Request for Letter of Authorization for the Incidental Harassment of Marine Mammals Resulting from Marine Structure Maintenance, Pile Replacement, and Select Waterfront Improvements

Naval Station Norfolk
Norfolk, Virginia

May 2020

Submitted to:

Office of Protected Resources,
National Marine Fisheries Service,
National Oceanic and Atmospheric Administration

Prepared by:

NAVFAC MIDLANT

Prepared for:

Naval Station Norfolk

This page intentionally left blank.

Executive Summary

The United States Department of the Navy (Navy) is applying for a Letter of Authorization for the incidental take of marine mammals resulting from the proposed marine structure maintenance, pile replacement, and select waterfront improvements to waterfront structures at Naval Station Norfolk, Defense Fuel Supply Point Craney Island, and Lambert's Point Deperming Station. Repair projects would include extraction of structurally unsound 12-inch dolphin and fender timber piles and installation of 16-inch composite fender piles. The Proposed Action would also provide upgrades to two waterfront facilities, the Morale, Welfare, and Recreation Marina and the V-Area. These projects would include the installation of load-bearing 24-inch pre-stressed concrete piles and 16-inch composite fender piles, as well as subsequent fender pile replacement during ongoing maintenance. These activities would occur over a five-year period (2021 through 2025). Vibratory and impact pile driving associated with proposed pile replacement activities have the potential to affect marine mammals within marine waters adjacent to these Navy installations and could result in harassment under the Marine Mammal Protection Act (MMPA) of 1972, as amended.

Pursuant to MMPA Section 101(a)(5)(A), the Navy submits this application to the National Marine Fisheries Service for the authorization of incidental, but not intentional, taking of individuals of five marine mammal species during pile driving activities for the Proposed Action from 2021 through 2025. The taking will be non-injurious and temporary. All taking is expected to have a negligible impact on populations of these species. In addition, the taking will not have an adverse impact on the availability of these species for ceremonial or subsistence use.

The Navy used the National Marine Fisheries Service promulgated thresholds for assessing pile driving impacts to marine mammals, and advanced noise transmission loss modeling that incorporated bathymetry and empirically measured source levels from other similar pile driving projects to estimate potential marine mammal exposures to pile driving noise. Predicted exposures are described in detail in Section 6 (Numbers and Species Exposed) and summarized in Table ES-1. Level A harassments associated with pile driving activities will be avoided for all species by implementing mitigation measures described in Section 11 (Means of Effecting the Least Practicable Adverse Impacts). The conservative assumptions (including marine mammal densities and other assumptions) used to estimate the exposures are likely to overestimate the potential number of exposures.

Regulations governing the issuance of incidental take under certain circumstances are codified at 50 Code of Federal Regulations part 216, subpart I (sections 216.101–216.108). Section 216.104 sets forth 14 specific items that must be addressed in requests for take pursuant to section 101 (a)(5)(A) of the MMPA. These 14 items are addressed in Sections 1 through 14 of this Letter of Authorization application.

Table ES-1 Total Underwater Exposure Estimates by Species by Year

Species	*Level A*	*Level B*					
		2021	*2022*	*2023*	*2024*	*2025*	*Total*
Humpback whale	0	3	2	1	2	4	12
Bottlenose dolphin	0	4,401	1,777	381	1,608	3,977	12,144
Harbor porpoise	0	7	3	1	3	6	20
Harbor seal	0	208	84	18	76	188	574
Gray seal	0	3	2	1	2	4	12

This page intentionally left blank.

TABLE OF CONTENTS

1 Introduction and Description of Activities 1-1

1.1 Introduction 1-1

1.2 Description of Activities 1-3

1.2.1 Fender Pile Replacement; NAVSTA Norfolk Piers, Craney Island, and Lambert's Point 1-3
1.2.2 Waterfront Improvements; MWR Marina and V-Area 1-3
1.2.3 General Description of Pile Removal and Installation Methods 1-7
1.2.4 Pile Driving Information by Pile Type 1-8
1.2.5 Marine Structure Maintenance 1-9
1.2.6 Construction Access and Project Staging 1-11

1.3 Best Management Practices and Mitigation and Minimization Measures 1-11

2 Dates, Duration, and Location of Activities 2-1

2.1 Dates and Duration of Activities 2-1

2.2 Project Location Description 2-1

2.2.1 Marine and Bathymetric Setting 2-2
2.2.2 Shorelines 2-2
2.2.3 Water Quality 2-2
2.2.4 Sediments 2-3
2.2.5 Ambient Sound 2-4

3 Marine Mammal Species and Numbers 3-1

3.1 Marine Mammal Species Likely to be Found within the Activity Area 3-1

3.2 Estimates of Abundance within the Activity Area 3-1

3.2.1 Humpback Whale 3-2
3.2.2 Bottlenose Dolphin 3-3
3.2.3 Harbor Porpoise 3-4
3.2.4 Harbor Seal 3-4
3.2.5 Gray Seal 3-5

4 Affected Species Status and Distribution 4-1

4.1 Humpback Whale 4-1

4.1.1 Status and Management 4-1
4.1.2 Distribution 4-1
4.1.3 Site-Specific Occurrence 4-2

4.2 Bottlenose Dolphin 4-2

4.2.1 Status and Management 4-2
4.2.2 Distribution 4-3
4.2.3 Site-Specific Occurrence 4-3

4.3 Harbor Porpoise 4-4

4.3.1 Status and Management 4-4
4.3.2 Distribution 4-4
4.3.3 Site-Specific Occurrence 4-4

4.4 Harbor Seal 4-5
4.4.1 Status and Management 4-5
4.4.2 Distribution 4-5
4.4.3 Site-Specific Occurrence 4-5

4.5 Gray Seal 4-6
4.5.1 Status and Management 4-6
4.5.2 Distribution 4-6
4.5.3 Site-Specific Occurrence 4-6

5 Take Authorization Requested 5-1

5.1 Take Authorization Request 5-1

5.2 Method of Incidental Taking 5-1

6 Numbers and Species Exposed 6-1

6.1 Introduction 6-1

6.2 Description of Noise Sources 6-1

6.3 Marine Mammal Hearing 6-2

6.4 Sound Exposure Criteria and Thresholds 6-3

6.5 Limitations of Existing Noise Criteria 6-5

6.6 Auditory Masking 6-6

6.7 Modeling Potential Noise Impacts from Pