2	0.8	0.4	0.3	1.1	2.8	2.2	5.9	470.8
Sei whale*	1.6	2.1	1.1	1.4	0.3	0.3	0.2	0.2	0.3	0.4	<0.1	<0.1	0.1	0.3	0.1	0.3	105.9
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 43. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation.

Species	May		June		July		August		September		October		November		December		*t*>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.7	0.4	0.9	0.5	2.1	1.2	2.5	1.4	3.1	1.7	3.5	2	2.6	2.6	0.5	0.5	191.0
Atlantic white sided dolphin	152.5	96.2	142.1	89.6	97.1	61.3	52.9	33.4	58.3	36.8	87.4	55.2	105.7	132	139.4	174.1	8955.8
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	10.6	7.8	37.6	27.7	79.9	58.9	80.4	59.2	85.6	63.1	42.6	31.4	32	46.3	28.1	40.7	13513.1
Short beaked common dolphin	76.1	49.8	81	52.9	75.7	49.5	107.6	70.3	177.5	116	223.3	146	221.3	262	459.9	544.4	49385.3
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	7.8	11	8.5	11.9	10.2	14.4	9.7	13.7	8.4	11.8	5.6	7.9	4.7	15.6	4.8	16	501.0
Gray seal	109.3	124.8	73.2	83.6	24.7	28.2	10.1	11.5	14.9	17	27	30.8	21.4	62.1	116.7	338.6	17660.9
Harbor porpoise	129.3	3285.7	8.1	206.3	5.5	140	5.9	150.6	5.5	140.7	13.7	348.3	96	5442.3	92.9	5267.4	19489.8
Harbor seal	98.2	115	65.8	77.1	22.2	26	9.1	10.6	13.4	15.7	24.2	28.4	21.9	60.7	119.2	330.8	17984.6
Humpback whale*	5.6	7.4	6.2	8.2	2.9	3.8	3.9	5.2	13.4	17.5	6.6	8.6	2.1	5.9	3.1	8.6	2153.5
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	0
Minke whale	15.3	18	13.4	15.7	4.4	5.1	2.5	2.9	2.5	3	4.6	5.4	3	9.3	4.3	13.2	164.4
North Atlantic right whale*	8.8	12.4	6.9	9.7	0.2	0.3	0.1	0.2	0.9	1.3	<0.1	<0.1	<0.1	0.1	3.7	12.5	355.1
Risso's dolphin	0.2	0.1	0.2	0.1	0.7	0.4	1	0.7	0.6	0.4	0.2	0.1	0.5	0.6	1	1.3	171.2
Sei whale*	0.8	1.1	0.5	0.7	0.1	0.2	0.1	0.1	0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	0.1	40.0
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 44. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation.

Species	May		June		July		August		September		October		November		December		t>NMFS (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.5	0.3	0.7	0.4	1.4	0.8	1.7	0.9	2.2	1.2	2.5	1.3	1.6	1.3	0.3	0.2	110.3
Atlantic white sided dolphin	107.1	62.7	99.7	58.4	68.2	39.9	37.2	21.7	40.9	23.9	61.4	35.9	61.7	58.5	81.5	77.2	5069.5
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	5.4	4.7	19.3	16.6	40.9	35.3	41.2	35.5	43.8	37.9	21.8	18.8	13.3	19.9	11.7	17.5	8113.9
Short beaked common dolphin	40.4	29.3	43	31.2	40.2	29.1	57.2	41.4	94.3	68.3	118.7	86	95	122.2	197.4	253.9	21127.5
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	5	7.2	5.5	7.8	6.6	9.4	6.3	9	5.4	7.8	3.6	5.2	2.8	7.2	2.9	7.4	292.5
Gray seal	60.1	72.9	40.3	48.8	13.6	16.4	5.5	6.7	8.2	9.9	14.8	18	9.6	26.8	52.2	145.9	10813.4
Harbor porpoise	78.9	2001.4	5	125.6	3.4	85.3	3.6	91.7	3.4	85.7	8.4	212.2	50.7	5179.2	49.1	5012.7	11613.4
Harbor seal	54.4	66.4	36.5	44.5	12.3	15	5	6.1	7.4	9.1	13.4	16.4	9.9	26.7	54.1	145.3	11190.4
Humpback whale*	3.7	4.8	4.1	5.3	1.9	2.5	2.6	3.4	8.7	11.4	4.3	5.6	1.3	2.9	1.8	4.3	1229.1
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	10.2	12	8.9	10.5	2.9	3.4	1.6	1.9	1.7	2	3	3.6	1.9	4.1	2.6	5.9	89.7
North Atlantic right whale*	5.8	8.1	4.6	6.3	0.1	0.2	0.1	0.1	0.6	0.8	<0.1	<0.1	<0.1	0.1	2.2	5.8	204.1
Risso's dolphin	0.1	0.1	0.1	0.1	0.5	0.3	0.7	0.4	0.4	0.2	0.1	0.1	0.3	0.3	0.6	0.6	100.7
Sei whale*	0.5	0.7	0.3	0.5	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	23.5
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Table 45. The mean number of marine mammals estimated to experience sound levels above Level B exposure criteria (NOAA 2005, Wood et al. 2012) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation.

Species	**May**		**June**		**July**		**August**		**September**		**October**		**November**		**December**		$t_{>NMFS}$ (min)
	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	NMFS ($L_{p,24hr}$)	Wood ($L_{p,24hr}$)	
Atlantic spotted dolphin	0.4	0.2	0.6	0.3	1.2	0.6	1.5	0.8	1.8	1	2.1	1.1	1.4	0.9	0.3	0.2	85.4
Atlantic white sided dolphin	85.9	49.9	80	46.5	54.7	31.8	29.8	17.3	32.8	19.1	49.2	28.6	52.2	36.9	68.9	48.6	3953.2
Mesoplodont beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Blue whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Common bottlenose dolphin	4.3	3.5	15.3	12.5	32.6	26.6	32.8	26.8	34.9	28.5	17.4	14.2	10.7	11.2	9.4	9.8	6504.6
Short beaked common dolphin	32.8	21.6	34.9	23	32.6	21.5	46.4	30.5	76.6	50.3	96.3	63.3	71.5	75.5	148.5	156.9	13615.6
Cuvier's beaked whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Fin whale*	4.3	5.7	4.6	6.2	5.6	7.5	5.3	7.1	4.6	6.2	3.1	4.1	2.4	5.2	2.4	5.3	225.2
Gray seal	52.5	55.8	35.2	37.4	11.8	12.6	4.8	5.1	7.2	7.6	12.9	13.8	7.9	18.9	43	102.9	8397.5
Harbor porpoise	67	1584.2	4.2	99.5	2.9	67.5	3.1	72.6	2.9	67.8	7.1	167.9	41.6	5112.7	40.2	4948.3	9149.0
Harbor seal	45.1	51.9	30.2	34.8	10.2	11.7	4.2	4.8	6.2	7.1	11.1	12.8	7.8	18.9	42.7	103.2	9165.3
Humpback whale*	3.1	3.9	3.5	4.3	1.6	2	2.2	2.7	7.4	9.2	3.7	4.6	1.1	2.2	1.6	3.1	943.0
Killer whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Pilot whale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0
Minke whale	8.8	10.1	7.7	8.8	2.5	2.9	1.4	1.6	1.5	1.7	2.6	3	1.5	2.9	2.1	4.1	69.2
North Atlantic right whale*	5	6.4	3.9	5.1	0.1	0.1	0.1	0.1	0.5	0.7	<0.1	<0.1	<0.1	<0.1	1.9	4.2	157.0
Risso's dolphin	0.1	0.1	0.1	0.1	0.4	0.2	0.6	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.5	0.4	78.6
Sei whale*	0.5	0.6	0.3	0.4	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18.5
Sperm whale*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0

* Endangered species

Behavioral aversion, moving away from loud sounds, was modeled for North Atlantic right whale, harbor porpoise, a species known to avoid pile driving sounds (Tougaard et al. 2009), and humpback whale. For comparison, exposure estimates with aversion for these species are shown in Table 46 for the Maximum Design scenario without a difficult-to-drive pile assuming no attenuation. Details of implementing aversion in JASMINE are provided in Appendix A.

Table 46. Comparison of exposure estimates for humpback whale (September), North Atlantic right whale (May), and harbor porpoise (May) when aversion is included in animal movement models relative to models without aversion.

Species	No attenuation–no aversion				No attenuation–with aversion			
	L_E	L_{pk}	Behavior NMFS ($L_{p,24hr}$)	Behavior Wood ($L_{p,24hr}$)	L_E	L_{pk}	Behavior NMFS ($L_{p,24hr}$)	Behavior Wood ($L_{p,24hr}$)
Humpback whale*	20.52	0.12	25.1	31.7	12.44	<0.01	16.59	26.99
North Atlantic right whale*	5.16	0.09	17.6	23.2	0.82	<0.01	11.62	19.36
Harbor porpoise	26.67	20.46	249.7	5468.6	0.39	2.33	39.23	4275.90

* Endangered species

4. Acoustic Exposure Estimation–Sea Turtles

Sea turtles are also found near the SFWF area and may be affected by pile driving sounds. Relative to marine mammals, less is understood about sea turtle hearing and how sound may affect them. The mechanisms of impacts, however, are expected to be the same as marine mammals or fish (Popper et al. 2014). For this study the acoustic analysis for sea turtles follows the same approach that was used for marine mammals (Section 3), except that no frequency weighting is used for sea turtles.

4.1. Species that May be Present in the SFWF

All four species of sea turtles that may occur near the SFWF—loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*)—are listed as threatened or endangered. While many species of sea turtle prefer coastal waters, loggerhead and leatherback sea turtles are known to occupy deeper water habitats and are considered common during summer and fall in the SFWF area. Kemp's ridley turtles are also thought to be regular visitors during those seasons.

4.1.1. Density Estimates

Sea turtles generally prefer warmer water, so their presence near the SFWF area is limited mainly to summer and fall (Hawkes et al. 2007, Dodge et al. 2014, DoN, 2017). In the New York Bight, Normandeau and APEM (2016, 2018) conducted aerial surveys for sea turtles in 2016 and 2017 using high-resolution photography to aid in species identification. By an order of magnitude, the most commonly identified turtles were loggerhead sea turtles. North of the SFWF, sea turtles were most commonly observed in summer and fall, absent in winter, and nearly absent in spring (Kraus et al. 2016).

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, 2007, DoN, 2012). These numbers were adjusted by data from the Sea Mammal Research Unit (SMRU, 2013), available in the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (Halpin et al. 2009). These data are summarized seasonally (winter, spring, summer, and fall) and provided as a range of potential densities per square kilometer within each grid square. The sea turtle densities used in animal movement modeling are listed in Table 47.

Table 47. Sea turtle density estimates for the South Fork Wind Farm (SFWF). Density estimates are derived from SERDP-SDSS NODE database (density estimate from http://seamap.env.duke.edu/serdp).

Common name	Density (animals/km^2 [0.386 miles^2])			
	Spring	Summer	Fall	Winter
Kemp's ridley sea turtle	9.25E-03	9.25E-03	9.25E-03	9.25E-03
Leatherback sea turtle	5.88E-03	0.011	5.88E-03	5.88E-03
Loggerhead sea turtle	0.035	0.038	0.035	0.035

4.2. Acoustic Criteria–Injury and Behavior

Few data are available to inform thresholds for impacts to sea turtles from exposure to sound generated during pile driving activities. NOAA has not established formal acoustic thresholds for behavioral harassment or injury for sea turtles. The ANSI-accredited report by Popper et al. (2014) follows a similar approach as Southall et al. (2007) in suggesting the dual criteria of peak pressure and accumulated sound energy for evaluating potential injury. Both BOEM and NMFS have adopted the following thresholds based on the literature:

- Level A: 210 dB cumulative sound exposure level (L_E), or greater than 207 dB peak sound level (L_{pk}) (Popper et al. 2014).
- Level B: 175 dB re 1 µPa rms (L_p) (Blackstock et al. 2017).

These thresholds were developed based on NMFS criteria for marine mammals of 180 dB rms re 1 µPa for Level A harassment (prior to NMFS (2018)), and refined by the results of McCauley et al. (2000). Level B thresholds were developed by the U.S. Navy (Blackstock et al. 2017). Popper et al. (2014) did not define sound levels that may result in behavioral response but indicated a high likelihood of response near an impulsive source (tens of meters), moderate response at intermediate ranges (hundreds of meters), and low response far from the source (thousands of meters) (Popper et al. 2014). The NMFS criteria (SPL of 180 dB re 1 µPa), the Popper et al. (2014) criteria, and the Blackstock et al. (2017) Navy criteria were evaluated in this analysis.

Noise from pile driving may cause temporary, localized displacement of sea turtles. McCauley et al. (2000) suggest that sea turtles display behavior indicative of avoidance within 1 km (0.62 miles) of an operating seismic vessel. Above SPL 175 dB re 1µPa, McCauley et al. (2000) described sea turtle behavior as erratic, suggesting that they were agitated. They suggested that, because they observed increasing swimming behavior with increasing received sound level, the 175 dB re 1µPa rms indicated the point at which sea turtles would exhibit avoidance behavior. Acoustic measurements during pile-driving events in the construction of the Block Island Wind Farm measured peak pressure levels of 188 dB at 500 m (1,640 ft) from the source (Miller and Potty 2017). It is likely that sea turtles would avoid this area if they exhibit similar behavioral patterns to those observed by McCauley et al. (2000).

4.3. Predicted Sound Fields

Sound fields were predicted for sea turtles in the same way as they were predicted for marine mammals (Section 3.3 and Denes et al. 2018). Though not used for estimating exposures, the ranges to Level A and Level B exposure criteria for sea turtles for monopile installation were calculated using the same methods as those used for marine mammals (Section 3.3). Table 48 provides a summary of radial ranges estimated for the 10.97 m (36 ft) monopile foundations. The values were calculated as the mean of the two modeled sites using the hammer and hammer energy combination producing the largest radial distance. A more detailed description is found in(Denes et al. 2018).

Table 48. Ranges ($R_{95\%}$ in meters) to thresholds for sea turtles in summer (NMFS and NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) due to impact hammering of a 10.97 m (36 ft) pile in summer in 24 hours, using an IHC S-4000 hammer with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation.

Impact	Metric	Threshold (dB)	No attenuation	6 dB	10 dB	12 dB
Mortality and Potential Mortal Injury	$L_{E,24hr}$	210	1,923	878	440	293
	L_{pk}	207	633	226	115	87
Behavioral Response	L_p	175	3,190	2,250	1,660	1,300

Table 49. Ranges ($R_{95\%}$ in meters) to thresholds for sea turtles in winter (NMFS and NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) due to impact hammering of a 10.97 m (36 ft) pile in winter in 24 hours, using an IHC S-4000 hammer with no attenuation, 6 dB, 10 dB, and 12 dB sound attenuation.

Impact	Metric	Threshold (dB)	No attenuation	6 dB	10 dB	12 dB
Mortality and Potential Mortal Injury	$L_{E,24hr}$	210	2,021	899	453	289
	L_{pk}	207	633	226	115	87
Behavioral Response	L_p	175	3,354	2,316	1,710	1,344

4.4. Animal Movement and Exposure Modeling

The same animal movement modeling and exposure estimate procedures were used for sea turtles as were used for marine mammals (Section 3.4 and Appendix A). Movement parameters specific to the sea turtle species are shown in Appendix A. Sea turtle animat exposure probabilities were adjusted by the species' real-world density provided in Table 47, to obtain the mean number of individual sea turtles expected to exceed acoustic criteria. The following sections show the sea turtle exposure estimates for the Maximum Design Scenario (Section 4.4.1) and the Most Likely Scenario (Section 4.4.2).

4.4.1. Maximum Design Scenario (six piles per week)

Similar to the marine mammals, Table 50 shows the mean number of individual sea turtles expected to receive sound levels exceeding the Level A exposure criteria (NOAA 2005, Popper et al. 2014) for the entire project (construction period May to December) for the Maximum Design scenario (Table 2). The mean number of individual sea turtles predicted to receive sound levels exceeding the Level A criteria were estimated with no attenuation, and then with the sound fields attenuated by 6 dB (Table 51), 10 dB (Table 52), and 12 dB (Table 53). Tables 54–57 shows similar results for the Maximum Design scenario, except it includes one difficult-to-drive pile that requires a total of 8,000 hammer strikes instead of 4,500 (Table 1). Tables 58–61 show the mean number of individual sea turtles expected to receive sound levels exceeding the Level B exposure criteria (NOAA 2005, Blackstock et al. 2017) for the entire project (May to December) for the Maximum Design scenario, and the total time, in minutes, above the NOAA 2005 threshold of SPL 175 dB re 1 µPa with different levels of attenuation assumed. Tables 62–65 show similar Level B results for the Maximum Design scenario with one difficult-to-drive pile.

Table 50. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with no attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	3.68	0.38	0.71	3.68	0.38	0.71	3.68	0.38	0.71	3.68	0.38	0.71	3.68	0.38	0.71	3.68	0.38	0.71	3.26	0.33	0.66	3.26	0.33	0.66
Leatherback turtle*	2.34	0.15	0.61	4.38	0.27	1.15	4.38	0.27	1.15	4.38	0.27	1.15	2.34	0.15	0.61	2.34	0.15	0.61	2.08	0.06	0.35	2.08	0.06	0.35
Loggerhead turtle	13.04	1.79	2.86	14.07	1.93	3.08	14.07	1.93	3.08	14.07	1.93	3.08	13.04	1.79	2.86	13.04	1.79	2.86	15	2.32	3.39	15	2.32	3.39

* Endangered species

Table 51. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	1.27	<0.01	0.19	1.27	<0.01	0.19	1.27	<0.01	0.19	1.27	<0.01	0.19	1.27	<0.01	0.19	1.27	<0.01	0.19	1.56	0.14	0.28	1.56	0.14	0.28
Leatherback turtle*	1.08	<0.01	0.09	2.02	<0.01	0.16	2.02	<0.01	0.16	2.02	<0.01	0.16	1.08	<0.01	0.09	1.08	<0.01	0.09	0.97	<0.01	0.09	0.97	<0.01	0.09
Loggerhead turtle	6.07	<0.01	1.25	6.55	<0.01	1.35	6.55	<0.01	1.35	6.55	<0.01	1.35	6.07	<0.01	1.25	6.07	<0.01	1.25	6.25	0.54	1.61	6.25	0.54	1.61

* Endangered species

Table 52. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.61	0.05	0.19	0.61	0.05	0.19
Leatherback turtle*	0.47	<0.01	0.03	0.88	<0.01	0.05	0.88	<0.01	0.05	0.88	<0.01	0.05	0.47	<0.01	0.03	0.47	<0.01	0.03	0.32	<0.01	0.03	0.32	<0.01	0.03
Loggerhead turtle	2.86	<0.01	0.18	3.08	<0.01	0.19	3.08	<0.01	0.19	3.08	<0.01	0.19	2.86	<0.01	0.18	2.86	<0.01	0.18	3.04	0.54	0.89	3.04	0.54	0.89

* Endangered species

Table 53. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.47	<0.01	<0.01	0.47	<0.01	<0.01	0.47	<0.01	<0.01	0.47	<0.01	<0.01	0.47	<0.01	<0.01	0.47	<0.01	<0.01	0.47	0.05	0.19	0.47	0.05	0.19
Leatherback turtle*	0.32	<0.01	0.03	0.6	<0.01	0.05	0.6	<0.01	0.05	0.6	<0.01	0.05	0.32	<0.01	0.03	0.32	<0.01	0.03	0.18	<0.01	0.03	0.18	<0.01	0.03
Loggerhead turtle	1.96	<0.01	0.18	2.12	<0.01	0.19	2.12	<0.01	0.19	2.12	<0.01	0.19	1.96	<0.01	0.18	1.96	<0.01	0.18	2.14	0.36	0.89	2.14	0.36	0.89

* Endangered species

Table 54. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with no attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	3.69	0.39	0.72	3.69	0.39	0.72	3.69	0.39	0.72	3.69	0.39	0.72	3.69	0.39	0.72	3.69	0.39	0.72	3.31	0.36	0.68	3.31	0.36	0.68
Leatherback turtle*	2.39	0.16	0.64	4.48	0.29	1.19	4.48	0.29	1.19	4.48	0.29	1.19	2.39	0.16	0.64	2.39	0.16	0.64	2.16	0.1	0.4	2.16	0.1	0.4
Loggerhead turtle	13.43	1.86	3.05	14.49	2.01	3.29	14.49	2.01	3.29	14.49	2.01	3.29	13.43	1.86	3.05	13.43	1.86	3.05	15.1	2.43	3.43	15.1	2.43	3.43

* Endangered species

Table 55. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 6 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	1.31	<0.01	0.19	1.31	<0.01	0.19	1.31	<0.01	0.19	1.31	<0.01	0.19	1.31	<0.01	0.19	1.31	<0.01	0.19	1.59	0.14	0.28	1.59	0.14	0.28
Leatherback turtle*	1.12	<0.01	0.1	2.09	0.01	0.18	2.09	0.01	0.18	2.09	0.01	0.18	1.12	<0.01	0.1	1.12	<0.01	0.1	1.02	0.01	0.11	1.02	0.01	0.11
Loggerhead turtle	6.36	0.02	1.27	6.87	0.02	1.37	6.87	0.02	1.37	6.87	0.02	1.37	6.36	0.02	1.27	6.36	0.02	1.27	6.31	0.57	1.69	6.31	0.57	1.69

* Endangered species

Table 56. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 10 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.63	0.05	0.18	0.63	0.05	0.18
Leatherback turtle*	0.48	<0.01	0.03	0.9	<0.01	0.06	0.9	<0.01	0.06	0.9	<0.01	0.06	0.48	<0.01	0.03	0.48	<0.01	0.03	0.37	0.01	0.05	0.37	0.01	0.05
Loggerhead turtle	2.95	<0.01	0.18	3.18	<0.01	0.2	3.18	<0.01	0.2	3.18	<0.01	0.2	2.95	<0.01	0.18	2.95	<0.01	0.18	3.13	0.54	0.9	3.13	0.54	0.9

* Endangered species

Table 57. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 12 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.48	<0.01	<0.01	0.48	<0.01	<0.01	0.48	<0.01	<0.01	0.48	<0.01	<0.01	0.48	<0.01	<0.01	0.48	<0.01	<0.01	0.49	0.05	0.18	0.49	0.05	0.18
Leatherback turtle*	0.32	<0.01	0.03	0.61	<0.01	0.06	0.61	<0.01	0.06	0.61	<0.01	0.06	0.32	<0.01	0.03	0.32	<0.01	0.03	0.22	0.01	0.05	0.22	0.01	0.05
Loggerhead turtle	2.01	<0.01	0.18	2.17	<0.01	0.2	2.17	<0.01	0.2	2.17	<0.01	0.2	2.01	<0.01	0.18	2.01	<0.01	0.18	2.24	0.35	0.9	2.24	0.35	0.9

* Endangered species

Table 58. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with no attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	6.1	6.1	6.1	6.1	6.1	6.1	6	6	2762.4
Leatherback turtle*	3.9	7.2	7.2	7.2	3.9	3.9	3.8	3.8	2560.2
Loggerhead turtle	21.1	22.7	22.7	22.7	21.1	21.1	24.8	24.8	11614.1

* Endangered species

Table 59. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 6 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	3.2	3.2	3.2	3.2	3.2	3.2	3	3	1169.0
Leatherback turtle*	2.1	3.9	3.9	3.9	2.1	2.1	2	2	1277.5
Loggerhead turtle	12.1	13.1	13.1	13.1	12.1	12.1	13.6	13.6	4768.7

* Endangered species

Table 60. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 10 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	677.0
Leatherback turtle*	1.3	2.5	2.5	2.5	1.3	1.3	1.1	1.1	762.6
Loggerhead turtle	6.8	7.3	7.3	7.3	6.8	6.8	7.5	7.5	2913.9

* Endangered species

Table 61. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario with 12 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	503.1
Leatherback turtle*	1	1.9	1.9	1.9	1	1	0.8	0.8	561.2
Loggerhead turtle	5	5.4	5.4	5.4	5	5	4.8	4.8	2260.4

* Endangered species

Table 62. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with no attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	6.2	6.2	6.2	6.2	6.2	6.2	6.1	6.1	2916.0
Leatherback turtle*	3.9	7.4	7.4	7.4	3.9	3.9	3.9	3.9	2697.3
Loggerhead turtle	21.6	23.4	23.4	23.4	21.6	21.6	25.1	25.1	12240.5

* Endangered species

Table 63. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 6 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	3.2	3.2	3.2	3.2	3.2	3.2	3	3	1222.9
Leatherback turtle*	2.1	4	4	4	2.1	2.1	2	2	1333.3
Loggerhead turtle	12.4	13.4	13.4	13.4	12.4	12.4	13.7	13.7	4971.1

* Endangered species

Table 64. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 10 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	708.9
Leatherback turtle*	1.4	2.6	2.6	2.6	1.4	1.4	1.2	1.2	798.5
Loggerhead turtle	7.1	7.7	7.7	7.7	7.1	7.1	7.5	7.5	3076.7

* Endangered species

Table 65. The mean number of sea turtles estimated to experience sound levels above Level B behavioral criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Maximum Design scenario, with one difficult to drive pile with 12 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	526.8
Leatherback turtle*	1	1.9	1.9	1.9	1	1	0.8	0.8	588.2
Loggerhead turtle	5.3	5.7	5.7	5.7	5.3	5.3	4.9	4.9	2395.7

* Endangered species

4.4.2. Most Likely Scenario (piling every other day)

The same type of information as the Maximum Design scenario (Section 4.4.1) is shown in Tables 66–81 for the Most Likely scenario. Table 66 shows the mean number of individual sea turtles expected to receive sound levels exceeding the Level A exposure criteria (NOAA 2005, Popper et al. 2014) for the entire project (construction period May to December) for the Most Likely scenario (Table 2), including estimates with no attenuation, and then with the sound fields attenuated by 6 dB, 10 dB, and 12 dB in the following tables. Table 70 shows Level A exposure estimates for the Most Likely scenario with one difficult-to-drive pile (Table 1) and no attenuation, and then with the sound fields attenuated by 6 dB, 10 dB, and 12 dB in the following tables. Tables 78–81 show the mean number of individual sea turtles expected to receive sound levels exceeding the Level B exposure criteria (NOAA 2005, Blackstock et al. 2017) for the Most Likely scenario, including the total time, in minutes, above the NOAA 2005 threshold of SPL 175 dB re 1 µPa with no attenuation, 6 dB of attenuation, 10 dB of attenuation, and 12 dB of attenuation.

Table 66. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with no attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	3.68	0.28	1.04	3.68	0.28	1.04	3.68	0.28	1.04	3.68	0.28	1.04	3.68	0.28	1.04	3.68	0.28	1.04	3.21	0.38	0.47	3.21	0.38	0.47
Leatherback turtle*	2.22	0.12	0.41	4.16	0.22	0.77	4.16	0.22	0.77	4.16	0.22	0.77	2.22	0.12	0.41	2.22	0.12	0.41	2.98	0.12	0.7	2.98	0.12	0.7
Loggerhead turtle	13.21	1.43	2.86	14.26	1.54	3.08	14.26	1.54	3.08	14.26	1.54	3.08	13.21	1.43	2.86	13.21	1.43	2.86	15	2.14	3.21	15	2.14	3.21

* Endangered species

Table 67. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 6 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	1.61	<0.01	0.09	1.61	<0.01	0.09	1.61	<0.01	0.09	1.61	<0.01	0.09	1.61	<0.01	0.09	1.61	<0.01	0.09	1.32	0.09	0.28	1.32	0.09	0.28
Leatherback turtle*	0.82	<0.01	0.06	1.53	<0.01	0.11	1.53	<0.01	0.11	1.53	<0.01	0.11	0.82	<0.01	0.06	0.82	<0.01	0.06	1.52	<0.01	0.18	1.52	<0.01	0.18
Loggerhead turtle	6.07	<0.01	0.71	6.55	<0.01	0.77	6.55	<0.01	0.77	6.55	<0.01	0.77	6.07	<0.01	0.71	6.07	<0.01	0.71	5.36	0.36	1.07	5.36	0.36	1.07

* Endangered species

Table 68. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 10 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.76	<0.01	<0.01	0.76	<0.01	<0.01	0.76	<0.01	<0.01	0.76	<0.01	<0.01	0.76	<0.01	<0.01	0.76	<0.01	<0.01	0.66	<0.01	0.09	0.66	<0.01	0.09
Leatherback turtle*	0.35	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.66	<0.01	<0.01	0.35	<0.01	<0.01	0.35	<0.01	<0.01	0.59	<0.01	0.06	0.59	<0.01	0.06
Loggerhead turtle	2.14	<0.01	0.36	2.31	<0.01	0.39	2.31	<0.01	0.39	2.31	<0.01	0.39	2.14	<0.01	0.36	2.14	<0.01	0.36	2.86	0.36	0.36	2.86	0.36	0.36

* Endangered species

Table 69. The mean number of sea turtles estimated to experience sound levels above Level A criteria (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario with 12 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.38	<0.01	0.09	0.38	<0.01	0.09
Leatherback turtle*	0.18	<0.01	<0.01	0.33	<0.01	<0.01	0.33	<0.01	<0.01	0.33	<0.01	<0.01	0.18	<0.01	<0.01	0.18	<0.01	<0.01	0.41	<0.01	0.06	0.41	<0.01	0.06
Loggerhead turtle	1.43	<0.01	0.36	1.54	<0.01	0.39	1.54	<0.01	0.39	1.54	<0.01	0.39	1.43	<0.01	0.36	1.43	<0.01	0.36	2.5	<0.01	0.36	2.5	<0.01	0.36

* Endangered species

Table 70. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	3.69	0.31	1.03	3.69	0.31	1.03	3.69	0.31	1.03	3.69	0.31	1.03	3.69	0.31	1.03	3.69	0.31	1.03	3.26	0.4	0.5	3.26	0.4	0.5
Leatherback turtle*	2.29	0.13	0.44	4.27	0.24	0.83	4.27	0.24	0.83	4.27	0.24	0.83	2.29	0.13	0.44	2.29	0.13	0.44	3.01	0.16	0.73	3.01	0.16	0.73
Loggerhead turtle	13.59	1.52	3.05	14.67	1.64	3.29	14.67	1.64	3.29	14.67	1.64	3.29	13.59	1.52	3.05	13.59	1.52	3.05	15.1	2.26	3.26	15.1	2.26	3.26

* Endangered species

Table 71. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	1.62	<0.01	0.11	1.62	<0.01	0.11	1.62	<0.01	0.11	1.62	<0.01	0.11	1.62	<0.01	0.11	1.62	<0.01	0.11	1.37	0.09	0.28	1.37	0.09	0.28
Leatherback turtle*	0.87	<0.01	0.07	1.63	0.01	0.13	1.63	0.01	0.13	1.63	0.01	0.13	0.87	<0.01	0.07	0.87	<0.01	0.07	1.54	0.01	0.19	1.54	0.01	0.19
Loggerhead turtle	6.36	0.02	0.77	6.87	0.02	0.83	6.87	0.02	0.83	6.87	0.02	0.83	6.36	0.02	0.77	6.36	0.02	0.77	5.47	0.4	1.19	5.47	0.4	1.19

* Endangered species

Table 72. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.75	<0.01	<0.01	0.75	<0.01	<0.01	0.75	<0.01	<0.01	0.75	<0.01	<0.01	0.75	<0.01	<0.01	0.75	<0.01	<0.01	0.68	<0.01	0.09	0.68	<0.01	0.09
Leatherback turtle*	0.37	<0.01	0.01	0.69	<0.01	0.01	0.69	<0.01	0.01	0.69	<0.01	0.01	0.37	<0.01	0.01	0.37	<0.01	0.01	0.61	0.01	0.07	0.61	0.01	0.07
Loggerhead turtle	2.28	<0.01	0.35	2.46	<0.01	0.38	2.46	<0.01	0.38	2.46	<0.01	0.38	2.28	<0.01	0.35	2.28	<0.01	0.35	2.96	0.37	0.4	2.96	0.37	0.4

* Endangered species

Table 73. The mean number of sea turtles estimated to experience sound levels above Level A (NOAA 2005, Popper et al. 2014) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation.

Species	May			June			July			August			September			October			November			December		
	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}	L_p	L_E	L_{pk}
Kemp's ridley turtle*	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.57	<0.01	<0.01	0.4	<0.01	0.09	0.4	<0.01	0.09
Leatherback turtle*	0.19	<0.01	0.01	0.35	<0.01	0.01	0.35	<0.01	0.01	0.35	<0.01	0.01	0.19	<0.01	0.01	0.19	<0.01	0.01	0.44	0.01	0.07	0.44	0.01	0.07
Loggerhead turtle	1.51	<0.01	0.35	1.63	<0.01	0.38	1.63	<0.01	0.38	1.63	<0.01	0.38	1.51	<0.01	0.35	1.51	<0.01	0.35	2.58	0.02	0.4	2.58	0.02	0.4

* Endangered species

Table 74. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with no attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	6.9	6.9	6.9	6.9	6.9	6.9	6.4	6.4	2872.7
Leatherback turtle*	3.7	6.9	6.9	6.9	3.7	3.7	4.4	4.4	2639.1
Loggerhead turtle	23.9	25.8	25.8	25.8	23.9	23.9	27.1	27.1	12158.5

* Endangered species

Table 75. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 6 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	3.2	3.2	3.2	3.2	3.2	3.2	3.1	3.1	1188.5
Leatherback turtle*	2	3.7	3.7	3.7	2	2	2.8	2.8	1181.1
Loggerhead turtle	11.4	12.3	12.3	12.3	11.4	11.4	12.9	12.9	5061.7

* Endangered species

Table 76. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 10 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	2.2	2.2	2.2	2.2	2.2	2.2	1.5	1.5	690.4
Leatherback turtle*	1.1	2	2	2	1.1	1.1	1.7	1.7	679.3
Loggerhead turtle	7.5	8.1	8.1	8.1	7.5	7.5	6.1	6.1	3004.8

* Endangered species

Table 77. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario with 12 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.3	1.3	1.3	1.3	1.3	1.3	1.1	1.1	518.3
Leatherback turtle*	0.8	1.4	1.4	1.4	0.8	0.8	1.3	1.3	481.4
Loggerhead turtle	5	5.4	5.4	5.4	5	5	5	5	2385.5

* Endangered species

Table 78. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with no attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	6.9	6.9	6.9	6.9	6.9	6.9	6.5	6.5	3019.4
Leatherback turtle*	3.8	7	7	7	3.8	3.8	4.4	4.4	2771.3
Loggerhead turtle	24.3	26.3	26.3	26.3	24.3	24.3	27.3	27.3	12750.8

* Endangered species

Table 79. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 6 dB of attenuation.

Species	May	June	July	August	September	October	November	December	t>NMFS (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	1240.6
Leatherback turtle*	2.1	3.8	3.8	3.8	2.1	2.1	2.8	2.8	1243.0
Loggerhead turtle	11.8	12.7	12.7	12.7	11.8	11.8	13	13	5245.7

* Endangered species

Table 80. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 10 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	2.2	2.2	2.2	2.2	2.2	2.2	1.6	1.6	708.4
Leatherback turtle*	1.1	2.1	2.1	2.1	1.1	1.1	1.7	1.7	720.4
Loggerhead turtle	7.8	8.4	8.4	8.4	7.8	7.8	6.2	6.2	3172.0

* Endangered species

Table 81. The mean number of sea turtles estimated to experience sound levels above Level B criteria (NOAA 2005, Popper et al. 2014, Blackstock et al. 2017) in the SFWF area for the Most Likely scenario, with one difficult to drive pile with 12 dB of attenuation.

Species	May	June	July	August	September	October	November	December	$t_{>NMFS}$ (min)
	L_p	L_p	L_p	L_p	L_p	L_p	L_p	L_p	
Kemp's ridley turtle*	1.3	1.3	1.3	1.3	1.3	1.3	1.1	1.1	533.1
Leatherback turtle*	0.8	1.5	1.5	1.5	0.8	0.8	1.4	1.4	513.3
Loggerhead turtle	5.3	5.7	5.7	5.7	5.3	5.3	5.1	5.1	2513.0

* Endangered species

5. Discussion

The mean numbers of marine mammals and sea turtles expected to receive sound levels resulting in injury or behavioral disruption were determined for species that may be present in the SFWF area during installation of monopile foundations. The exposure estimates for a Maximum Design scenario (marine mammals in Tables 14–29 and sea turtles in Tables 50–65) and a Most Likely scenario (marine mammals in Tables 30–45 and sea turtles in Tables 66–81) were found to be similar. This indicates there is little difference in impacts if one monopile foundation is installed each day versus every other day. The rare case where one of the foundation piles is difficult to install, requiring 8,000 strikes instead of 4,500 strikes, generally resulted in an increase in Level A exposure estimates (less than 5% for LF cetaceans and phocid seals and 25% for HF cetaceans). The behavioral response of animals avoiding loud sounds (aversion) produced during pile driving was also investigated for North Atlantic right whales, harbor porpoises, and humpback whales (Table 46). It was found that aversive behavior could result in substantial decreases in the exposure estimates, particularly for Level A (injury). Aversion is thought to be a common in marine mammals (Ellison et al. 2012), so the exposure estimates that do not include aversion are likely conservative.

Literature Cited

[DoN] Department of the Navy. 2007. *Navy OPAREA Density Estimate (NODE) for the Gulf of Mexico*. Report prepared by Geo-Marine, Inc. for the Department of the Navy, U.S. Fleet Forces Command. Contract #N62470-02 D-9997, CTO 0030. http://seamap.env.duke.edu/seamap2/downloads/resources/serdp/Gulf%20of%20Mexico%20NODE%20Final%20Report.pdf.

[DoN] Department of the Navy. 2012. *Commander Task Force 20, 4th, and 6th Fleet Navy marine species density database*. Technical report for Naval Facilities Engineering Command Atlantic, Norfolk, VA.

[DoN] Department of the Navy. 2017. *U.S. Navy marine species density database phase III for the Atlantic Fleet training and testing study area. NAVFAC Atlantic Final Technical Report*. Naval Facilities Engineering Command Atlantic, Norfolk, VA.

[HESS] High Energy Seismic Survey. 1999. *High Energy Seismic Survey Review Process and Interim Operational Guidelines for Marine Surveys Offshore Southern California*. Prepared for the California State Lands Commission and the United States Minerals Management Service Pacific Outer Continental Shelf Region by the High Energy Seismic Survey Team, Camarillo, CA. 98 pp.

[ISO] International Organization for Standardization. 2017. *ISO 18405:2017. Underwater Acoustics – Terminology*. Geneva. https://www.iso.org/standard/62406.html.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2011a. *Preliminary summer 2010 regional abundance estimate of loggerhead turtles (Caretta caretta) in northwestern Atlantic Ocean continental shelf waters*. *In*: U.S. Department of Commerce, N.F.S.C.R.D.-A. https://www.nefsc.noaa.gov/publications/crd/crd1103/1103.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2011b. *2010 Annual report to the inter-agency agreement M10PG00075/0001: A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/Final_2010AnnualReportAMAPPS_19Apr2011.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2011c. *2011 Annual report to the inter-agency agreement M10PG00075/0001: A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2011_annual_report_final_BOEM.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2012. *2012 Annual report to the inter-agency agreement M10PG00075/0001: A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2012_annual_report_FINAL.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2013. *Annual report to the inter-agency agreement M10PG00075/0001: A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean*.

https://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2013_annual_report_FINAL3.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2014. *2014 Annual report to the inter-agency agreement M10PG00075/0001: A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2014_annual_report_Final.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2015. *Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/NMFS_AMAPPS_2015_annual_report_Final.pdf.

[NEFSC] Northeast Fisheries Science Center and [SEFSC] Southeast Fisheries Science Center. 2016. *Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean – AMAPPS II*. https://www.nefsc.noaa.gov/psb/AMAPPS/docs/Annual%20Report%20of%202016%20AMAPPS_final.pdf.

[NMFS] National Marine Fisheries Service and [NOAA] National Oceanic and Atmospheric Administration. 2005. Endangered fish and wildlife: Notice of intent to prepare an environmental impact statement. *Federal Register* 70(7): 1871-1875. http://www.nmfs.noaa.gov/pr/pdfs/fr/fr70-1871.pdf.

[NMFS] National Marine Fisheries Service. 2016. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55. 178 pp.

[NMFS] National Marine Fisheries Service. 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 pp. https://www.fisheries.noaa.gov/webdam/download/75962998.

[SMRU] Sea Mammal Research Unit. 2013. *Supporting documentation for predicted density data*.

Acevedo-Gutierrez, A., D.A. Croll, and B.R. Tershy. 2002. High feeding cost limit dive time in the largest whales. *The Journal of Experimental Biology* 205: 1747-1753.

Acevedo-Gutiérrez, A., D.A. Croll, and B.R. Tershy. 2002. High feeding costs limit dive time in the largest whales. *Journal of Experimental Biology* 205(12): 1747-1753.

Alves, F., A. Dinis, I. Cascão, and L. Freitas. 2010. Bryde's whale (*Balaenoptera brydei*) stable associations and dive profiles: New insights into foraging behavior. *Marine Mammal Science* 26(1): 202-212. https://doi.org/10.1111/j.1748-7692.2009.00333.x.

Amano, M. and M. Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. *Marine Ecology Progress Series* 258: 291-295.

ANSI S1.1-2013. R2013. *American National Standard Acoustical Terminology*. American National Standards Institute, New York.

Aoki, K., M. Amano, M. Yoshioka, K. Mori, D. Tokuda, and N. Miyazaki. 2007. Diel diving behavior of sperm whales off Japan. *Marine Ecology Progress Series* 349: 277-287. https://doi.org/10.3354/meps07068.

Au, D. and W. Perryman. 1982. Movement and speed of dolphin schools responding to an approaching ship. *Fishery Bulletin* 80(2): 371-379. https://www.st.nmfs.noaa.gov/spo/FishBull/80-2/au.pdf.

Au, W.W.L. and M.C. Hastings. 2008. *Principles of Marine Bioacoustics*. Springer. 510. https://doi.org/10.1007/978-0-387-78365-9.

Baird, R.W. 1994. *Foraging behaviour and ecology of transient killer whales (Orcinus orca)*. Ph.D. Thesis. Simon Fraser University, Burnaby, BC.

Baird, R.W., J.F. Borsani, M.B. Hanson, and P.L. Tyack. 2002. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. *Marine Ecology Progress Series* 237: 301-305.

Baird, R.W., G.S. Shorr, D.J. Websater, D.J. McSweeney, and S.D. Mahaffy. 2006a. *Studies of beaked whale diving behavior and odontocete stock structure in Hawai'i in March/April 2006*. Report to Cascadia Research Collective, Olympia, WA from the Southwest Fisheries Science Center, National Marine Fisheries Service. 30 pp.

Baird, R.W., D.L. Webster, D.J. McSweeney, A.D. Ligon, G.S. Schorr, and J. Barlow. 2006b. Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i. *Canadian Journal of Zoology* 84(8): 1120-1128. http://dx.doi.org/10.1139/z06-095.

Baugmartner, M.F. and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. *Marine Ecology Progress Series* 264: 123-135.

Baumgartner, M.F. and B.R. Mate. 2005. Summer and fall habitat of North Atlantic right whales (*Eubalaena glacialis*) inferred from satellite telemetry. *Canadian Journal of Fisheries and Aquatic Sciences* 62(3): 527-543. https://doi.org/10.1139/f04-238.

Bearzi, G., R.R. Reeves, E. Remonato, N. Pierantonio, and S. Airoldi. 2011. Risso's dolphin *Grampus griseus* in the Mediterranean Sea. *Mammalian Biology* 76(4): 385-400. https://doi.org/10.1016/j.mambio.2010.06.003.

Beck, C.A., W.D. Bowen, J.I. McMillan, and S.J. Iverson. 2003. Sex differences in the diving behaviour of a size-dimorphic capital breeder: The grey seal. *Animal Behaviour* 66(4): 777-790. https://doi.org/10.1006/anbe.2003.2284.

Bentivegna, F. 2002. Intra-Mediterranean migrations of loggerhead sea turtles (*Caretta caretta*) monitored by satellite telemetry. *Marine Biology* 141: 795-800.

Blackstock, S.A., J.O. Fayton, P.H. Hulton, T.E. Moll, K.K. Jenkins, S. Kotecki, E. Henderson, S. Rider, C. Martin, et al. 2017. *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing*. Naval Undersea Warfare Center Division, Newport United States.

Blix, A.S. and L.P. Folkow. 1995. Daily energy expenditure in free living minke whales. *Acta Physiologica* 153(1): 61-66. https://doi.org/10.1111/j.1748-1716.1995.tb09834.x.

Bloch, D., M.P. Heide-Jorgensen, E. Stefansson, B. Mikkelsen, L.H. Ofstad, R. Dietz, and L.W. Andersen. 2003. Short-term movements of long-finned pilot whales *Globicephala melas* around the Faroe Islands. *Wildlife Biology* 9(1): 47-58.

Branch, T., K. Stafford, D. Palacios, C. Allison, J. Bannister, C. Burton, E. Cabrera, C. Carlson, B. Galletti Vernazzani, et al. 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. *Mammal Review* 37(2): 116-175.

Breed, G.A., I.D. Jonsen, R.A. Myers, W.D. Bowen, and M.L. Leonard. 2009. Sex-specific, seasonal foraging tactics of adult grey seals (*Halichoerus grypus*) revealed by state–space analysis. *Ecology* 90(11): 3209-3221. https://doi.org/10.1890/07-1483.1.

Buehler, D., R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015. *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*. Report Number CTHWANP-RT-15-306.01.01. California Department of Transportation (CALTRANS), Division of Environmental Analysis. 532 pp. http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf.

Cranford, T.W. and P. Krysl. 2015. Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. *PLoS ONE* 10(1): e0116222. https://doi.org/10.1371/journal.pone.0116222.

Croll, D.A., A. Acevedo-Gutiérrez, B.R. Tershy, and J. Urbán-Ramírez. 2001. The diving behavior of blue and fin whales: Is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology Part A* 129(4): 797-809. https://doi.org/10.1016/S1095-6433(01)00348-8.

Dahlheim, M.E. and D.K. Ljungblad. 1990. Preliminary hearing study on gray whales (*Eschrichtius robustus*) in the field. *In* Thomas, J. and R. Kastelein (eds.). *Sensory abilities of cetaceans*. Volume 196. Springer US. 335-346.

Dahlheim, M.E. and P.A. White. 2010. Ecological aspects of transient killer whales *Orcinus orca* as predators in southeastern Alaska. *Wildlife Biology* 16: 308-322.

Davis, R.W., G.A.J. Worthy, B. Wursig, and S.K. Lynn. 1996. Diving behavior and at-sea movements of an Atlantic spotted dolphin in the Gulf of Mexico. *Marine Mammal Science* 12(4): 569-581. https://doi.org/10.1111/j.1748-7692.1996.tb00069.x.

Denes, S.L., D.G. Zeddies, and M.J. Weirathmueller. 2018. *Turbine Foundation and Cable Installation at South Fork Wind Farm: Underwater Acoustic Modeling of Construction Noise*. Document Number 01584, Version 3.0. Technical report by JASCO Applied Sciences for Jacobs Engineering Group Inc.

Dodge, K.L., B. Galuardi, T.J. Miller, and M.E. Lutcavage. 2014. Leatherback Turtle Movements, Dive Behavior, and Habitat Characteristics in Ecoregions of the Northwest Atlantic Ocean. *PLoS ONE* 9(3): e91726. https://doi.org/10.1371/journal.pone.0091726.

Dolphin, W.F. 1987. Dive behavior and estimated energy expenditure of foraging humpback whales in southeast Alaska. *Canadian Journal of Zoology* 65(2): 354-362. https://doi.org/10.1139/z87-055.

Dunlop, R.A., M.J. Noad, D.H. Cato, E. Kniest, P.O. Miller, J.N. Smith, and M.D. Stokes. 2013. Mutivariate analysis of behavioural response experiments in humpback whales (*Megaptera novaeangliae*). *Journal of Experimental Biology* 216: 759-770. http://jeb.biologists.org/content/jexbio/216/5/759.full.pdf.

Dunlop, R.A., M.J. Noad, R.D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2017. Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology* 220(16): 2878-2886. http://jeb.biologists.org/content/jexbio/220/16/2878.full.pdf.

Eckert, S.A. 2006. High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. *Marine Biology* 149: 1257-1267.

Ellison, W.T., C.W. Clark, and G.C. Bishop. 1987. *Potential use of surface reverberation by bowhead whales, Balaena mysticetus, in under-ice navigation: Preliminary considerations*. Report of the International Whaling Commission. Volume 37. 329-332 pp.

Ellison, W.T. and A.S. Frankel. 2012. A common sense approach to source metrics. *In* Popper, A.N. and A.D. Hawkins (eds.). *The Effects of Noise on Aquatic Life*. Springer, New York. 433-438.

Erbe, C., R. McCauley, and A. Gavrilov. 2016. Characterizing marine soundscapes. *In* Popper, A.N. and A.D. Hawkins (eds.). *The Effects of Noise on Aquatic Life II*. Springer, New York. 265-271. https://dx.doi.org/10.1007/978-1-4939-2981-8_31.

Finneran, J.J. 2016. *Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise*. Technical Report for Space and Naval Warfare Systems Center Pacific, San Diego, CA. 49 pp. http://www.dtic.mil/dtic/tr/fulltext/u2/1026445.pdf.

Fossette, S., S. Ferraroli, H. Tanaka, R.-C. Y., N. Arai, K. Sato, Y. Naito, Y. Le Maho, and J.-Y. Georges. 2007. Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guinea. *Marine Ecology Progress Series* 338: 233-247.

Frankel, A.S., W.T. Ellison, and J. Buchanan. 2002. Application of the acoustic integration model (AIM) to predict and minimize environmental impacts. *OCEANS'02 MTS/IEEE*. 1438-1443 pp.

Gjertz, I., C. Lydersen, and Ø. Wiig. 2001. Distribution and diving of harbour seals (*Phoca vitulina*) in Svalbard. *Polar Biology* 24(3): 209-214. https://doi.org/10.1007/s003000000197.

Goldbogen, J.A., J. Calambokidis, R.E. Shadwick, E.M. Oleson, M.A. Mcdonald, and J.A. Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209(7): 1231-1244. http://jeb.biologists.org/content/209/7/1231.abstract.

Goldbogen, J.A., J. Calambokidis, E. Oleson, J. Potvin, N.D. Pyenson, G. Schorr, and R.E. Shadwick. 2011. Mechanics, hydrodynamics and energetics of blue whale lunge feeding: efficiency dependence on krill density. *Journal of Experimental Biology* 214: 131-146. http://jeb.biologists.org/content/jexbio/214/1/131.full.pdf.

Grace, M.A., J. Watson, and D. Foster. 2010. Time, temperature, and depth profiles for a loggerhead sea turtle (*Caretta caretta*) captured with a pelagic longline. *Southeastern Naturalist* 9(2): 191-200.

Griffin, R.B., R.W. Baird, and C. Hu. 2005. *Movement patterns and diving behavior of Atlantic spotted dolphins (Stenella frontalis) in relation to oceanographic features: A study using remotely-deployed suction-cup attached tags*. Document Number 1005. Project Number HBOI 2003-09. Technical report by Mote Marine Laboratory. http://hdl.handle.net/2075/668.

Halpin, P.N., A.J. Read, E. Fujioka, B.D. Best, B. Donnelly, L.J. Hazen, C. Kot, K. Urian, E. LaBrecque, et al. 2009. OBIS-SEAMAP: The world data center for marine mammal, sea bird, and sea turtle distributions. *Oceanography* 22(2): 104-115. https://doi.org/10.5670/oceanog.2009.42.

Hastie, G.D., B. Wilson, and P.M. Thompson. 2006. Diving deep in a foraging hotspot: Acoustic insights into bottlenose dolphin dive depths and feeding behaviour. *Marine Biology* 148: 1181-1188.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, and B.J. Godley. 2007. Only some like it hot—quantifying the environmental niche of the loggerhead sea turtle. *Diversity and Distributions* 13(4): 447-457. https://doi.org/10.1111/j.1472-4642.2007.00354.x.

Heide-Jorgensen, M.P., D. Bloch, E. Stefansson, B. Mikkelsen, L.H. Ofstad, and R. Dietz. 2002. Diving behaviour of long-finned pilot whales *Globicephala melas* around the Faroe Islands. *Wildlife Biology* 8(4): 307-313.

Herzing, D.L. and C.R. Elliser. 2016. Opportunistic sightings of cetaceans in nearshore and offshore waters of Southeast Florida. *Journal of Northwest Atlantic Fisheries and Science* 48: 21-31.

Hooker, S.K., H. Whitehead, and S. Gowans. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. *Conservation Biology* 13(3): 592-602. https://doi.org/10.1046/j.1523-1739.1999.98099.x

Houghton, J.D.R., A.C. Broderick, B.J. Godley, J.D. Metcalfe, and G.C. Hays. 2002. Diving behaviour during the internesting interval for loggerhead turtles *Caretta caretta* nesting in Cyprus. *Marine Ecology Progress Series* 227: 63-70.

Houser, D.S. and M.J. Cross. 1999. *Marine Mammal Movement and Behavior (3MB): A Component of the Effects of Sound on the Marine Environment (ESME) Distributed Model*. Version 8.08, by BIOMIMETICA.

Houser, D.S., D.A. Helweg, and P.W.B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. *Aquatic Mammals* 27(2): 82-91. http://aquaticmammalsjournal.org/share/AquaticMammalsIssueArchives/2001/AquaticMammals_27-02/27-02_Houser.PDF.

Houser, D.S. 2006. A method for modeling marine mammal movement and behavior for environmental impact assessment. *IEEE Journal of Oceanic Engineering* 31(1): 76-81. https://doi.org/10.1109/JOE.2006.872204.

Houser, D.S., L.A. Dankiewicz -Talmadge, T.K. Stockard, and P.J. Ponganis. 2010. Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. *Journal of Experimental Biology* 213(1): 52-62. http://jeb.biologists.org/content/jexbio/213/1/52.full.pdf.

Jessopp, M., M. Cronin, and T. Hart. 2013. Habitat-Mediated Dive Behavior in Free-Ranging Grey Seals. *PLoS ONE* 8(5): e63720. https://doi.org/10.1371/journal.pone.0063720.

Kraus, S.D., S. Leiter, K. Stone, B. Wikgren, C. Mayo, P. Hughes, R.D. Kenney, C.W. Clark, A.N. Rice, et al. 2016. *Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles*. US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2016-054, Sterling, Virginia. 117 + appendices pp.

Lafortuna, C., L., M. Jahoda, A. Azzellino, F. Saibene, and A. Colombini. 2003. Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (*Balaenoptera physalus*). *European Journal of Applied Physiology* 90(3-4): 387-395. https://doi.org/10.1007/s00421-003-0887-2.

Lander, M.E., J.T. Harvey, K.D. Hanni, and L.E. Morgan. 2002. Behavior, movements, and apparent survival of rehabilitated and free-ranging harbor seal pups. *Journal of Wildlife Management* 66(1): 19-28. http://www.jstor.org/stable/3802867.

Leiter, S.M., K.M. Stone, J.L. Thompson, C.M. Accardo, B.C. Wikgren, M.A. Zani, T.V.N. Cole, R.D. Kenney, C.A. Mayo, et al. 2017. North Atlantic right whale *Eubalaena glacialis* occurrence in offshore wind energy areas near Massachusetts and Rhode Island, USA. *Endangered Species Research* 34: 45-59. https://doi.org/10.3354/esr00827.

Lesage, V., M.O. Hammill, and K.M. Kovacs. 1999. Functional classification of harbor seal (*Phoca vitulina*) dives using depth profiles, swimming velocity, and an index of foraging success. *Canadian Journal of Zoology* 77(1): 74-87. https://doi.org/10.1139/z98-199.

Lopez, B.D. 2009. The bottlenose dolphin *Tursiops truncatus* foraging around a fish farm: Effects of prey abundance on dolphin's behavior. *Current Zoology* 55(4): 243-248.

Lowry, L.F., K.J. Frost, J.M. Hoep, and R.A. Delong. 2001. Movements of satellite-tagged subadult and adult harbor seals in Prince William Sound, Alaska. *Marine Mammal Science* 17(4): 835-861. https://doi.org/10.1111/j.1748-7692.2001.tb01301.x.

MacLeod, C.D. and A. D'Amico. 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management* 7(3): 211-221.

Madsen, P.T., M. Johnson, N. Aguilar Soto, W.M.X. Zimmer, and P. Tyack. 2005. Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*). *Journal of Experimental Biology* 208: 181-194. http://jeb.biologists.org/content/jexbio/208/2/181.full.pdf.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyak, and J.E. Bird. 1983. *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior*. Report Number 5366. http://www.boem.gov/BOEM-Newsroom/Library/Publications/1983/rpt5366.aspx.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. Phase II: January 1984 migration*. Report Number 5586. Report prepared by Bolt, Beranek and Newman Inc. for the U.S. Department of the Interior, Minerals Management Service, Cambridge, MA (USA). 357 pp. https://www.boem.gov/BOEM-Newsroom/Library/Publications/1983/rpt5586.aspx.

Mate, B.R., K.M. Stafford, R. Nawojchik, and J.L. Dunn. 1994. Movements and dive behavior of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the Gulf of Maine. *Marine Mammal Science* 10(1): 116-121. https://doi.org/10.1111/j.1748-7692.1994.tb00398.x.

Mate, B.R., B.A. Lagerquist, M. Winsor, J. Geraci, and J.H. Prescott. 2005. Movements and dive habits of a satellite-monitored longfinned pilot whale (*Globicephala melas*) in the northwest Atlantic. *Marine Mammal Science* 21(1): 136-144.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adihyta, J. Murdoch, et al. 2000. Marine seismic surveys: A study of environmental implications. *Australian Petroleum Production Exploration Association (APPEA) Journal* 40(1): 692-708. https://doi.org/10.1071/AJ99048.

Meynecke, J.O., S. Vindenes, and D. Teixeira. 2013. Monitoring humpback whale (*Megaptera novaeangliae*) behaviour in a highly urbanised coastline: Gold Coast, Australia. (Chapter 8) *In* Moksness, E., E. Dahl, and J. Støttru (eds.). *Global Challenges in Integrated Coastal Zone Management*. 101-113.

Miller, J.H. and G.R. Potty. 2017. Overview of underwater acoustic and seismic measurements of the construction and operation of the Block Island Wind Farm. *Journal of the Acoustical Society of America* 141(5): 3993-3993. https://doi.org/10.1121/1.4989144.

Miller, P.J.O., M.P. Johnson, P.L. Tyack, and E.A. Terray. 2004. Swimming gaits, passive drag and buoynacy of diving sperm whales *Physeter macrocephalus*. *Journal of Experimental Biology* 207: 1953-1967. http://jeb.biologists.org/content/jexbio/207/11/1953.full.pdf.

Miller, P.J.O., K. Aoki, L.E. Rendell, and M. Amano. 2008. Stereotypical resting behavior of the sperm whale. *Current Biology* 18(1): R21-R23. https://doi.org/10.1016/j.cub.2007.11.003.

Miller, P.J.O., A.D. Shapiro, and V.B. Deecke. 2010. The diving behaviour of mammal-eating killer whales (*Orcinus orca*): Variations with ecological not physiological factors. *Canadian Journal of Zoology* 88(11): 1103-1112. https://doi.org/10.1139/Z10-080.

Minamikawa, S., T. Iwasaki, Y. Tanaka, A. Ryono, S. Noji, H. Soto, S. Kurosawa, and H. Kato. 2003. Diurnal pattern of diving behavior in striped dolphins, *Stenella coeruleoalba*. *International Symposium on Bio-logging Science*. 17-21 March 2003. National Institute of Polar Research, Tokyo, Japan. 23-24 pp.

Murase, H., T. Tamura, S. Otani, and S. Nishiwaki. 2015. Satellite tracking of Bryde's whales *Balaenoptera edeni* in the offshore western North Pacific in summer 2006 and 2008. *Fisheries Science* 82(1): 35-45. https://doi.org/10.1007/s12562-015-0946-8.

Nedwell, J.R. and A.W. Turnpenny. 1998. The use of a generic frequency weighting scale in estimating environmental effect. *Workshop on Seismics and Marine Mammals*. 23–25 Jun 1998, London, U.K.

Nedwell, J.R., A.W.H. Turnpenny, J. Lovell, S.J. Parvin, R. Workman, and J.A.L. Spinks. 2007. *A validation of the dB_{ht} as a measure of the behavioural and auditory effects of underwater noise*. Document Number 534R1231 Report prepared by Subacoustech Ltd. for the UK Department of Business, Enterprise and Regulatory Reform under Project No. RDCZ/011/0004. http://www.subacoustech.com/wp-content/uploads/534R1231.pdf.

Normandeau Associates Inc. and APEM Inc. 2016. *Digital Aerial Baseline Survey of Marine Wildlife in Support of Offshore Wind Energy: Summer 2016 Taxonomic Analysis Summary Report*. Prepared for New York State Energy Research and Development Authority. https://remote.normandeau.com/docs/NYSERDA%20Summer%202016_Taxonomic%20Analysis%20Summary%20Report_final%20Updated.pdf.

Normandeau Associates Inc. and APEM Inc. 2018. *Digital Aerial Baseline Survey of Marine Wildlife in Support of Offshore Wind Energy: Summer 2017 Taxonomic Analysis Summary Report*. Prepared for New York State Energy Research and Development Authority. https://remote.normandeau.com/docs/NYSERDA_SUMMER%202017_Taxonomic_Analysis_Summary_Report.pdf.

Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and R. Brown. 1996. *Assessment of the Status of Harbor Porpoise (Phocoena phocoena) in Oregon and Washington Waters*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-76. 46 pp. https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-76.pdf.

Otani, S., Y. Naito, A. Kawamura, M. Kawasaki, S. Nishiwaki, and A. Kato. 1998. Diving behavior and performance of harbor porpoises, *Phocoena phocoena*, in Funka Bay, Hokkaido, Japan. *Marine Mammal Science* 14(2): 209-220. http://dx.doi.org/10.1111/j.1748-7692.1998.tb00711.x.

Otani, S., Y. Naito, A. Kato, and A. Kawamura. 2000. Diving behavior and swimming speed of a free-ranging harbor porpoise, *Phocoena phocoena*. *Marine Mammal Science* 16(4): 811-814. http://dx.doi.org/10.1111/j.1748-7692.2000.tb00973.x.

Parks, S.E., C.W. Clark, and P.L. Tyack. 2007. Short-and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America* 122(6): 3725-3731. https://doi.org/10.1121/1.2799904.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. ASA S3/SC1.4 TR-2014. SpringerBriefs in Oceanography. ASA Press and Springer. 73 pp. https://doi.org/10.1007/978-3-319-06659-2.

Reichmuth, C., J. Mulsow, J.J. Finneran, D.S. Houser, and A.Y. Supin. 2007. Measurement and Response Characteristics of Auditory Brainstem Responses in Pinnipeds. *Aquatic Mammals* 33(1): 132-150.

Renaud, M.L. and J.A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. *Bulletin of Marine Science* 55(1): 1-15.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, CA. 576.

Roberts, J.J., B.D. Best, L. Mannocci, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, and W.M. McLellan. 2015. *Density Model for Seals (Phocidae) Along the U.S. East Coast, Preliminary Results*. Version 3.2. Marine Geospatial Ecology Lab, Duke University, Durham, NC.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, et al. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. *Scientific Reports* 6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4776172/.

Roberts, J.J., L. Mannocci, and P.N. Halpin. 2017. *Final project report: Marine species density data gap assessments and update for the AFTT study area, 2016-2017 (Opt. Year 1)*. Document version 1.4. Report prepared for Naval Facilities Engineering Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, NC.

Roberts, J.J., L. Mannocci, R.S. Schick, and P.N. Halpin. 2018. *Final Project Report: Marine Species Density Data Gap Assessments and Update for the AFTT Study Area, 2017-2018 (Opt. Year 2)*. Document version 1.2. Report by the Duke University Marine Geospatial Ecology Lab for Naval Facilities Engineering Command, Atlantic Durham, NC, USA.

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, and R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawai'i. *Endangered Species Research* 10: 203-213. https://doi.org/10.3354/esr00229.

Scott, M.D. and S.J. Chivers. 2009. Movements and diving behavior of pelagic spotted dolphins. *Marine Mammal Science* 25(1): 137-160.

Sears, R. and W. Perrin. 2009. Blue whale. *In* Perrin, W.F., B. Wursig, and J.G.M. Thewissen (eds.). *Encyclopedia of Marine Mammals*. Academic Press.

Sills, J.M., B.L. Southall, and C. Reichmuth. 2014. Amphibious hearing in spotted seals (*Phoca largha*): Underwater audiograms, aerial audiograms and critical ratio measurements. *Journal of Experimental Biology* 217(5): 726-734. http://jeb.biologists.org/content/jexbio/217/5/726.full.pdf.

Smith, J.N., H.S. Grantham, N. Gales, M.C. Double, M.J. Noad, and D. Paton. 2012. Identification of humpback whale breeding and calving habitat in the Great Barrier Reef. *Marine Ecology Progress Series* 447: 259-272. https://doi.org/10.3354/meps09462.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-521. https://doi.org/10.1080/09524622.2008.9753846.

Southall, B.L., W. Ellison, C. Clark, and D. Tollit. 2016. *A risk assessment framework to assess the biological significance of noise exposure on marine mammals*. *Poster presented at the 21st Conference on the Biology of Marine Mammals*, San Francisco. http://sea-inc.net/wp-content/uploads/2016/01/EWG-Framework_SMM-poster.jpg.

Stockin, K.A., R.S. Fairbairns, E.C.M. Parsons, and D.W. Sims. 2001. Effects of diel and seasonal cycles on the dive duration of the minke whale (*Balaenoptera acutorostrata*). *Journal of the Marine Biological Association of the United Kingdom* 81(1): 189-190.

Tougaard, J., J. Carstensen, J. Teilmann, H. Skov, and P. Rasmussen. 2009. Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.)). *Journal of the Acoustical Society of America* 126(1): 11-14. https://doi.org/10.1121/1.3132523.

Tubelli, A., A. Zosuls, D. Ketten, and D.C. Mountain. 2012. *Prediction of a mysticete audiogram via finite element analysis of the middle ear*. *The effects of noise on aquatic life*.

Tyack, P., M. Johnson, N. Aguilar Soto, A. Sturlese, and P.T. Madsen. 2006. Extreme diving of beaked whales. *Journal of Experimental Biology* 209: 4238-4253. http://jeb.biologists.org/content/jexbio/209/21/4238.full.pdf.

Ward, B.G. 1999. *Movement patterns and feeding ecology of the Pacific coast bottlenose dolphin (Tursiops truncatus)*. Master Thesis. San Diego State University. 98 pp.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters of the northeast U.S. *Marine Mammal Science* 17(4): 703-717. https://doi.org/10.1111/j.1748-7692.2001.tb01294.x.

Wartzok, D. and D.E. Ketten. 1999. Marine Mammal Sensory Systems. *In* Reynolds, J. and S. Rommel (eds.). *Biology of Marine Mammals*. Smithsonian Institution Press, Washington, DC. 117-175.

Watwood, S.L., P.J.O. Miller, M.P. Johnson, P.T. Madsen, and P.L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Animal Ecology* 75(3): 814-825. https://doi.org/10.1111/j.1365-2656.2006.01101.x

Watwood, S.L. and D.M. Buonantony. 2012. *Dive distribution and group size parameters for marine species occuring in Navy training and testing areas in the North Atlantic and North Pacifiic Oceans*. NUWC-NPT Technical Document 12,085. Naval Undersea Warfare Center Division, Newport, Rhode Island.

Wells, R.S., C.A. Manire, L. Byrd, D. Smith, J.G. Gannon, D. Fauquier, and K.D. Mullin. 2009. Movements and dive patterns of a rehabilitated Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean. *Marine Mammal Science* 25(2): 420-429.

Westgate, A.J., A.J. Head, P. Berggren, H.N. Koopman, and D.E. Gaskin. 1995. Diving behaviour of harbour porpoises, *Phocoena phocoena*. *Canadian Journal of Fisheries and Aquatic Sciences* 52(5): 1064-1073. https://doi.org/10.1139/f95-104.

Wood, J., B.L. Southall, and D.J. Tollit. 2012. *PG&E offshore 3 D Seismic Survey Project EIR-Marine Mammal Technical Draft Report*. SMRU Ltd.

Würsig, B. and M. Würsig. 1979. Behavior and ecology of the bottlenose dolphin, *Tursiops truncatus* in the South Atlantic. *Fishery Bulletin* 77(2): 399-412. https://www.st.nmfs.noaa.gov/spo/FishBull/77-2/wursig.pdf.

Appendix A. Animal Movement and Exposure Modeling

To assess the risk of impacts from exposure, an estimate of received sound levels for the animals in the area during operation of the Project is required. Sound sources move as do animals. The sound fields may be complex, and the sound received by an animal is a function of where the animal is at any given time. To a reasonable approximation, the location of the sound source(s) is known, and acoustic modeling can be used to predict the 3-D sound field. The location and movement of animals within the sound field, however, is unknown. Realistic animal movement within the sound field can be simulated. Repeated random sampling (Monte Carlo method simulating many animals within the operations area) is used to estimate the sound exposure history of the population of simulated animals during the operation.

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

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behavior. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behavior model (3MB, Houser 2006) and used to predict the exposure of animats (virtual marine mammals and sea turtles) to sound arising from sound sources in simulated representative surveys. Inside JASMINE, the sound source location mimics the movement of the source vessel through the proposed survey pattern. Animats are programmed to behave like the marine animals likely to be present in the survey area. The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, and surface times.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species (see Appendix A.2). An individual animat's modeled sound exposure levels are summed over the total simulation duration, such as 24 hours or the entire simulation, to determine its total received energy, and then compared to the assumed threshold criteria.

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

A.1. Animal movement parameters

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

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

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

Dive sub-models

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

A.1.1. Exposure integration time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (L_p) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 hr 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 hr 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 is limited to a few weeks, the approximate scale of the collected data (Houser 2006). For this study, one-week simulations (i.e., 7 days) were modeled for each scenario.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the survey area during an operation 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 200 km (124.2 miles) from the SFWF. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering 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 (Appendices A.2 and A.3). The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

A.1.2. Aversion

Aversion is a common response of marine mammals to sound, particularly at relatively high sound exposure levels (Ellison et al. 2012). As received sound level generally decreases with distance from a source, this aspect of natural behavior can strongly influence the estimated maximum sound levels an animal is predicted to receive and significantly affects the probability of more pronounced direct or subsequent behavioral effects. Additionally, animals are less likely to respond to sound levels far from a source, even when those levels elicit response at closer ranges. Both proximity and received levels are important factors in aversion response (Dunlop et al. 2017).

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 this dearth of information and to be consistent within this report, aversion parameters follow the suggestions by Southall et al. (2016) that are, in part, based on the Wood et al. (2012) step function that was used to estimate potential behavioral disruption. Animats are assumed to avert by changing their headings by a fixed amount away from the source, with higher received levels associated with a greater deflection (Table A-1). Animats remain in the aversive state for a specified amount of time, depending on the level of exposure that triggered the aversion (Table A-1). During this time, travel parameters are recalculated periodically as with normal behaviors. At the end of the aversion interval, the aversion criteria (Table A-1), are applied to determine if the animat enters another aversion interval or transitions to a non-aversive behavior; while aversion begins immediately, transition to a regular behavior occurs at the end of the next surface interval, consistent with regular behavior transitions.

Table A-1. Aversion parameters for the animal movement simulation based on Southall et al. (2016) behavioral response criteria.

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

A.1.3. Seeding density and scaling

The exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 0.5 animats/km^2 over the entire simulation area. Some species have depth preference restrictions, e.g., Sperm whales prefer water >1000 m, and the simulation location contained a relatively high portion of shallow water areas. The local modeling density, that is the density of animats near the construction area, was determined by dividing the simulation seeding density by the proportion of seedable area for each species. To evaluate potential injury or behavioral disruptions, threshold exceedance was determined in 24 hr time windows for each species. From the numbers of animats exceeding threshold, the numbers of individual animals for each species predicted to exceed threshold were determined by scaling the animat results by the ratio of local real-world density to local modeling density. As described in Section 3.1.1, the local real-world density estimates were obtained from the habitat-based models of Roberts et al. (2015, 2017).

A.2. Marine Mammal Species-Specific Details

There are several species of marine mammals that may be present in the vicinity of the proposed operations site, including several endangered species (Sperm Whales and several mysticetes), and the critically endangered North Atlantic right whales. Details for each of the marine mammal species evaluated in this study are listed below.

A.2.1. Blue Whales (*Balaenoptera musculus*)

Table A-2. *Blue whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Non-foraging (deep)	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 2.78 (1.39)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 2.1 (0.52)	Croll et al. (2001)
	Descent rate (m/s)	Gaussian 2.2 (0.38)	Croll et al. (2001)
	Dive depth (m)	Gaussian 154.3 (38.8)	Croll et al. (2001)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1.5 (0.5)	Acevedo-Gutierrez et al. (2002)
	Probability of reversal	0.7	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 0.7 (0.2)	Watwood and Buonantony (2012)
	Reversal descent dive rate (m/s)	Gaussian 0.7 (0.2)	Watwood and Buonantony (2012)
	Time in reversal (s)	Gaussian 90.0 (30.0)	Acevedo-Gutierrez et al. (2002)
	Surface interval (s)	Gaussian 78.0 (30.2)	Acevedo-Gutierrez et al. (2002)
	Bout duration (s)	Gaussian 600 (120): 1900 - 0600 hr Gaussian 3600 (420): 0600 - 1900 hr	Approximated (Watwood and Buonantony 2012)
Non-foraging (shallow)	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 2.78 (1.39)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 2.1 (0.52)	Croll et al. (2001)
	Descent rate (m/s)	Gaussian 2.2 (0.38)	Croll et al. (2001)
	Dive depth (m)	Gaussian 26.8 (1.5)	Croll et al. (2001)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 78.0 (30.2)	Acevedo-Gutierrez et al. (2002)

Behavior	Variable	Value	Reference
	Bout duration (s)	Gaussian 0 (0): 1900 - 0600 hr Gaussian 3600 (420): 0600 - 1900 hr	Approximated (Watwood and Buonantony 2012)
Foraging	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.25 (0.42)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 1.6 (0.5)	Goldbogen et al. (2011)
	Descent rate (m/s)	Gaussian 2.6 (0.5)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 201.0 (52.0)	Goldbogen et al. (2011)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 3.5 (1.1)	Goldbogen et al. (2011)
	Probability of reversal	0.7	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 2.4 (0.9)	Croll et al. (2001)
	Reversal descent dive rate (m/s)	Gaussian 1.5 (0.4)	Croll et al. (2001)
	Time in reversal (s)	Gaussian 300.0 (60.0)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 162.0 (66.0)	Goldbogen et al. (2011)
	Bout duration (s)	Gaussian 3600.0 (1800.0)	Approximated (Watwood and Buonantony 2012)
General	Shore following (m)	200	Approximated (Branch et al. 2007)
	Depth limit on seeding (m)	200.0 (minimum), 8000.0 (maximum)	Approximated (Branch et al. 2007)

A.2.2. Fin Whales (*Balaenoptera physalus*)

Table A-3. *Fin whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Non-foraging shallow	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.7 (0.5)	Lafortuna et al. (2003)
	Ascent rate (m/s)	Gaussian 1.7 (0.4)	Croll et al. (2001)
	Descent rate (m/s)	Gaussian 2.0 (0.2)	Croll et al. (2001)
	Average depth (m)	Gaussian 28.2 (1.8)	Croll et al. (2001)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 90 (30)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	1	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 0.7 (0.2)	Approximated (Croll et al. 2001)
	Reversal descent dive rate (m/s)	Gaussian 0.7 (0.2)	Approximated (Croll et al. 2001)
	Time in reversal (s)	Gaussian 1 (0.2)	Approximated (Croll et al. 2001)
	Surface interval (s)	Gaussian 123.8 (42.3)	Acevedo-Gutierrez et al. (2002)
	Bout duration (s)	Sigmoidal T_{50} = 10, k = 10	Approximated (Watwood and Buonantony 2012)
Non-foraging Deep	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.7 (0.5)	Lafortuna et al. (2003)
	Ascent rate (m/s)	Gaussian 1.7 (0.4)	Croll et al. (2001)
	Descent rate (m/s)	Gaussian 2.0 (0.2)	Croll et al. (2001)
	Average depth (m)	Gaussian 120 (33.5)	Croll et al. (2001)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 80 (19.2)	Acevedo-Gutiérrez et al. (2002)
	Bout duration (s)	Sigmoidal T_{50} = 15, k = 15	Approximated (Watwood and Buonantony 2012)
Foraging Shallow	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.6 (0.6)	Goldbogen et al. (2006)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Goldbogen et al. (2006)
	Descent rate (m/s)	Gaussian 3.0 (0.2)	Goldbogen et al. (2006)
	Average depth (m)	Gaussian 46 (4.8)	Croll et al. (2001)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 3.1 (1.1)	Croll et al. (2001) Goldbogen et al. (2006)
	Probability of reversal	0.95	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 1.7 (0.4)	Croll et al. (2001)
	Reversal descent dive rate (m/s)	Gaussian 1.4 (0.5)	Croll et al. (2001)
	Time in reversal (s)	Gaussian 13.7 (2.8)	Croll et al. (2001)
	Surface interval (s)	Gaussian 123.8 (42.3)	Acevedo-Gutiérrez et al. (2002)
	Bout duration (s)	Sigmoidal $T_{50} = 30$, k = 15	Approximated (Watwood and Buonantony 2012)
Foraging Deep	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.6 (0.6)	Goldbogen et al. (2006)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Goldbogen et al. (2006)
	Descent rate (m/s)	Gaussian 3.0 (0.2)	Goldbogen et al. (2006)
	Average depth (m)	Gaussian 248.0 (18.0)	Goldbogen et al. (2006)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 3.1 (1.1)	Croll et al. (2001) Goldbogen et al. (2006)
	Probability of reversal	0.95	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 1.7 (0.4)	Croll et al. (2001)
	Reversal descent dive rate (m/s)	Gaussian 1.4 (0.5)	Croll et al. (2001)
	Time in reversal (s)	Gaussian 13.7 (2.8)	Croll et al. (2001)
	Surface interval (s)	Gaussian 123.8 (42.3)	Acevedo-Gutiérrez et al. (2002)
	Bout duration (s)	Sigmoidal $T_{50} = 50$, k = 15	Approximated (Watwood and Buonantony 2012)
General	Shore following (m)	30	Approximated (Watwood and Buonantony 2012)
	Depth limit on seeding (m)	30 (minimum), 2000 (maximum)	Approximated (Watwood and Buonantony 2012)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.3. Humpback Whales (*Megaptera novaeangliae*)

Table A-4. *Humpback whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Migrating	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.8–0.25	Meynecke et al. (2013) Murase et al. (2015)
	Ascent rate (m/s)	Gaussian 1.9 (0.25)	Dolphin (1987)
	Descent rate (m/s)	Gaussian 1.7 (0.7)	Dolphin (1987)
	Average depth (m)	Gaussian 45 (10)	Smith et al. (2012)
	Bottom following	No	Approximated (based on figure in Dunlop et al. 2013)
	Reversals	Gaussian 7 (3)	Alves et al. (2010)
	Probability of reversal	1	Approximated (based on figure in Dunlop et al. 2013)
	Reversal ascent dive rate (m/s)	Gaussian 0.1 (0.1)	Approximated (based on figure in Dunlop et al. 2013)
	Reversal descent dive rate (m/s)	Gaussian 0.1 (0.1)	Approximated (based on figure in Dunlop et al. 2013)
	Time in reversal (s)	Gaussian 60 (15)	Approximated (based on figure in Dunlop et al. 2013)
	Surface interval (s)	Gaussian, 60 (27)	Dolphin (1987)
General	Shore following (m)	10	Approximated (based on Smith et al. 2012)
	Depth limit on seeding (m)	20 (minimum), 70 (maximum)	Approximated (based on Smith et al. 2012)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.4. Minke Whales (*Balaenoptera acutorostrata*)

Table A-5. *Minke whales:* Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Feeding dive	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 3.25 (0.3)	Approximated (Blix and Folkow 1995)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Approximated (fin whale - Goldbogen et al. 2011)
	Descent rate (m/s)	Gaussian 3 (0.2)	Approximated (fin whale - Goldbogen et al. 2011)
	Average depth (m)	Gaussian 35 (20)	Approximated (based on figure in Blix and Folkow 1995)
	Bottom following	No	Approximated (Blix and Folkow 1995)
	Reversals	Gaussian 3.1 (1.1)	Approximated (fin whale - Croll et al. 2001, Goldbogen et al. 2006)
	Probability of reversal	0.95	Approximated (Blix and Folkow 1995)
	Reversal ascent dive rate (m/s)	Gaussian 1.7 (0.4)	Fin whale–Croll et al. (2001)
	Reversal descent dive rate (m/s)	Gaussian 1.4 (0.5)	Fin whale–Croll et al. (2001)
	Time in reversal (s)	Gaussian 13.7 (2.8)	Fin whale–Croll et al. (2001)
	Surface interval (s)	Gaussian 66.1 (96.7)	Stockin et al. (2001)
	Bout duration (s)	Gaussian 1500 (500)	Approximated (based on figure in Blix and Folkow 1995)
Cruising dive	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 3.25 (0.3)	Approximated (Blix and Folkow 1995)

Behavior	Variable	Value	Reference
	Ascent rate (m/s)	Gaussian 1.7 (0.4)	Approximated (fin whale - Goldbogen et al. 2011)
	Descent rate (m/s)	Gaussian 2.0 (0.2)	Approximated (fin whale - Goldbogen et al. 2011)
	Average depth (m)	Gaussian 15 (10)	Approximated (based on figure in Blix and Folkow 1995)
	Bottom following	No	Approximated (based on figure in Blix and Folkow 1995)
	Reversals	No	Approximated (based on figure in Blix and Folkow 1995)
	Surface interval (s)	Gaussian 66.1 (96.7)	Stockin et al. (2001)
	Bout duration (s)	Gaussian 1000 (600)	Approximated (based on figure in Blix and Folkow 1995)
Sleeping	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 3.25 (0.3)	Approximated (Blix and Folkow 1995)
	Ascent rate (m/s)	Gaussian 1.7 (0.4)	Approximated (fin whale - Goldbogen et al. 2011)
	Descent rate (m/s)	Gaussian 2.0 (0.2)	Approximated (fin whale - Goldbogen et al. 2011)
	Average depth (m)	Gaussian 10 (5)	Approximated (based on figure in Blix and Folkow 1995)
	Bottom following	No	Approximated (based on figure in Blix and Folkow 1995)
	Reversals	No	Approximated (based on figure in Blix and Folkow 1995)
	Surface interval (s)	Gaussian 66.1 (96.7)	Stockin et al. (2001)
	Bout duration (s)	Gaussian 2000 (400)	Approximated (based on figure in Blix and Folkow 1995)
Unknown	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 3.25 (0.3)	Approximated (Blix and Folkow 1995)
	Ascent rate (m/s)	Gaussian 1.7 (0.4)	Approximated (fin whale - Goldbogen et al. 2011)
	Descent rate (m/s)	Gaussian 2.0 (0.2)	Approximated (fin whale - Goldbogen et al. 2011)
	Average depth (m)	Gaussian 20 (10)	Approximated (based on figure in Blix and Folkow 1995)
	Bottom following	No	Approximated (based on figure in Blix and Folkow 1995)
	Reversals	No	Approximated (based on figure in Blix and Folkow 1995)
	Surface interval (s)	Gaussian 66.1 (96.7)	Stockin et al. (2001)
	Bout duration (s)	Gaussian 1500 (500)	Approximated (based on figure in Blix and Folkow 1995)
General	Shore following (m)	20	Approximated (Hooker et al. 1999)
	Depth limit on seeding (m)	20 (minimum), 200 (maximum)	Approximated (Kraus et al. 2016)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.5. North Atlantic Right Whales (*Eubalaena glacialis*)

Table A-6. *North Atlantic right whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Foraging dive	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Ascent rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Descent rate (m/s)	Gaussian 1.4 (0.3)	Baugmartner and Mate (2003)
	Average depth (m)	Gaussian 121.2 (24.2)	Baugmartner and Mate (2003)
	Bottom following	No	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversals	Gaussian 1.0 (0)	Approximated (based on figure in Baugmartner and Mate 2003)
	Probability of reversal	1.0	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversal ascent dive rate (m/s)	Gaussian 0.01 (0.01)	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversal descent dive rate (m/s)	Gaussian 0.01 (0.01)	Approximated (based on figure in Baugmartner and Mate 2003)
	Time in reversal (s)	Gaussian 420.0 (60)	Approximated (based on figure in Baugmartner and Mate 2003)
	Surface interval (s)	Gaussian 187.8 (59.4)	Baugmartner and Mate (2003)
	Bout duration (s)	Gaussian 3600 (600)	Approximated (based on figure in Baugmartner and Mate 2003)
V-shape	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Ascent rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Descent rate (m/s)	Gaussian 1.4 (0.3)	Baugmartner and Mate (2003)

Behavior	Variable	Value	Reference
	Average depth (m)	Gaussian 121.2 (24.2)	Baugmartner and Mate (2003)
	Bottom following	No	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversals	No	Approximated (based on figure in Baugmartner and Mate 2003)
	Surface interval (s)	Gaussian 440 (120)	Baugmartner and Mate (2003)
	Bout duration (s)	Gaussian 1800 (600)	Approximated (based on figure in Baugmartner and Mate 2003)
Other	Travel direction	Correlated random walk	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (based on fin whale - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Ascent rate (m/s)	Gaussian 1.47 (0.26)	Baugmartner and Mate (2003)
	Descent rate (m/s)	Gaussian 1.4 (0.3)	Baugmartner and Mate (2003)
	Average depth (m)	Gaussian 121.2 (24.2)	Baugmartner and Mate (2003)
	Bottom following	No	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversals	Random 1.0–10	Approximated (based on figure in Baugmartner and Mate 2003)
	Probability of reversal	0.3	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversal ascent dive rate (m/s)	Gaussian 0.08 (0.05)	Approximated (based on figure in Baugmartner and Mate 2003)
	Reversal descent dive rate (m/s)	Gaussian 0.01 (0.01)	Approximated (based on figure in Baugmartner and Mate 2003)
	Time in reversal (s)	Gaussian 200 (60)	Approximated (based on figure in Baugmartner and Mate 2003)
	Surface interval (s)	Gaussian 440 (120)	Approximated (based on figure in Baugmartner and Mate 2003)
	Bout duration (s)	Gaussian 1200 (600)	Approximated (based on figure in Baugmartner and Mate 2003)
General	Shore following (m)	30	Approximated (based on Baugmartner and Mate 2003)

Behavior	Variable	Value	Reference
	Depth limit on seeding (m)	30 (minimum), 200 (maximum)	Baumgartner and Mate (2005)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.6. Sei Whales (*Balaenoptera borealis*)

We used the fin whale behavior definition (Table A-3) as a surrogate for sei whales.

A.2.7. Atlantic Spotted Dolphin

Table A-7. *Atlantic spotted dolphins*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Behavior1	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Random 0.08 - 5.69	Davis et al. (1996)
	Ascent rate (m/s)	Gaussian 1.15 (0.8)	Davis et al. (1996)
	Descent rate (m/s)	Gaussian 1.23 (0.48)	Davis et al. (1996)
	Dive depth (m)	Random 2.0 - 60.0	Davis et al. (1996)
	Bottom following	No	Scott and Chivers (2009)
	Reversals	Gaussian 2.0 (2.0)	Griffin et al. (2005)
	Probability of reversal	0.5	Approximated (Davis et al. 1996)
	Reversal ascent dive rate (m/s)	Gaussian 1.15 (0.8)	Davis et al. (1996)
	Reversal descent dive rate (m/s)	Gaussian 1.23 (0.48)	Davis et al. (1996)
	Time in reversal (s)	Gaussian 20.81 (21.5)	Griffin et al. (2005)
	Surface interval (s)	Gaussian 63.59 (52.66)	Griffin et al. (2005)
General	Shore following (m)	10	Scott and Chivers (2009)
	Depth limit on seeding (m)	10.0 (minimum), 6000.0 (maximum)	Scott and Chivers (2009)

A.2.8. Atlantic White-sided Dolphins (*Lagenorhynchus acutus*)

Table A-8. *Atlantic white-sided dolphins*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Day	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10.0	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 1.58 (1.02)	Mate et al. (1994)
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Spotted dolphin value (Scott and Chivers 2009)
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Spotted dolphin value (Scott and Chivers 2009)
	Average depth (m)	Gaussian 22.1 (15.71)	Spotted dolphin value (Scott and Chivers 2009)
	Bottom following	Yes	Approximated spotted dolphin value (Scott and Chivers 2009)
	Reversals	No	Approximated spotted dolphin value (Scott and Chivers 2009)
	Surface interval (s)	Gaussian 68.4 (304.8)	Spotted dolphin value–(Scott and Chivers 2009)
	Bout duration (s)	Sigmoidal T_{50} = 3600, k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
Night	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10.0	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 1.58 (1.02)	Mate et al. (1994)
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Spotted dolphin value (Scott and Chivers 2009)
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Spotted dolphin value (Scott and Chivers 2009)
	Average depth (m)	Gaussian 24.0 (27.1)	Spotted dolphin value (Scott and Chivers 2009)
	Bottom following	No	Approximated spotted dolphin value (Scott and Chivers 2009)

Behavior	Variable	Value	Reference
	Reversals	Gaussian 3.0 (1.0)	Approximated spotted dolphin value (Scott and Chivers 2009)
	Probability of reversal	0.5	Approximated spotted dolphin value (Scott and Chivers 2009)
	Reversal ascent dive rate (m/s)	Gaussian 0.74 (0.41)	Spotted dolphin value (Scott and Chivers 2009)
	Reversal descent dive rate (m/s)	Gaussian 0.93 (0.54)	Spotted dolphin value (Scott and Chivers 2009)
	Time in reversal (s)	Gaussian 39.0 (55.2)	Spotted dolphin value (Scott and Chivers 2009)
	Surface interval (s)	Gaussian 49.8 (108.6)	Spotted dolphin value (Scott and Chivers 2009)
	Bout duration (s)	Sigmoidal $T_{50} = 3600$, k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
General	Shore following (m)	2	Approximated spotted dolphin value (Scott and Chivers 2009)
	Depth limit on seeding (m)	2 (minimum), 300 (maximum)	Approximated spotted dolphin value (Scott and Chivers 2009)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.9. Bottlenose Dolphins (*Tursiops truncatus*)

Table A-9. *Bottlenose dolphins*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Foraging	Travel direction	Vector model	Ward (1999)
	Travel rate (m/s)	Vector model	Ward (1999)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. (2010)
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. (2010)
	Average depth (m)	Gaussian 25 (5)	Hastie et al. (2006)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 18 (1.1)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.09	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	1.0 (0.2)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	1.0 (0.2)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 1 (0.1)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 46.4 (2.5)	Lopez (2009)
	Bout duration (s)	Gaussian 252 (210)	Ward (1999)
Playing	Travel direction	Vector model	Ward (1999)
	Travel rate (m/s)	Vector model	Ward (1999)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. (2010)
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. (2010)
	Average depth (m)	Gaussian 7 (3)	Würsig and Würsig (1979), Hastie et al. (2006)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 3 (2)	Approximated (Watwood and Buonantony 2012)
	Bout duration (s)	Gaussian 138 (54)	Ward (1999)
Resting	Travel direction	Vector model	Ward (1999)
	Travel rate (m/s)	Vector model	Ward (1999)
	Ascent rate (m/s)	Gaussian 0.5 (0.1)	Approximated (Watwood and Buonantony 2012)
	Descent rate (m/s)	Gaussian 0.5 (0.1)	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Average depth (m)	Random, max = 2	Approximated (Watwood and Buonantony 2012)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 3 (2)	Approximated (Watwood and Buonantony 2012)
	Bout duration (s)	Gaussian 174 (96)	Ward (1999)
Socializing	Travel direction	Vector model	Ward (1999)
	Travel rate (m/s)	Vector model	Ward (1999)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. (2010)
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. (2010)
	Average depth (m)	Random, max = 10	Hastie et al. (2006) Würsig and Würsig (1979)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 3 (2)	Approximated (Watwood and Buonantony 2012)
	Bout duration (s)	Gaussian 204 (174)	Ward (1999)
Travel	Travel direction	Vector model	Ward (1999)
	Travel rate (m/s)	Vector model	Ward (1999)
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. (2010)
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. (2010)
	Average depth (m)	Gaussian 7 (3)	Hastie et al. (2006) Würsig and Würsig (1979)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 3 (2)	Approximated (Watwood and Buonantony 2012)
	Bout duration	Gaussian 306 (276)	Ward (1999)
General	Shore following (m)	2	Würsig and Würsig (1979)
	Depth limit on seeding (m)	2 (minimum), 40 (maximum)	Würsig and Würsig (1979)

Approximated: value based on the best fit for diving profile. Those values were not available from literature but were estimated producing a diving profile similar to D-tag results for example.

A.2.10. Cuvier's Beaked Whales

Table A-10. *Cuvier's beaked whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Deep Foraging Dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 1.5 (0.5)	Approximated (Schorr et al. 2009)
	Ascent rate (m/s)	Gaussian 0.69 (0.19)	Baird et al. (2006b), Tyack et al. (2006)
	Descent rate (m/s)	Gaussian 1.47 (0.13)	Baird et al. (2006b), Tyack et al. (2006)
	Dive depth (m)	Gaussian 1070.0 (317.0)	Tyack et al. (2006)
	Bottom following	No	(Baird et al. 2006b)
	Reversals	Gaussian 20.0 (2.0)	Approximated (Baird et al. 2006b)
	Probability of reversal	0.95	Approximated (Baird et al. 2006b)
	Reversal ascent dive rate (m/s)	Gaussian 0.8 (0.2)	Approximated (Baird et al. 2006b)
	Reversal descent dive rate (m/s)	Gaussian 0.8 (0.2)	Approximated (Baird et al. 2006b)
	Time in reversal (s)	Gaussian 40.0 (20.0)	Tyack et al. (2006)
	Surface interval (s)	Gaussian 474.0 (996.0)	Baird et al. (2006b)
	Bout duration (s)	Sigmoidal T50 = 1200.0, k = 10.0	MacLeod and D'Amico (2006)
Shallow Dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 1.5 (0.5)	Approximated (Schorr et al. 2009)
	Ascent rate (m/s)	Gaussian 0.61 (0.2)	Baird et al. (2006b), Tyack et al. (2006)
	Descent rate (m/s)	Gaussian 0.53 (0.24)	Baird et al. (2006b), Tyack et al. (2006)
	Dive depth (m)	Gaussian 221.0 (100.0)	Tyack et al. (2006)
	Bottom following	No	(Baird et al. 2006b)

Behavior	Variable	Value	Reference
	Reversals	No	Tyack et al. (2006)
	Surface interval (s)	Gaussian 474.0 (996.0)	(Baird et al. 2006b)
	Bout duration (s)	Gaussian 3780.0 (1860.0)	Tyack et al. (2006)
General	Shore following (m)	1000	(Baird et al. 2006b)
	Depth limit on seeding (m)	1000.0 (minimum), 80000.0 (maximum)	(Baird et al. 2006b)

A.2.11. Killer Whales

Table A-11. *Killer whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Shallow	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 2.0 (1.61)	Dahlheim and White (2010)
	Ascent rate (m/s)	Gaussian 1.832 (1.448)	Baird (1994)
	Descent rate (m/s)	Gaussian 1.822 (1.51)	Baird (1994)
	Dive depth (m)	Gaussian 8.0 (2.0)	Miller et al. (2010)
	Bottom following	No	Approximated
	Reversals	No	Approximated (Miller et al. 2010)
	Surface interval (s)	Gaussian 3.0 (2.0)	Approximated (Miller et al. 2010)
	Bout duration (s)	Sigmoidal T50 = 300, k = 7: 1900 - 0600 h Sigmoidal T50 = 600, k = 7: 0600 - 1900 h	Approximated (Miller et al. 2010)
Deep	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Perturbation value	10	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale Watwood and Buonantony (2012))
	Travel rate (m/s)	Gaussian 2.0 (1.61)	Dahlheim and White (2010)
	Ascent rate (m/s)	Gaussian 1.832 (1.448)	Baird (1994)
	Descent rate (m/s)	Gaussian 1.822 (1.51)	Baird (1994)
	Dive depth (m)	Gaussian 40.0 (20.0)	Baird (1994)
	Bottom following	No	Approximated
	Reversals	Gaussian 3.5 (1.5)	Approximated (Miller et al. 2010)
	Probability of reversal	1	Approximated (Miller et al. 2010)
	Reversal ascent dive rate (m/s)	Gaussian 1.832 (1.448)	Baird (1994)
	Reversal descent dive rate (m/s)	Gaussian 1.822 (1.51)	Baird (1994)
	Time in reversal (s)	Gaussian 10.0 (1.0)	Approximated (Miller et al. 2010)

Behavior	Variable	Value	Reference
	Surface interval (s)	Gaussian 3.0 (2.0)	Approximated (Miller et al. 2010)
	Bout duration (s)	Gaussian 300 (7): 1800 - 0600 hr Gaussian 600 (7): 0600 - 1800 h	Approximated (Miller et al. 2010)
General	Shore following (m)	100	Approximated
	Depth limit on seeding (m)	100.0 (minimum), 6000.0 (maximum)	Approximated

A.2.12. Mesoplodont Beaked Whales

Table A-12. *Mesoplodont beaked whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Deep foraging dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.5 (0.5)	(Baird et al. 2006b)
	Ascent rate (m/s)	Gaussian 0.79 (0.13)	Baird et al. (2006a), Tyack et al. (2006)
	Descent rate (m/s)	Gaussian 1.45 (0.2)	Baird et al. (2006a), Tyack et al. (2006)
	Dive depth (m)	Gaussian 835.0 (143.0)	Tyack et al. (2006)
	Bottom following	No	(Baird et al. 2006b)
	Reversals	Gaussian 20.0 (2.0)	Tyack et al. (2006)
	Probability of reversal	0.95	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.8 (0.2)	Madsen et al. (2005)
	Reversal descent dive rate (m/s)	Gaussian 0.8 (0.2)	Madsen et al. (2005)
	Time in reversal (s)	Gaussian 40.0 (20.0)	Tyack et al. (2006)
	Surface interval (s)	Gaussian 228.0 (276.0)	Tyack et al. (2006)
	Bout duration (s)	Sigmoidal T50 = 1200.0, k = 600.0	Tyack et al. (2006)
Shallow dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.5 (0.5)	(Baird et al. 2006b)
	Ascent rate (m/s)	Gaussian 0.35 (0.2)	Baird et al. (2006a), Tyack et al. (2006)
	Descent rate (m/s)	Gaussian 0.34 (0.2)	Baird et al. (2006a), Tyack et al. (2006)
	Dive depth (m)	Gaussian 71.0 (52.0)	Tyack et al. (2006)
	Bottom following	No	Approximated
	Reversals	No	Approximated
	Surface interval (s)	Gaussian 228.0 (276.0)	Tyack et al. (2006)
	Bout duration (s)	Gaussian 3780.0 (1860.0)	Tyack et al. (2006)
General	Shore following (m)	633	Waring et al. (2001), Baird et al. (2006b)

Behavior	Variable	Value	Reference
	Depth limit on seeding (m)	633.0 (minimum), 100000.0 (maximum)	Waring et al. (2001), Baird et al. (2006b)

A.2.13. Pilot Whales (*Globicephala sp.*)

Table A-13. *Long-finned pilot whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Deep–Night	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.3 (0.8)	Bloch et al. (2003)
	Ascent rate (m/s)	Gaussian 2.02 (0.68)	Baird et al. (2002)
	Descent rate (m/s)	Gaussian 1.75 (0.34)	Baird et al. (2002)
	Average depth (m)	Random 50–828	Heide-Jorgensen et al. (2002)
	Bottom following	No	Approximated (figure in Baird et al. 2002)
	Reversals	Gaussian 3.0 (1.0)	Approximated (figure in Baird et al. 2002)
	Probability of reversal	0.8	Approximated (figure in Baird et al. 2002)
	Reversal ascent dive rate (m/s)	Gaussian 0.02 (0.02)	Approximated (figure in Baird et al. 2002)
	Reversal descent dive rate (m/s)	Gaussian 0.02 (0.02)	Approximated (figure in Baird et al. 2002)
	Time in reversal (s)	Gaussian 50.0 (30.0)	Approximated (figure in Baird et al. 2002)
	Surface interval (s)	Gaussian 480 (30)	Approximated (Baird et al. 2002)
	Bout duration (s)	Gaussian 600 (300)	Approximated (figure in Baird et al. 2002)
Shallow - Day	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.3 (0.8)	Bloch et al. (2003)
	Ascent rate (m/s)	Gaussian 2.02 (0.68)	Baird et al. (2002)
	Descent rate (m/s)	Gaussian 1.75 (0.34)	Baird et al. (2002)
	Average depth (m)	Gaussian 15 (3.0)	Heide-Jorgensen et al. (2002)

Behavior	Variable	Value	Reference
	Bottom following	No	Approximated (figure in Baird et al. 2002)
	Reversals	No	Approximated (figure in Baird et al. 2002)
	Surface interval (s)	Gaussian 30 (30)	Approximated (figure in Baird et al. 2002)
	Bout duration (s)	Gaussian 3000 (600)	Approximated (figure in Baird et al. 2002)
General	Shore following (m)	100	Approximated (Mate et al. 2005)
	Depth limit on seeding (m)	100 (minimum), 3000 (maximum)	Approximated (Mate et al. 2005)

Approximated: value based on the best fit for diving profile. Those values were not available from literature but were estimated producing a diving profile similar to D-tag results for example.

A.2.14. Risso's Dolphins (*Grampus griseus*)

Table A-14. *Risso's dolphins:* Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Shallow dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.997 (1.058)	Wells et al. (2009)
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Spotted dolphin value (Scott and Chivers 2009)
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Spotted dolphin value (Scott and Chivers 2009)
	Average depth (m)	Gaussian 8.0 (20.0)	Wells et al. (2009)
	Bottom following	No	Approximated spotted dolphin value (Scott and Chivers 2009)
	Surface interval (s)	Gaussian 11.0 (4.0)	Bearzi et al. (2011)
	Bout duration (s)	T_{50} = 3600 (s), k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
Deep dive	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 1.997 (1.058)	Wells et al. (2009)
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Spotted dolphin value (Scott and Chivers 2009)
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Spotted dolphin value (Scott and Chivers 2009)
	Average depth (m)	Random 20–500	Wells et al. (2009)
	Bottom following	No	Approximated spotted dolphin value (Scott and Chivers 2009)
	Reversals	No	Approximated spotted dolphin value (Scott and Chivers 2009)
	Surface interval (s)	Gaussian 11.0 (4.0)	Bearzi et al. (2011)

Behavior	Variable	Value	Reference
	Bout duration (s)	T_{50} = 3600 (s), k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
General	Shore following (m)	2	Approximated (Wells et al. 2009)
	Depth limit on seeding (m)	2 (minimum), 500 (maximum)	Approximated (Wells et al. 2009)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.15. Short-beaked Common Dolphins (*Delphinus delphis*)

Table A-15. *Short-beaked common dolphins*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Day	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 3.035 (1.22)	Au and Perryman (1982)
	Ascent rate (m/s)	Gaussian 0.6 (0.368)	Minamikawa et al. (2003)
	Descent rate (m/s)	Gaussian 0.538 (0.343)	Minamikawa et al. (2003)
	Dive depth (m)	Gaussian 22.6 (17.5)	Minamikawa et al. (2003)
	Bottom following	No	Approximated
	Reversals	No	Approximated
	Surface interval (s)	Gaussian 55.7 (32.1)	Minamikawa et al. (2003)
	Bout duration (s)	Sigmoidal T50 = 3600, k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
Night	Travel direction	Correlated random walk	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Perturbation value	10	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Termination coefficient	0.2	Approximated (odontocete - sperm whale (Watwood and Buonantony 2012))
	Travel rate (m/s)	Gaussian 3.035 (1.22)	Au and Perryman (1982)
	Ascent rate (m/s)	Gaussian 1.542 (0.709)	Minamikawa et al. (2003)
	Descent rate (m/s)	Gaussian 1.463 (0.668)	Minamikawa et al. (2003)
	Dive depth (m)	Gaussian 126.7 (120.9)	Minamikawa et al. (2003)
	Bottom following	No	Approximated
	Reversals	Gaussian 3.0 (2.0)	Approximated spotted dolphin value (Scott and Chivers 2009)
	Probability of reversal	0.5	Approximated spotted dolphin value (Scott and Chivers 2009)
	Reversal ascent dive rate (m/s)	Gaussian 1.542 (0.709)	Minamikawa et al. (2003)
	Reversal descent dive rate (m/s)	Gaussian 1.463 (0.668)	Minamikawa et al. (2003)
	Time in reversal (s)	Gaussian 39.0 (55.2)	Approximated spotted dolphin value (Scott and Chivers 2009)
	Surface interval (s)	Gaussian 65.8 (32.0)	Minamikawa et al. (2003)
	Bout duration (s)	Sigmoidal T50 = 3600, k = 7	Approximated spotted dolphin value (Scott and Chivers 2009)
General	Shore following (m)	40	Approximated
	Depth limit on seeding (m)	40.0 (minimum), 300.0 (maximum)	Approximated

A.2.16. Sperm Whales (*Physeter macrocephalus*)

Table A-16. *Sperm whales*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Deep foraging dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. (2004)
	Ascent rate (m/s)	Gaussian 1.3 (0.2)	Watwood et al. (2006)
	Descent rate (m/s)	Gaussian 1.1 (0.2)	Watwood et al. (2006)
	Average depth (m)	Gaussian 546.9 (130)	Watwood et al. (2006)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 8.2 (4.2)	Aoki et al. (2007)
	Probability of reversal	1	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	1.8 (0.5)	Aoki et al. (2007)
	Reversal descent dive rate (m/s)	1.8 (0.5)	Aoki et al. (2007)
	Time in reversal (s)	Gaussian 141 (82.7)	Aoki et al. (2007) Amano and Yoshioka (2003)
	Surface interval (s)	Gaussian 486 (156)	Watwood et al. (2006)
	Bout duration (s)	Gaussian 42012 (20820)	Approximated (Watwood and Buonantony 2012)
V Dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. (2004)
	Ascent rate (m/s)	Gaussian 0.67 (0.43)	Amano and Yoshioka (2003)
	Descent rate (m/s)	Gaussian 0.85 (0.05)	Amano and Yoshioka (2003)
	Average depth (m)	Gaussian 282.7 (69.9)	Amano and Yoshioka (2003)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 408 (114)	Approximated (Watwood and Buonantony 2012)
	Bout duration (s)	Gaussian 2286 (384)	Approximated (Watwood and Buonantony 2012)
Inactive bottom time	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. (2004)
	Ascent rate (m/s)	Gaussian 1.13 (0.07)	Amano and Yoshioka (2003)
	Descent rate (m/s)	Gaussian 1.4 (0.13)	Amano and Yoshioka (2003)
	Average depth (m)	Gaussian 490 (74.6)	Amano and Yoshioka (2003)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1 (0)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	1	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	0.1 (0.1)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	0.1 (0.1)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 1188 (174.6)	Amano and Yoshioka (2003)
	Surface interval (s)	Gaussian 486 (156)	Watwood et al. (2006)
	Bout duration (s)	Gaussian 6192 (4518)	Approximated (Watwood and Buonantony 2012)
Surface active	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. (2004)
	Ascent rate (m/s)	Gaussian 0.67 (0.43)	Amano and Yoshioka (2003)
	Descent rate (m/s)	Gaussian 0.85 (0.05)	Amano and Yoshioka (2003)
	Average depth (m)	Gaussian 25 (25)	Amano and Yoshioka (2003)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 408 (114)	Amano and Yoshioka (2003)
	Bout duration (s)	Gaussian 3744 (2370)	Approximated (Watwood and Buonantony 2012)
Surface inactive–head up	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Travel rate (m/s)	Gaussian 0 (0)	Approximated (Watwood and Buonantony 2012)
	Ascent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. (2008)
	Descent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. (2008)
	Average depth (m)	Gaussian 8.6 (4.8)	Miller et al. (2008)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1 (0)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	1	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	0 (0)	Miller et al. (2008)
	Reversal descent dive rate (m/s)	0 (0)	Miller et al. (2008)
	Time in reversal (s)	Gaussian 708 (522)	Miller et al. (2008)
	Surface interval (s)	Gaussian 462 (360)	Miller et al. (2008)
	Bout duration	T50 = 486 (s), k = 0.9	Approximated (Watwood and Buonantony 2012)
Surface inactive–head down	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0 (0)	Approximated (Watwood and Buonantony 2012)
	Ascent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. (2008)
	Descent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. (2008)
	Average depth (m)	Gaussian 16.5 (4.9)	Miller et al. (2008)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1 (0)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	1	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	0 (0)	Miller et al. (2008)
	Reversal descent dive rate (m/s)	0 (0)	Miller et al. (2008)
	Time in reversal (s)	Gaussian 804 (522)	Miller et al. (2008)
	Surface interval (s)	Gaussian 462 (360)	Miller et al. (2008)
	Bout duration	T50 = 486 (s), k = 0.9	Approximated (Watwood and Buonantony 2012)
General	Depth limit on seeding (m)	500	Herzing and Elliser (2016)

Approximated: value based on the best fit for diving profile. Those values were not available from literature but were estimated producing a diving profile similar to D-tag results for example.

A.2.17. Harbor Porpoises (*Phocoena phocoena*)

Table A-17. *Harbor porpoises*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Daytime	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.9 (0.3)	Otani et al. (2000)
	Ascent rate (m/s)	Gaussian 0.87 (0.38)	Westgate et al. (1995)
	Descent rate (m/s)	Gaussian 0.99 (0.34)	Westgate et al. (1995)
	Average depth (m)	Gaussian 22.5 (11.6)	Westgate et al. (1995)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1 (0)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.84	Westgate et al. (1995)
	Reversal ascent dive rate (m/s)	Gaussian 0.0 (0.0)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 0.0 (0.0)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 20.5 (27.8)	Westgate et al. (1995)
	Surface interval (s)	Gaussian 31.6 (73.8)	Otani et al. (1998) Otani et al. (2000)
	Bout duration (s)	T_{50} = 600 (s), k = 1	Approximated (Watwood and Buonantony 2012)
Nighttime	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.9 (0.3)	Westgate et al. (1995)
	Ascent rate (m/s)	Gaussian 1.34 (0.53)	Westgate et al. (1995)
	Descent rate (m/s)	Gaussian 1.44 (0.51)	Westgate et al. (1995)
	Average depth (m)	Gaussian 37.5 (12.5)	Westgate et al. (1995)
	Bottom following	Yes	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 1 (0)	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Probability of reversal	0.84	Approximated (Watwood and Buonantony 2012)
	Reversal ascent dive rate (m/s)	Gaussian 0.0 (0.0)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 0.0 (0.0)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 10.3 (13.9)	Westgate et al. (1995)
	Surface interval (s)	Gaussian 31.6 (73.8)	Otani et al. (1998) Otani et al. (2000)
	Bout duration (s)	T_{50} = 600 (s), k = 1	Approximated (Watwood and Buonantony 2012)
General	Shore following (m)	10	Approximated (Watwood and Buonantony 2012)
	Depth limit on seeding (m)	10 (minimum), 200 (maximum)	Osmek et al. (1996)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.18. Gray Seals (*Halichoerus grypus*)

Table A-18. *Gray seals:* Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Square	Travel direction	Correlated random walk	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.111 (0.861)	Breed et al. (2009)
	Ascent rate (m/s)	Gaussian 0.9 (0.04)	Beck et al. (2003)
	Descent rate (m/s)	Gaussian 1.0 (0.03)	Beck et al. (2003)
	Average depth (m)	Gaussian 62 (3.5)	Beck et al. (2003)
	Bottom following	Yes	Approximated (Beck et al. 2003)
	Reversals	No	Approximated (Beck et al. 2003)
	Surface interval (s)	Gaussian 132 (7.2)	Approximated (Beck et al. 2003)
	Bout duration (s)	Gaussian 2700 (1800)	Approximated (Beck et al. 2003)
Right skewed square	Travel direction	Correlated random walk	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.111 (0.861)	Breed et al. (2009)
	Ascent rate (m/s)	Gaussian 0.6 (0.02)	Beck et al. (2003)
	Descent rate (m/s)	Gaussian 1.5 (0.05)	Beck et al. (2003)
	Average depth (m)	Gaussian 53.0 (3.9)	Beck et al. (2003)
	Bottom following	No	Approximated (Beck et al. 2003)
	Reversals	No	Approximated (Beck et al. 2003)
	Surface interval (s)	Gaussian 132 (7.2)	Approximated (Beck et al. 2003)
	Bout duration (s)	Gaussian 1200 (300)	Approximated (Beck et al. 2003)

Behavior	Variable	Value	Reference
Left skewed square	Travel direction	Correlated random walk	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.111 (0.861)	Breed et al. (2009)
	Ascent rate (m/s)	Gaussian 1.2 (0.12)	Beck et al. (2003)
	Descent rate (m/s)	Gaussian 0.4 (0.05)	Beck et al. (2003)
	Average depth (m)	Gaussian 32.0 (1.7)	Beck et al. (2003)
	Bottom following	No	Approximated (Beck et al. 2003)
	Reversals	No	Approximated (Beck et al. 2003)
	Surface interval (s)	Gaussian 132 (7.2)	Approximated (Beck et al. 2003)
	Bout duration (s)	Gaussian 1200 (300)	Approximated (Beck et al. 2003)
V-shaped	Travel direction	Correlated random walk	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.111 (0.861)	Breed et al. (2009)
	Ascent rate (m/s)	Gaussian 0.7 (0.11)	Beck et al. (2003)
	Descent rate (m/s)	Gaussian 0.5 (0.05)	Beck et al. (2003)
	Average depth (m)	Gaussian 26.0 (1.1)	Beck et al. (2003)
	Bottom following	No	Approximated (Beck et al. 2003)
	Reversals	No	Approximated (Beck et al. 2003)
	Surface interval (s)	Gaussian 132 (7.2)	Approximated (Beck et al. 2003)
	Bout duration (s)	Gaussian 600 (300)	Approximated (Beck et al. 2003)
Wiggle	Travel direction	Correlated random walk	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Perturbation value	10	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.111 (0.861)	Breed et al. (2009)
	Ascent rate (m/s)	Gaussian 0.9 (0.08)	Beck et al. (2003)
	Descent rate (m/s)	Gaussian 1.0 (0.04)	Beck et al. (2003)
	Average depth (m)	Gaussian 26.0 (1.1)	Beck et al. (2003)
	Bottom following	No	Approximated (Beck et al. 2003)
	Reversals	Random 2–4	Approximated (Beck et al. 2003)
	Probability of reversal	1.0	Approximated (Beck et al. 2003)
	Time in reversal (s)	Random 30–90	Approximated (Beck et al. 2003)
	Surface interval (s)	Gaussian 132 (7.2)	Approximated (Beck et al. 2003)
	Bout duration	Gaussian 1800 (900)	Approximated (Beck et al. 2003)
General	Shore following (m)	2.1	Approximated (harbor seal surrogate - Watwood and Buonantony 2012)
	Depth limit on seeding (m)	<500 m	Approximated (Jessopp et al. 2013)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.2.19. Harbor Seals (*Phoca vitulina*)

Table A-19. *Harbor seals*: Data values and references input in JASMINE to create diving behavior (number values represent means [standard deviations] unless otherwise indicated).

Behavior	Variable	Value	Reference
Type 0 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.37 (0.39)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 0.71 (0.46)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 0.76 (0.47)	Lesage et al. (1999)
	Average depth (m)	Gaussian 2 (1)	Lesage et al. (1999)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 10 (2)	Lesage et al. (1999)
	Bout duration (s)	Gaussian 198 (1674)	Approximated (Watwood and Buonantony 2012)
Type 1 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.48 (0.32)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 1.13 (0.16)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 1.12 (0.19)	Lesage et al. (1999)
	Average depth (m)	Gaussian 282.7 (69.9)	Lesage et al. (1999)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 5 (2)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.08	Lesage et al. (1999)
	Reversal ascent dive rate (m/s)	Gaussian 1.13 (0.16)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 1.12 (0.19)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 5 (2)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 42.6 (23.5)	Lesage et al. (1999)
	Bout duration (s)	Gaussian 654 (1314)	Approximated (Watwood and Buonantony 2012)
Type 2 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)

Behavior	Variable	Value	Reference
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.37 (0.39)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 0.61 (0.25)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 0.66 (0.27)	Lesage et al. (1999)
	Average depth (m)	Gaussian 12.2 (9.07)	Lesage et al. (1999)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	No	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 43.8 (60.7)	Lesage et al. (1999)
	Bout duration (s)	Gaussian 138 (180)	Approximated (Watwood and Buonantony 2012)
Type 3 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.89 (0.42)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 0.85 (0.23)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 0.64 (0.25)	Lesage et al. (1999)
	Average depth (m)	Gaussian 51.85 (21.56)	Lesage et al. (1999)
	Bottom following	No	Approximated (Watwood and Buonantony 2012)
	Reversals	Gaussian 5 (2)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.08	Lesage et al. (1999)
	Reversal ascent dive rate (m/s)	Gaussian 0.85 (0.23)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 0.64 (0.25)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 5 (1)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 408 (114)	Lesage et al. (1999)
	Bout duration (s)	Gaussian 252 (306)	Approximated (Watwood and Buonantony 2012)
Type 4 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.5 (0.32)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 0.38 (0.18)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 0.76 (0.19)	Lesage et al. (1999)
	Average depth (m)	Gaussian 27.27 (10.14)	Lesage et al. (1999)
	Bottom following	Yes	Lesage et al. (1999)

Behavior	Variable	Value	Reference
	Reversals	Gaussian 5 (2)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.08	Lesage et al. (1999)
	Reversal ascent dive rate (m/s)	Gaussian 0.38 (0.18)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 0.76 (0.19)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 5 (1)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 38.6 (34.8)	Lesage et al. (1999)
	Bout duration	Gaussian 306 (498)	Approximated (Watwood and Buonantony 2012)
Type 5 dive	Travel direction	Correlated random walk	Approximated (Watwood and Buonantony 2012)
	Perturbation value	10	Approximated (Watwood and Buonantony 2012)
	Termination coefficient	0.2	Approximated (Watwood and Buonantony 2012)
	Travel rate (m/s)	Gaussian 0.21 (0.31)	Lesage et al. (1999)
	Ascent rate (m/s)	Gaussian 0.78 (0.74)	Lesage et al. (1999)
	Descent rate (m/s)	Gaussian 0.70 (0.17)	Lesage et al. (1999)
	Average depth (m)	Gaussian 65.14 (31.07)	Lesage et al. (1999)
	Bottom following	Yes	Lesage et al. (1999)
	Reversals	Gaussian 5 (2)	Approximated (Watwood and Buonantony 2012)
	Probability of reversal	0.08	Lesage et al. (1999)
	Reversal ascent dive rate (m/s)	Gaussian 0.38 (0.18)	Approximated (Watwood and Buonantony 2012)
	Reversal descent dive rate (m/s)	Gaussian 0.76 (0.19)	Approximated (Watwood and Buonantony 2012)
	Time in reversal (s)	Gaussian 5 (1)	Approximated (Watwood and Buonantony 2012)
	Surface interval (s)	Gaussian 44.8 (31.9)	Lesage et al. (1999)
	Bout duration	Gaussian 414 (1122)	Approximated (Watwood and Buonantony 2012)
General	Shore following (m)	2.1	Approximated (Watwood and Buonantony 2012)
	Depth limit on seeding (m)	<250 m	Lowry et al. (2001) Gjertz et al. (2001) Lander et al. (2002)

Approximated: Value based on the best fit for diving profile. Those values were unavailable from literature, but they were estimated to produce a diving profile similar to D-tag results, for example.

A.3. Sea Turtles

Three species of sea turtle may be near the operations site: Kemp's ridley, leatherback, and loggerhead. Movement parameter details and exposure results for each species are listed below.

A.3.1. Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

Loggerhead sea turtle behavior definitions (Table A-21) were used as a surrogate for Kemp's ridley sea turtles.

A.3.2. Leatherback Sea Turtle (*Caretta caretta*)

Table A-20. *Leatherback sea turtle*: Data values and references for inputs in JASMINE Software to create diving behavior (number values represent means [standard deviation] unless otherwise indicated).

Behavior	Variable	Value	Reference
Type 1	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.45 (0.25)	Eckert (2006)
	Ascent rate (m/s)	Gaussian 0.12 (0.06)	Fossette et al. (2007)
	Descent rate (m/s)	Gaussian 0.11 (0.06)	Fossette et al. (2007)
	Average depth (m)	Gaussian 4.9 (3.5)	Fossette et al. (2007)
	Bottom following	No	Approximated
	Reversals	Gaussian 7.9 (5.5)	Fossette et al. (2007)
	Probability of reversal	0.5	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.12 (0.06)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.11 (0.06)	Approximated
	Time in reversal (s)	Gaussian 17.5 (17.4)	Fossette et al. (2007)
	Surface interval (s)	Gaussian 66 (330)	Fossette et al. (2007)
	Bout duration (s)	Gaussian 204 (426)	Approximated
Type 2	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.45 (0.25)	Eckert (2006)
	Ascent rate (m/s)	Gaussian 0.08 (0.005)	Fossette et al. (2007)
	Descent rate (m/s)	Gaussian 0.16 (0.12)	Fossette et al. (2007)
	Average depth (m)	Gaussian 15.5 (7.1)	Fossette et al. (2007)
	Bottom following	No	Approximated
	Reversals	Gaussian 14.3 (8.1)	Fossette et al. (2007)
	Probability of reversal	0.5	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.08 (0.005)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.16 (0.12)	Approximated
	Time in reversal (s)	Gaussian 14.3 (8.1)	Fossette et al. (2007)
	Surface interval (s)	Gaussian 102 (72)	Fossette et al. (2007)
	Bout duration (s)	Gaussian 510 (222)	Approximated
Type 3	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated

Behavior	Variable	Value	Reference
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.45 (0.25)	Eckert (2006)
	Ascent rate (m/s)	Gaussian 0.2 (0.52)	Fossette et al. (2007)
	Descent rate (m/s)	Gaussian 0.2 (0.07)	Fossette et al. (2007)
	Average depth (m)	Gaussian 40.2 (18.9)	Fossette et al. (2007)
	Bottom following	No	Approximated
	Reversals	Gaussian 54.1 (33.1)	Fossette et al. (2007)
	Probability of reversal	0.5	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.2 (0.52)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.2 (0.07)	Approximated
	Time in reversal (s)	Gaussian 14.5 (7.4)	Fossette et al. (2007)
	Surface interval (s)	Gaussian 234 (294)	Fossette et al. (2007)
	Bout duration (s)	Gaussian 1020 (540)	Approximated
Type 4	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.45 (0.25)	Eckert et al. 2006
	Ascent rate (m/s)	Gaussian 0.12 (0.09)	Fossette et al. (2007)
	Descent rate (m/s)	Gaussian 0.16 (0.11)	Fossette et al. (2007)
	Average depth (m)	Gaussian 10.7 (6.9)	Fossette et al. (2007)
	Bottom following	No	Approximated
	Reversals	Gaussian 38.7 (17.8)	Fossette et al. 2007
	Probability of reversal	0.5	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.12 (0.09)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.16 (0.11)	Approximated
	Time in reversal (s)	Gaussian 9.9 (10.1)	Fossette et al. (2007)
	Surface interval (s)	Gaussian 84 (60)	Fossette et al. (2007)
	Bout duration (s)	Gaussian 468 (240)	Approximated
General	Shore following (m)	20	Approximated
	Depth limit on seeding (m)	20 (minimum), 10000 (maximum)	Approximated

A.3.3. Loggerhead Sea Turtle (*Dermochelys coriacea*)

Table A-21. *Loggerhead turtle*: Data values and references for inputs in JASMINE Software to create diving behavior (number values represent means [standard deviation] unless otherwise indicated).

Behavior	Variable	Value	Reference
Type 1 (a)	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.215 (0.063)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.3 (0.1)	Houghton et al. 2002
	Average depth (m)	Gaussian 41 (3)	Houghton et al. (2002) Grace et al. (2010)
	Bottom following	No	Approximated
	Reversals	Gaussian 1 (0)	Approximated
	Probability of reversal	1	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.215 (0.063)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.3 (0.1)	Approximated
	Time in reversal (s)	Gaussian 586.9 (194)	Approximated
	Surface interval (s)	Gaussian 267 (26.7)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 7200 (600)	Approximated
Type 1 (b)	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.15 (0.01)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.26 (0.07)	Houghton et al. (2002)
	Average depth (m)	Gaussian 45 (8)	Houghton et al. (2002) Grace et al. (2010)
	Bottom following	No	Approximated
	Reversals	Gaussian 2.6 (3)	Approximated
	Probability of reversal	1	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.15 (0.01)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.26 (0.07)	Approximated
	Time in reversal (s)	Gaussian 125.8 (18.39)	Approximated
	Surface interval (s)	Gaussian 600 (60)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 3600 (300)	Approximated
Type 2	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.165 (0.07)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.245 (0.0634)	Houghton et al. (2002)
	Average depth (m)	Gaussian 16.3 (2)	Houghton et al. (2002) Grace et al. (2010)

Behavior	Variable	Value	Reference
	Bottom following	No	Approximated
	Reversals	No	Approximated
	Surface interval (s)	Gaussian 360 (36)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 1800 (60)	Approximated
Type 3	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.1 (0.014)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.045 (0.7)	Houghton et al. (2002)
	Average depth (m)	Gaussian 26.6 (3)	Houghton et al. (2002) Grace et al. (2010)
	Bottom following	No	Approximated
	Reversals	Gaussian 1 (0)	Approximated
	Probability of reversal	1	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0 (0)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.001 (0.001)	Approximated
	Time in reversal (s)	Gaussian 175.9 (153.1)	Approximated
	Surface interval (s)	Gaussian 2238 (223.8)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 5400 (420)	Approximated
Type 4	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.1 (0.0141)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.26 (0.0566)	Houghton et al. (2002)
	Average depth (m)	Gaussian 25.2 (2)	Houghton et al. (2002) Grace et al. (2010)
	Bottom following	No	Approximated
	Reversals	Gaussian 1.1 (0)	Approximated
	Probability of reversal	0.8	Approximated
	Reversal ascent dive rate (m/s)	Gaussian 0.05 (0.05)	Approximated
	Reversal descent dive rate (m/s)	Gaussian 0.001 (0.001)	Approximated
	Time in reversal (s)	Gaussian 200.5 (179.7)	Approximated
	Surface interval (s)	Gaussian 600 (60)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 1200 (420)	Approximated
Type 5	Travel direction	Correlated random walk	Approximated
	Perturbation value	10	Approximated
	Termination coefficient	0.2	Approximated
	Travel rate (m/s)	Gaussian 0.33 (0.11)	Bentivegna (2002)
	Ascent rate (m/s)	Gaussian 0.085 (0.021)	Houghton et al. (2002)
	Descent rate (m/s)	Gaussian 0.125 (0.049)	Houghton et al. (2002)
	Average depth (m)	Random, 0–2	Houghton et al. (2002) Grace et al. (2010)

Behavior	Variable	Value	Reference
	Bottom following	No	Approximated
	Reversals	No	Approximated
	Surface interval (s)	Gaussian 150 (15)	Houghton et al. (2002) Grace et al. (2010)
	Bout duration (s)	Gaussian 7800 (1200)	Approximated
General	Shore following (m)	13	Renaud and Carpenter (1994)
	Depth limit on seeding (m)	13 (minimum), 10000 (maximum)	Approximated

A.4. Animat Seeding Area

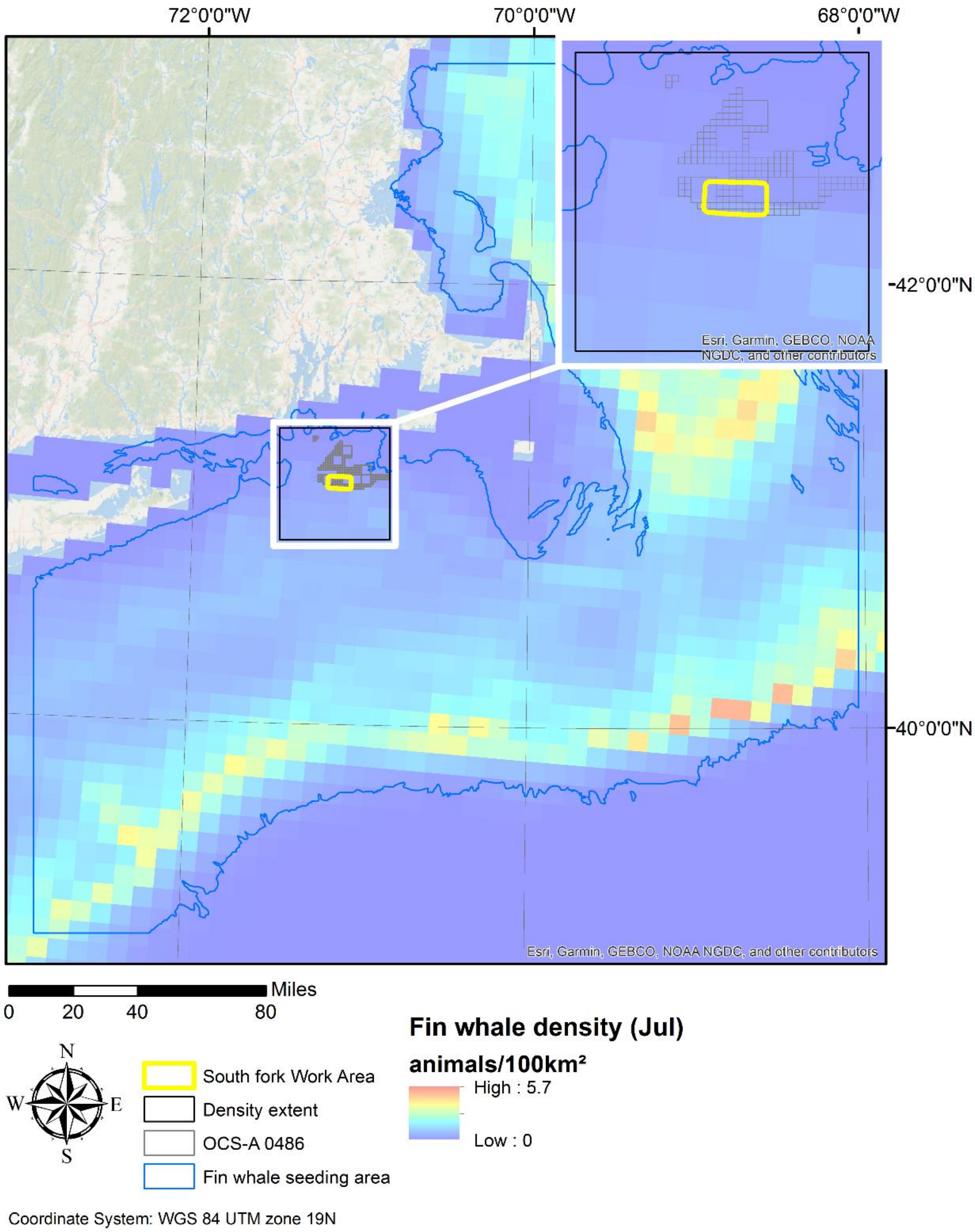

Figure A-1. Map of fin whale animat seeding range with density from Roberts et al. (2016) for July, the month with the highest density in the simulation.

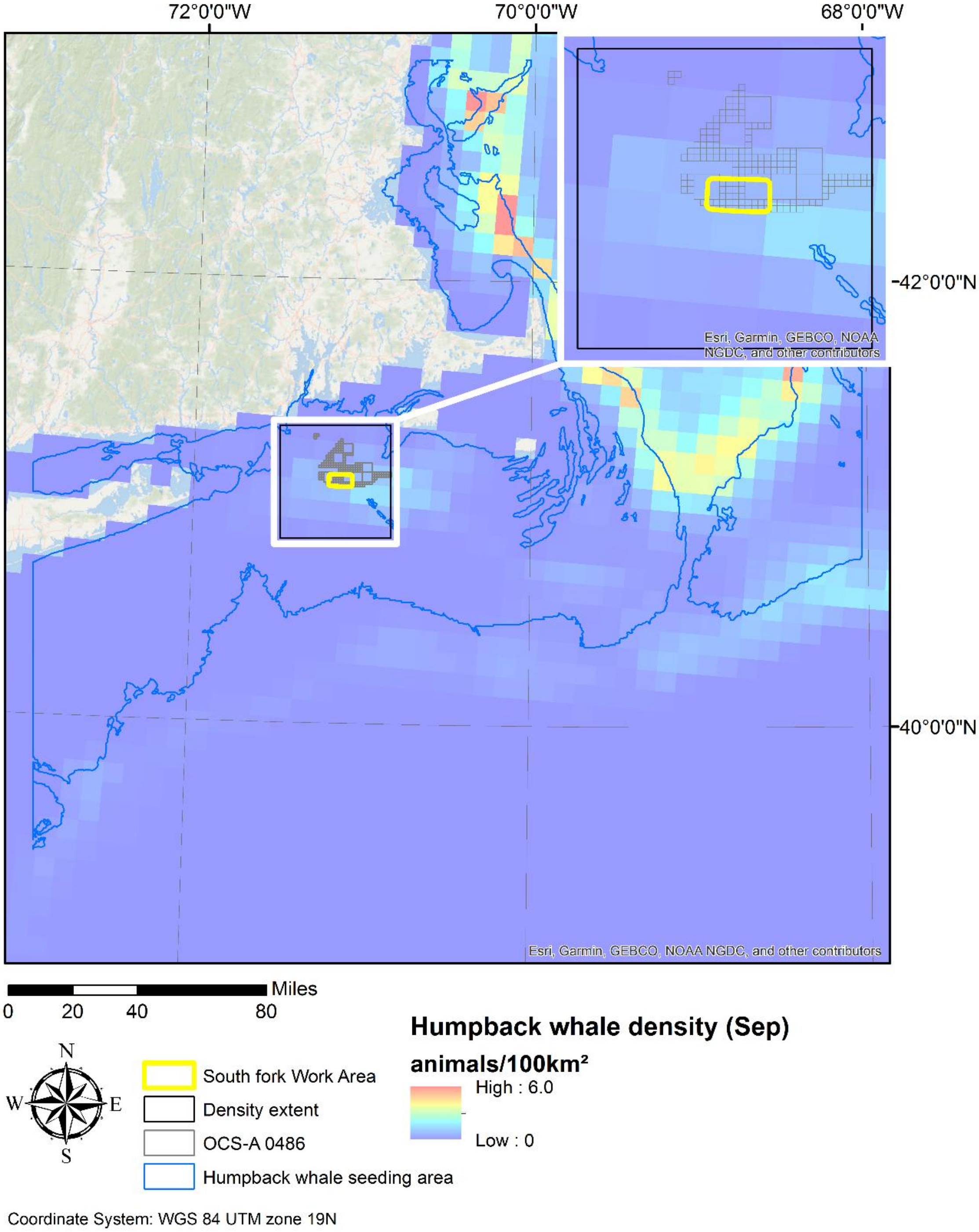

Figure A-2. Map of humpback whale animat seeding range with density from Roberts et al. (2016) for September, the month with the highest density in the simulation.

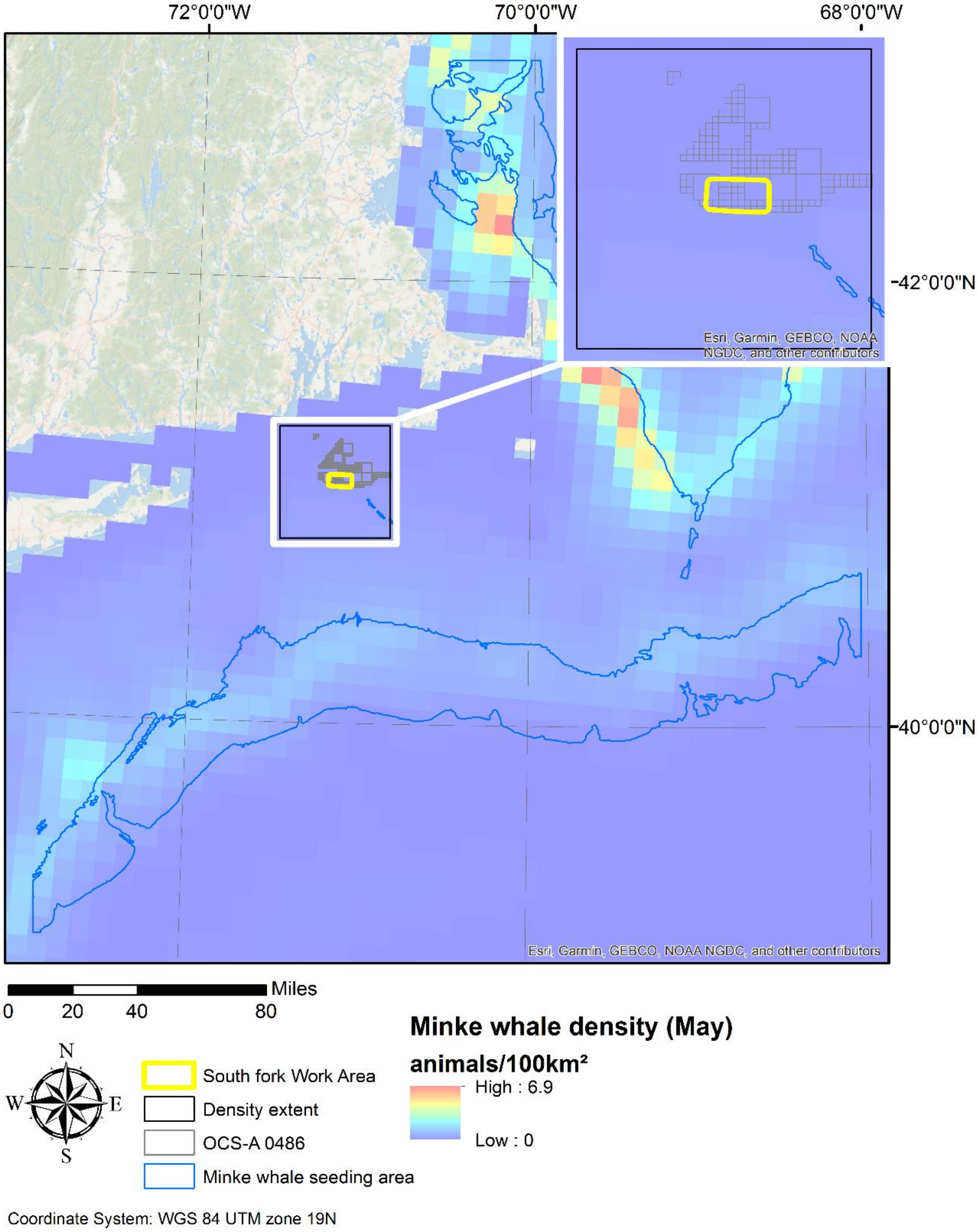

Figure A-3. Map of minke whale animat seeding range with density from Roberts et al. (2016) for May, the month with the highest density in the simulation.

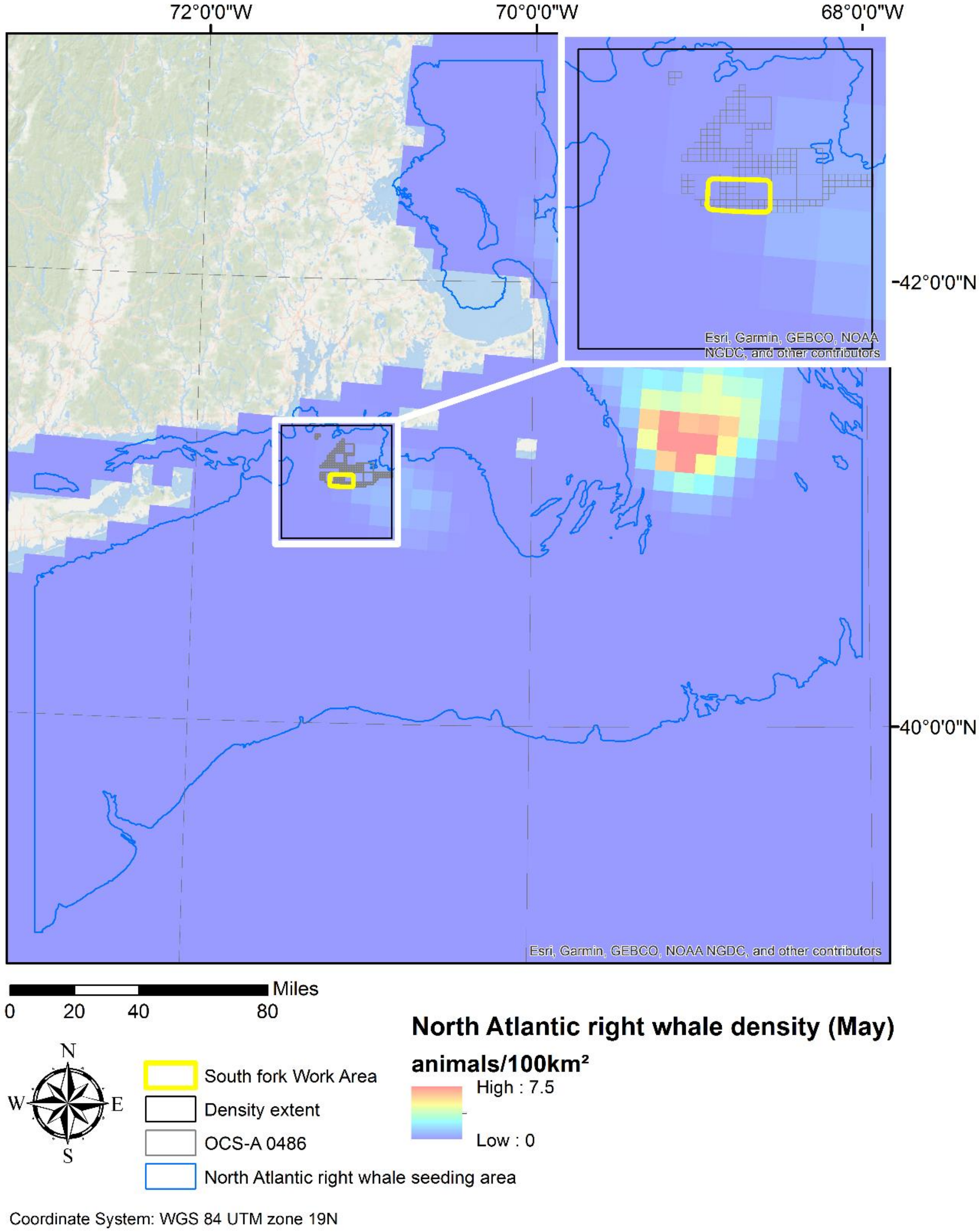

Figure A-4. Map of North Atlantic right whale animat seeding range with density from Roberts et al. (2016) for May, the month with the highest density in the simulation.

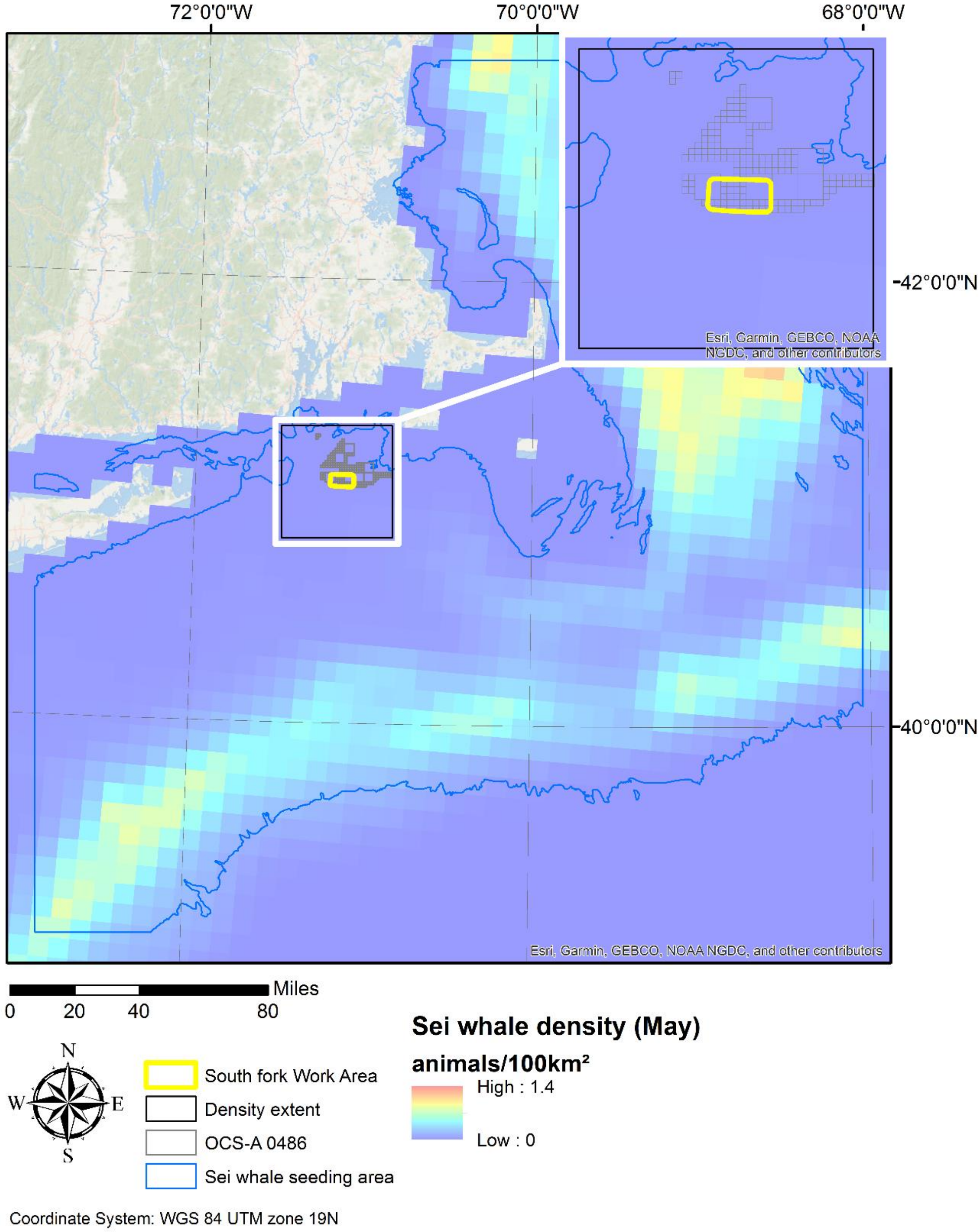

Figure A-5. Map of sei whale animat seeding range with density from Roberts et al. (2016) for May, the month with the highest density in the simulation.

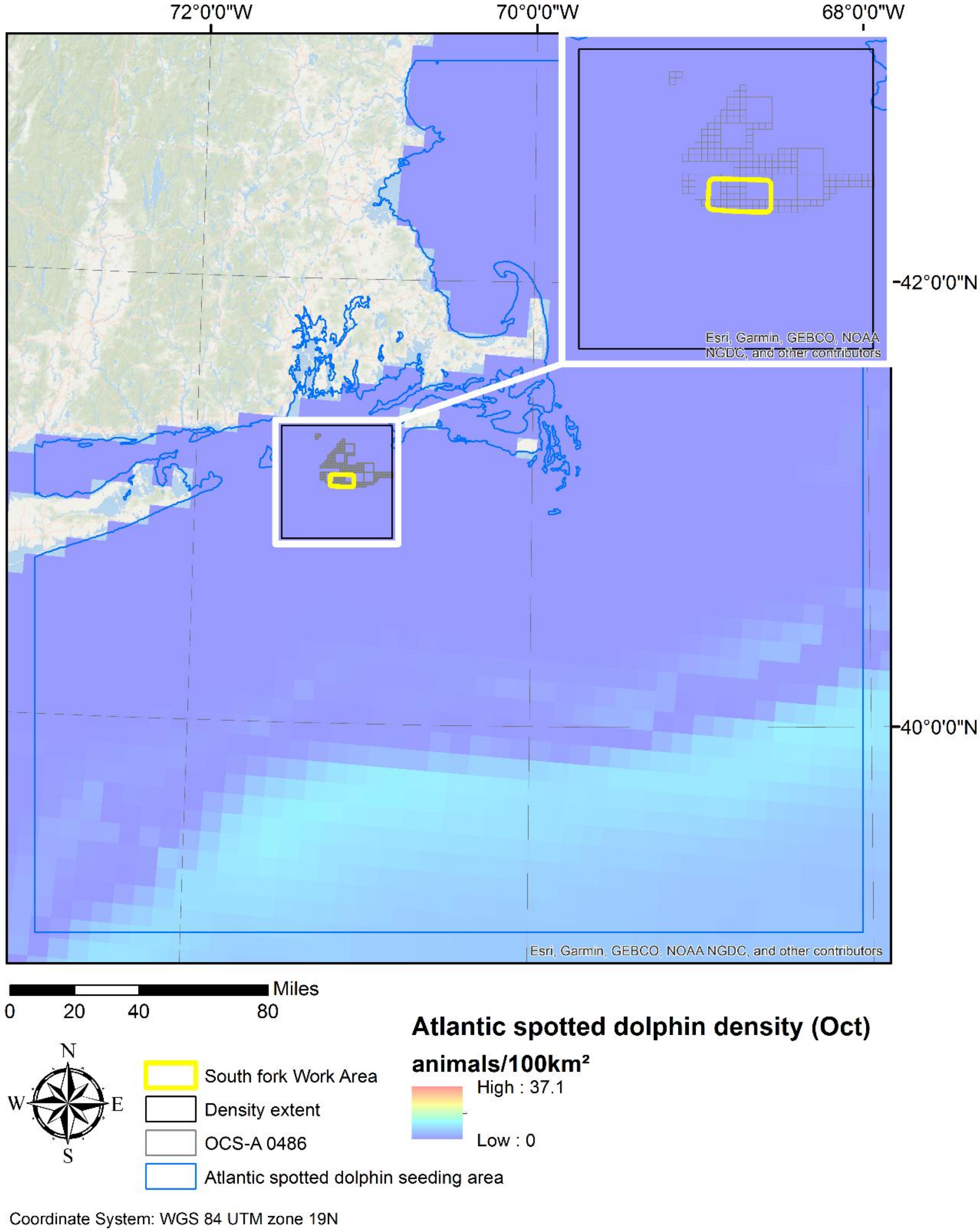

Figure A-6. Map of Atlantic spotted dolphin animat seeding range with density from Roberts et al. (2016) for October, the month with the highest density in the simulation.

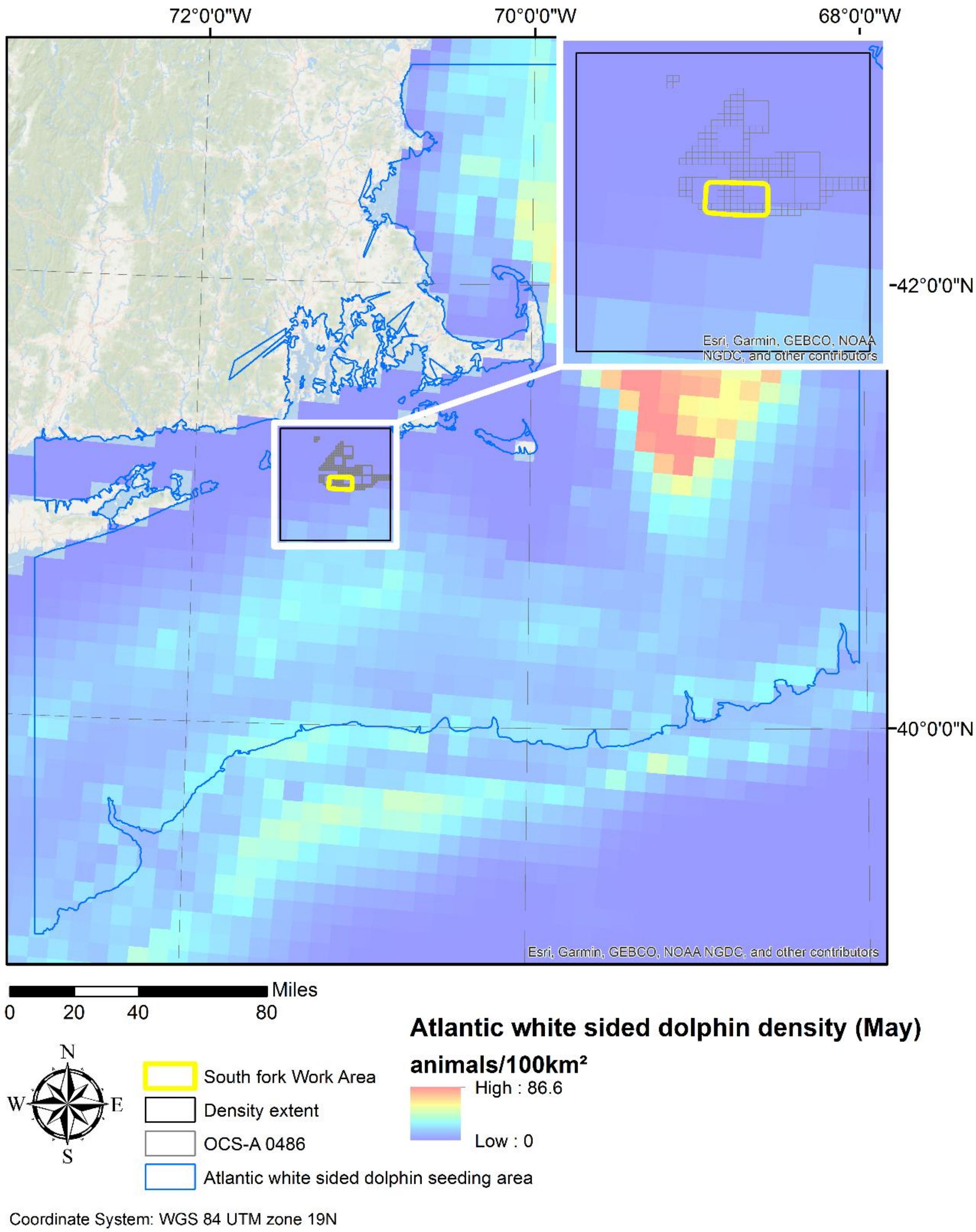

Figure A-7. Map of Atlantic white-sided dolphin animat seeding range with density from Roberts et al. (2016) for May, the month with the highest density in the simulation.

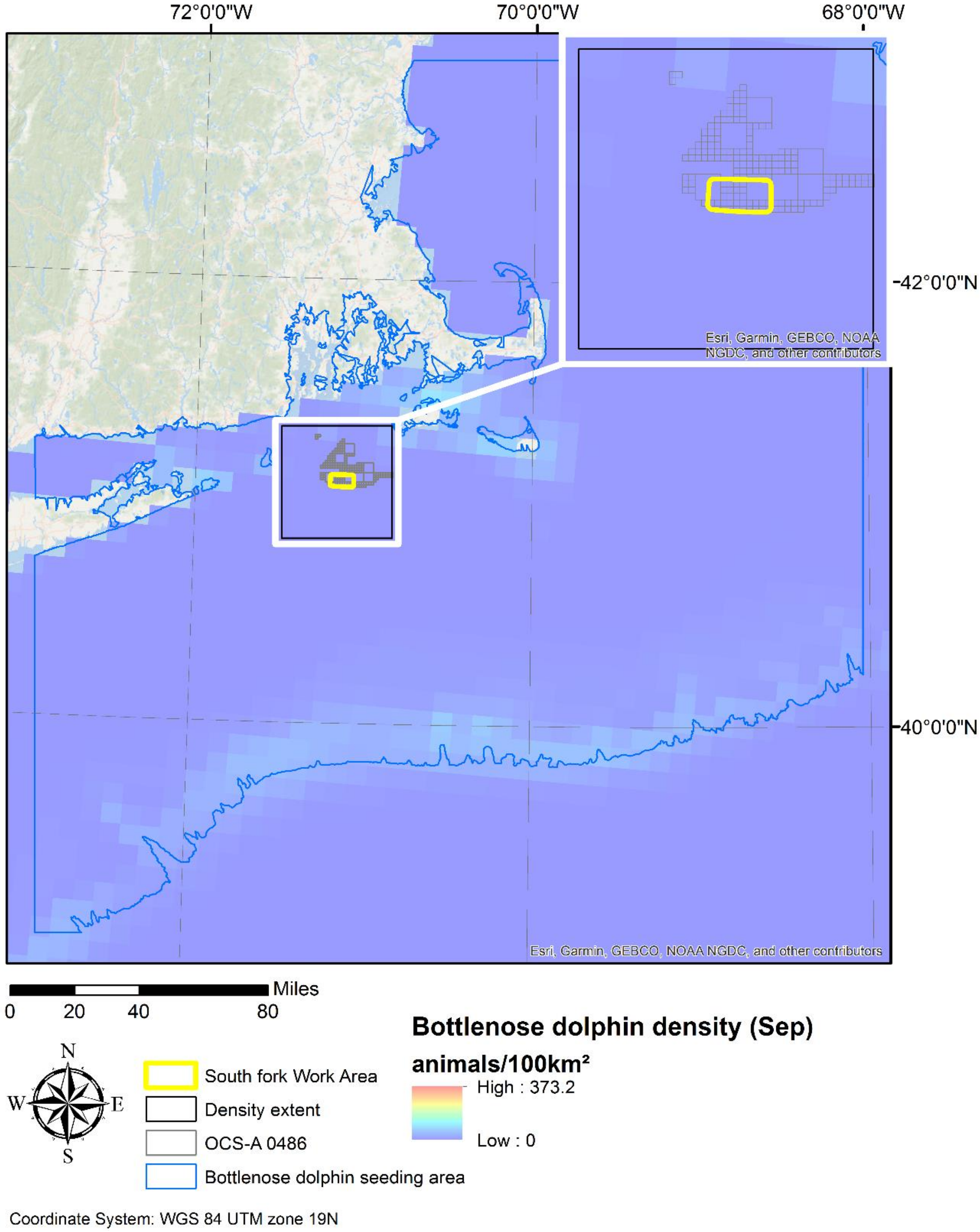

Figure A-8. Map of bottlenose dolphin animat seeding range with density from Roberts et al. (2016) for September, the month with the highest density in the simulation.

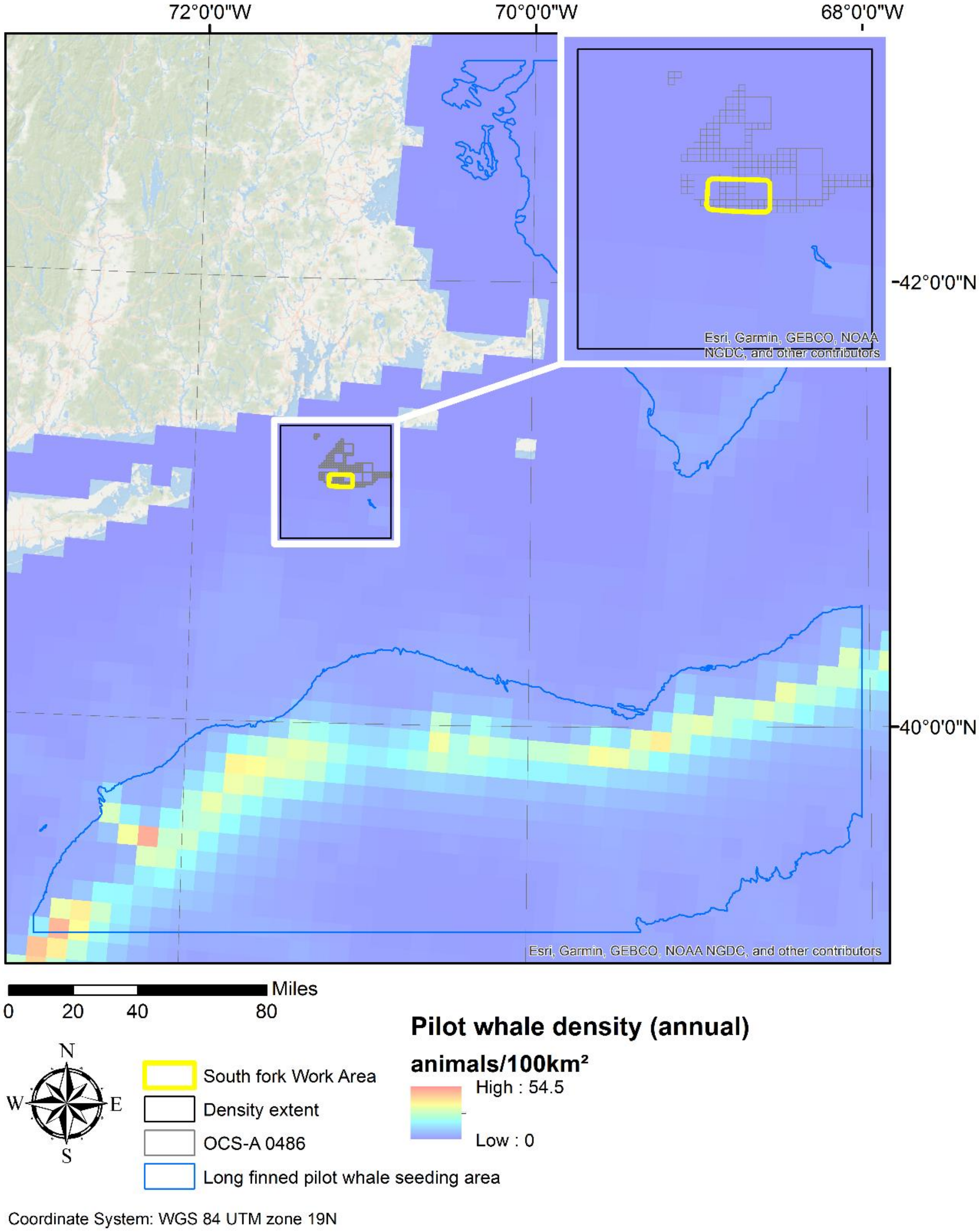

Figure A-9. Map of pilot whale animat seeding range with annual density from Roberts et al. (2016).

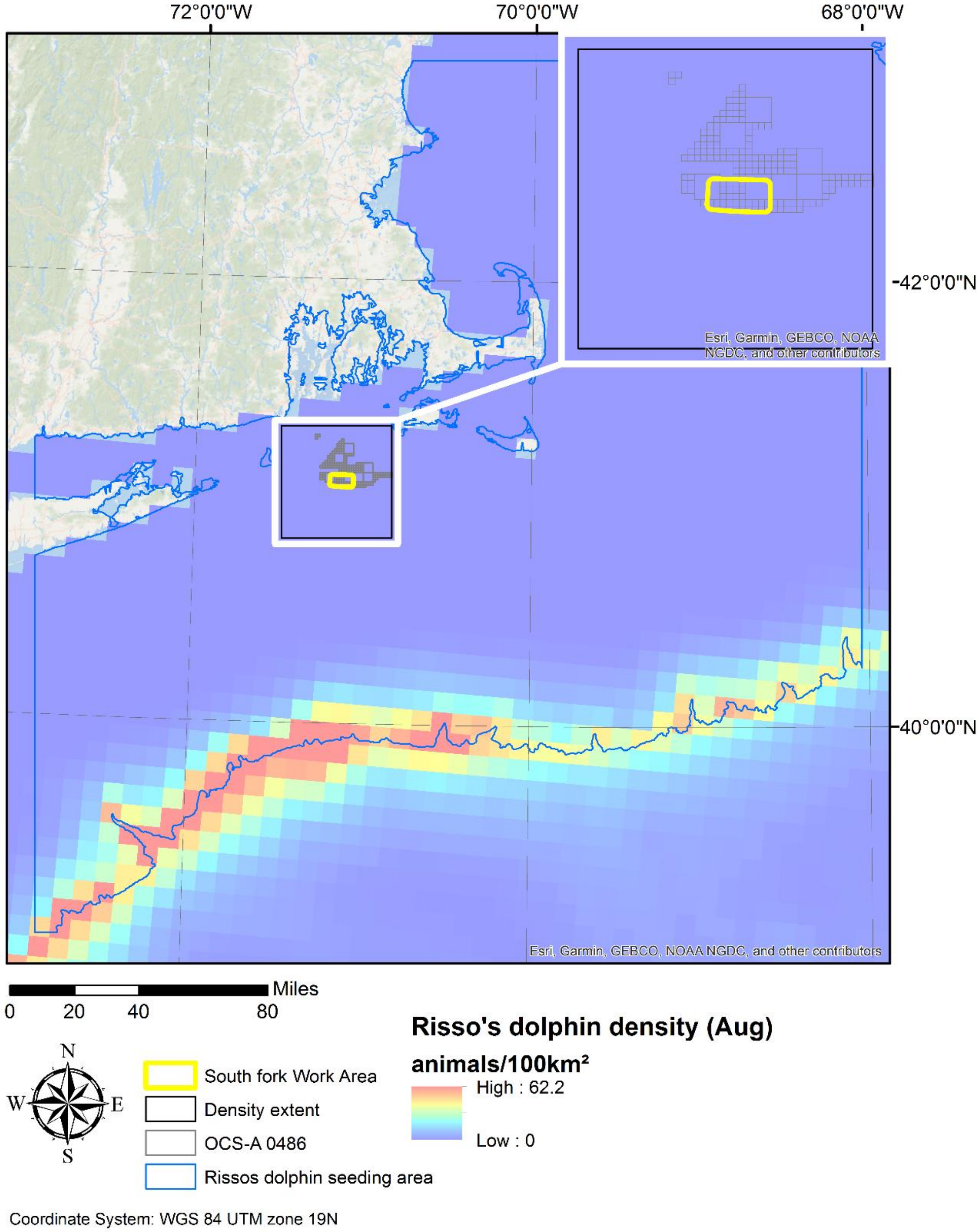

Figure A-10. Map of Risso's dolphin animat seeding range with density from Roberts et al. (2016) for August, the month with the highest density in the simulation.

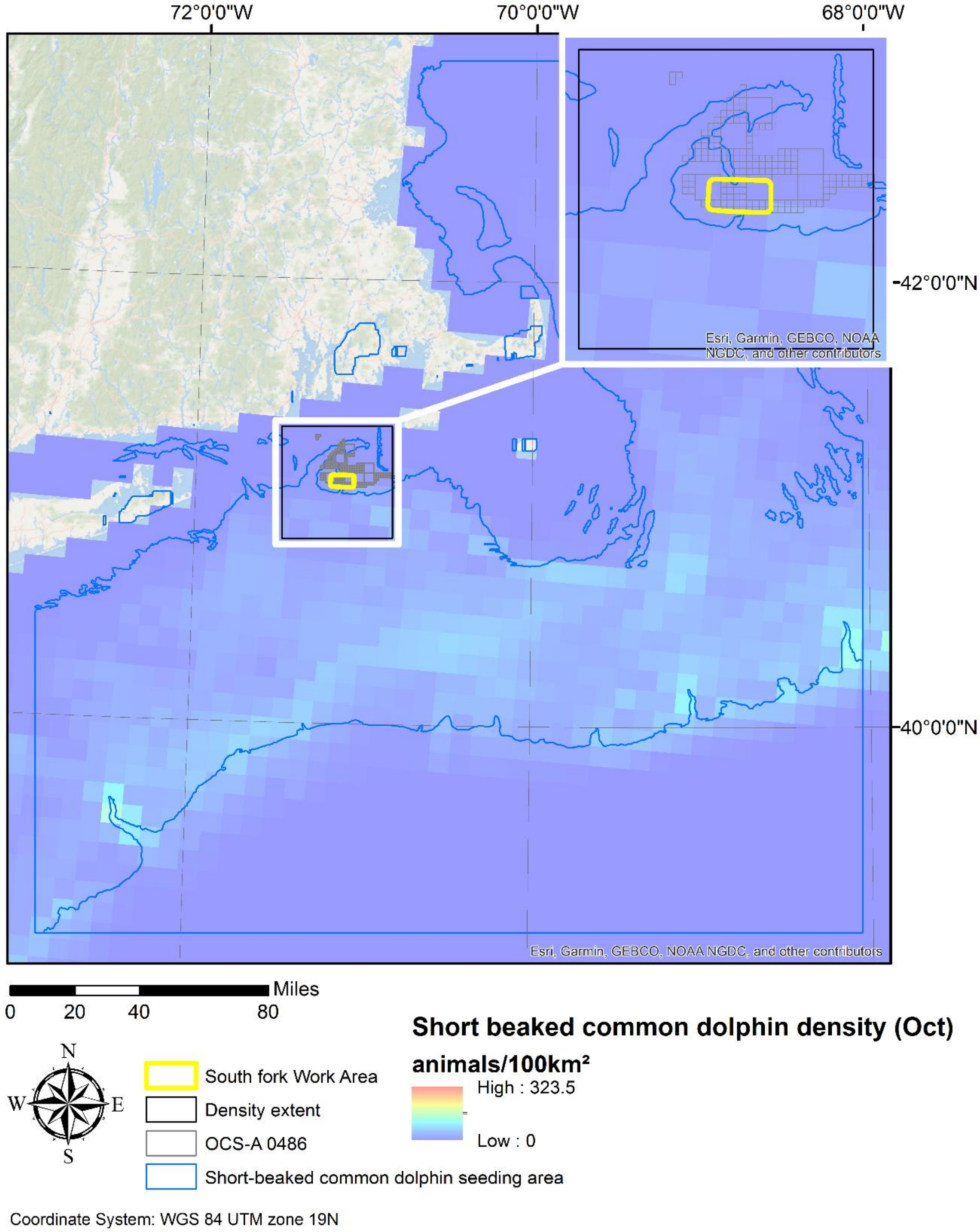

Figure A-11. Map of short-beaked common dolphin animat seeding range with density from Roberts et al. (2016) for October, the month with the highest density in the simulation.

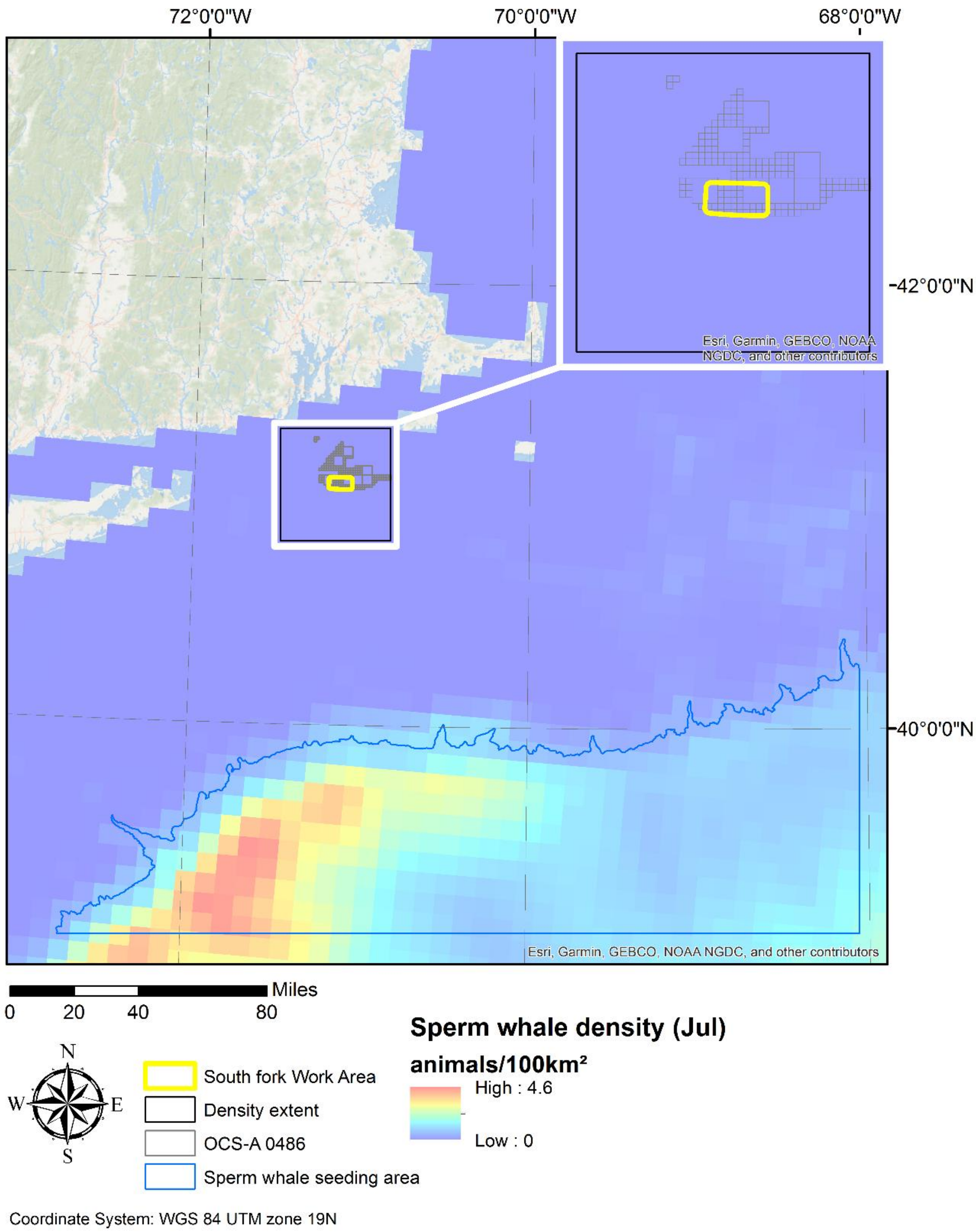

Figure A-12. Map of sperm whale animat seeding range with density from Roberts et al. (2016) for July, the month with the highest density in the simulation.

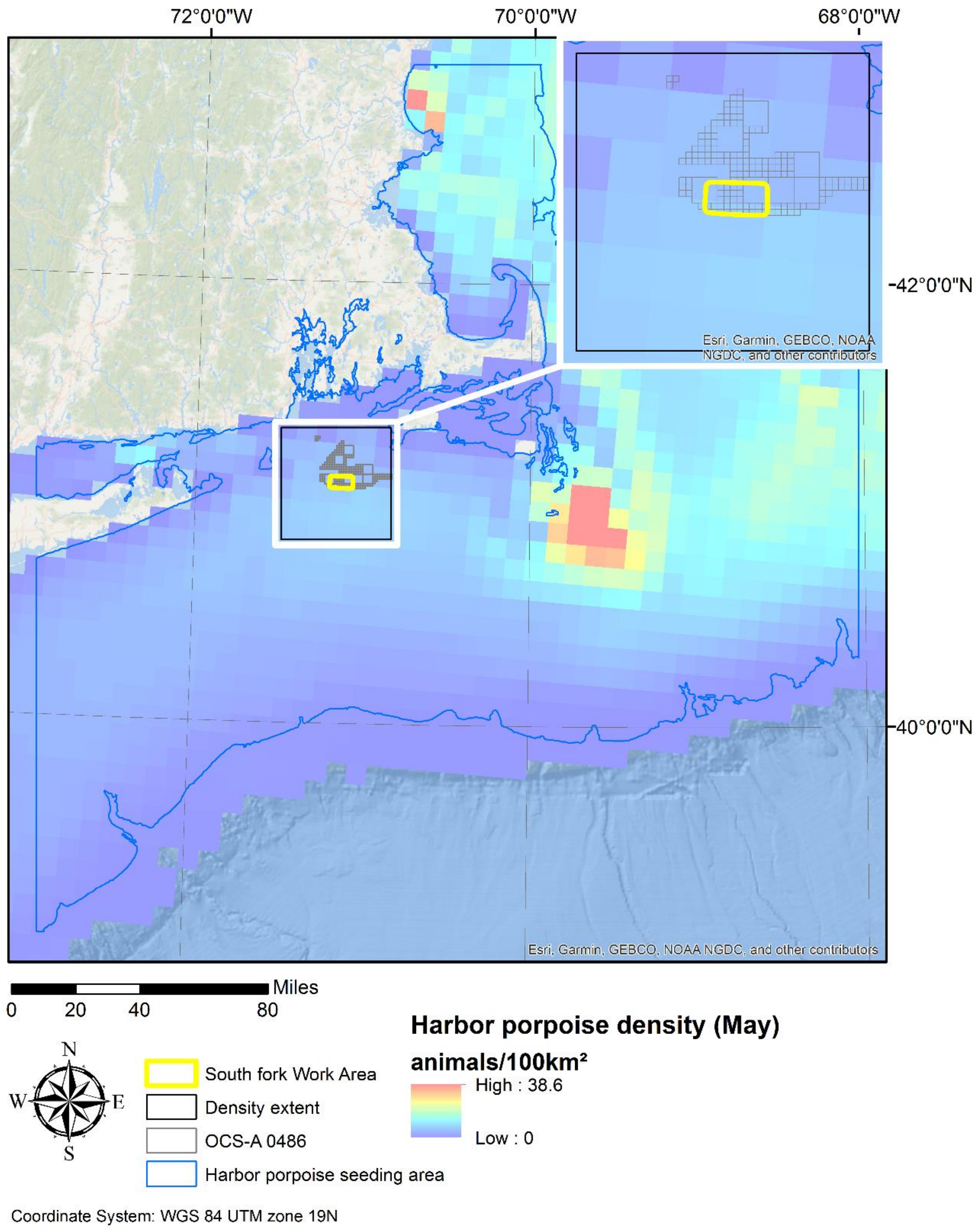

Figure A-13. Map of harbor porpoise animat seeding range with density from Roberts et al. (2016) for May, the month with the highest density in the simulation.

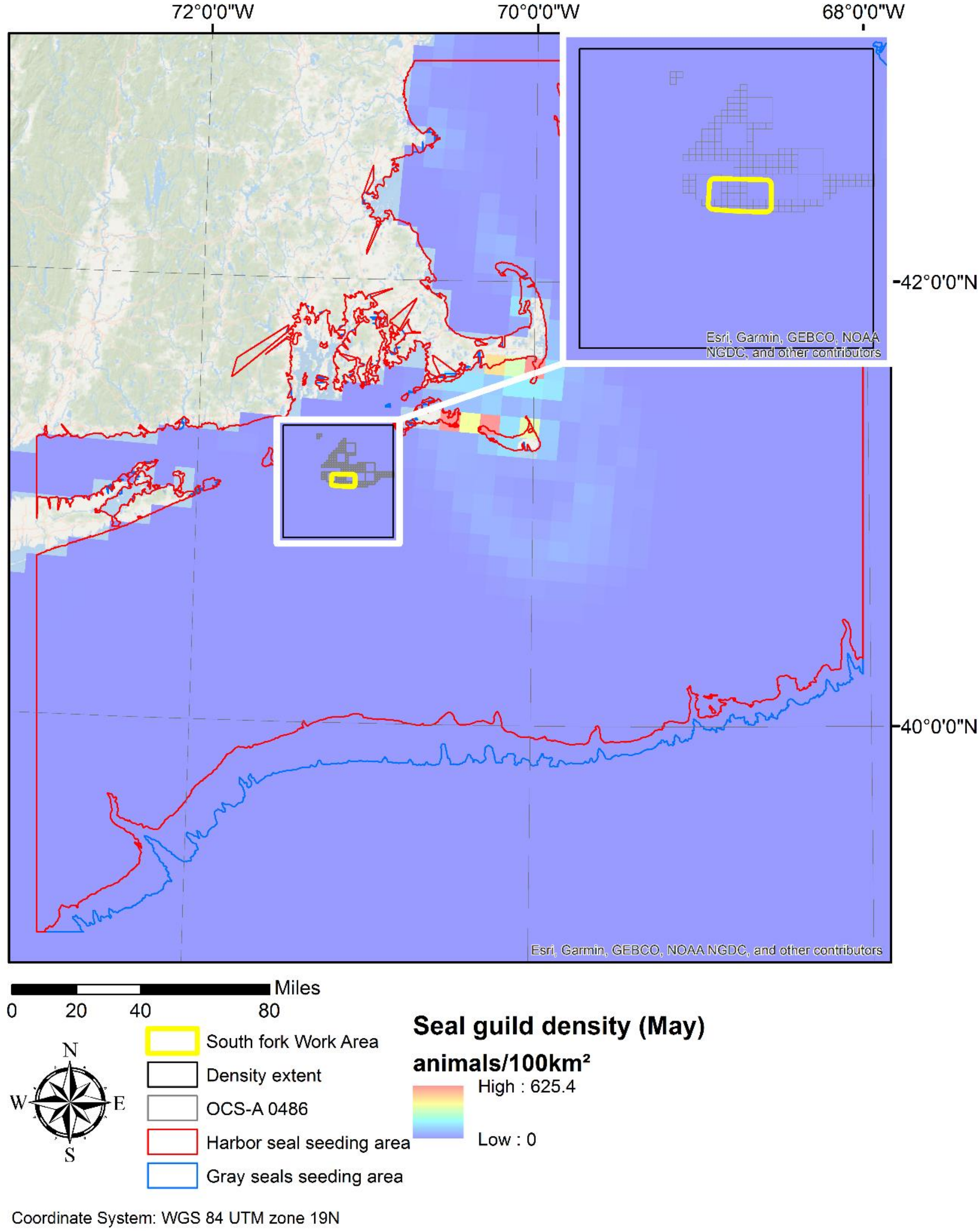

Figure A-14. Map of gray and harbor seal animat seeding range with density from Roberts et al. (2015) for May, the month with the highest density in the simulation.

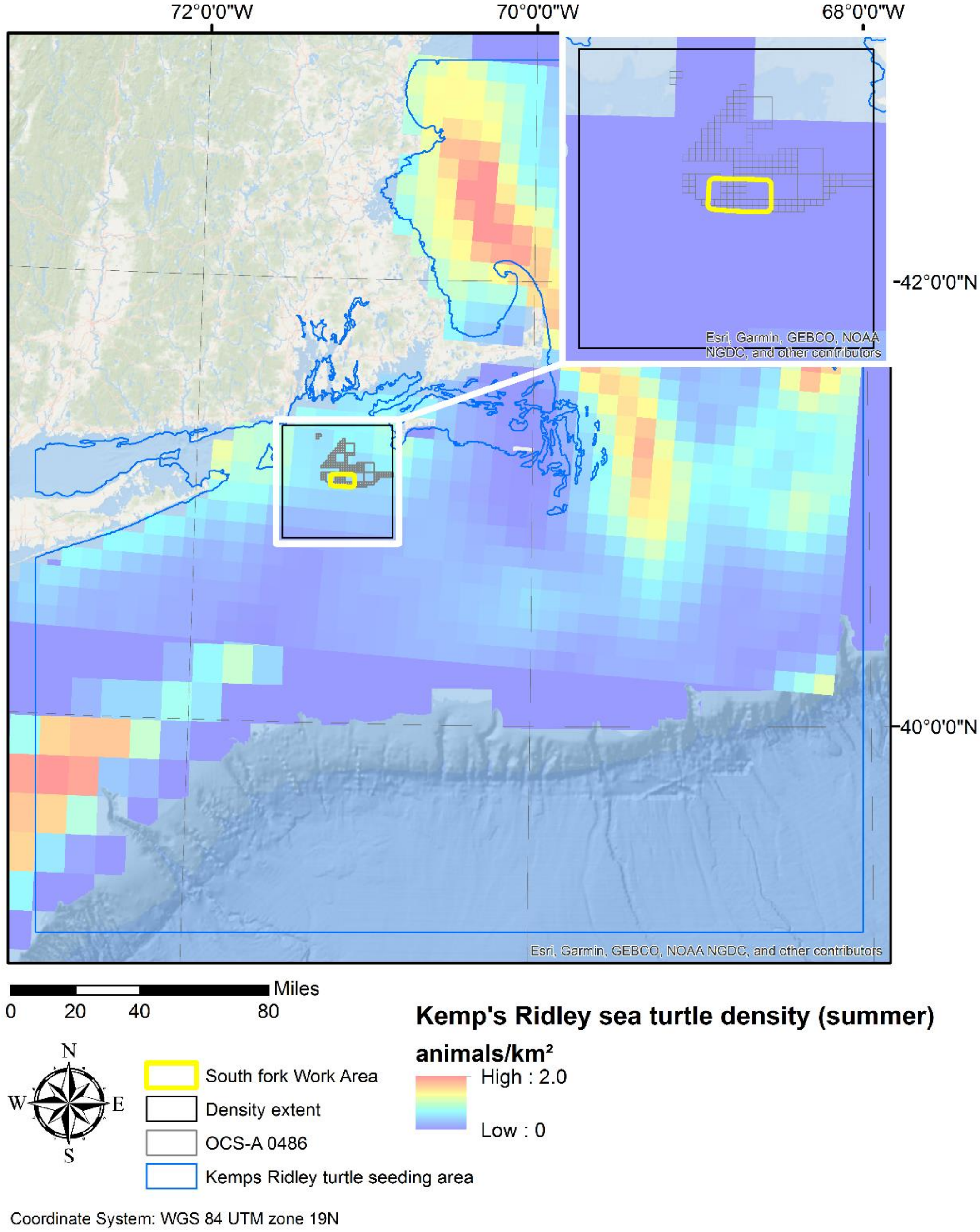

Figure A-15. Map of Kemp's ridley turtle animat seeding range with density from DoN (2017) for summer, the season during which the SFWF will occur.

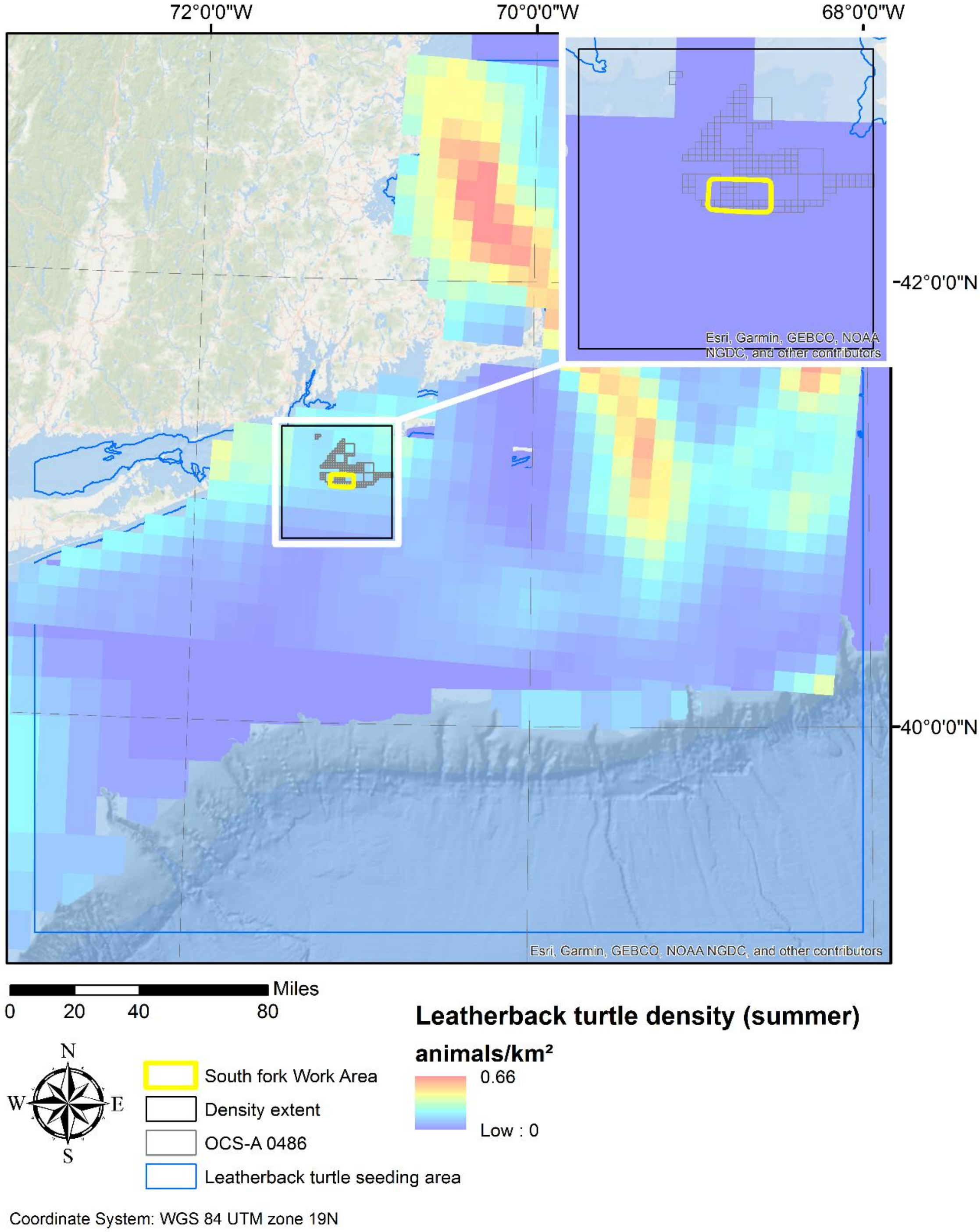

Figure A-16. Map of leatherback sea turtle animat seeding range with density from DoN (2017) for summer, the season during which the SFWF will occur.

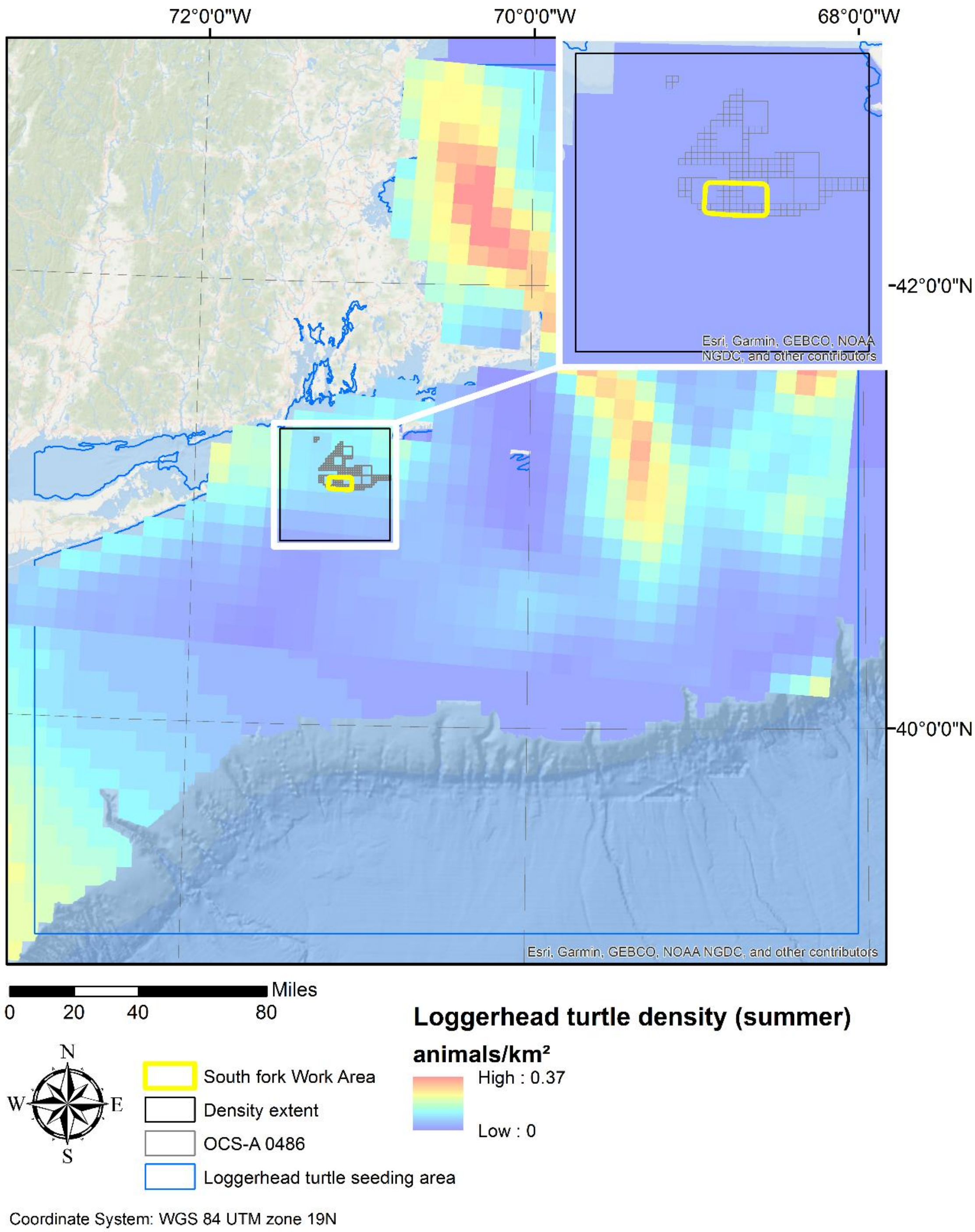

Figure A-17. Map of loggerhead sea turtle animat seeding range with density from DoN (2017) for summer, the season during which the SFWF will occur.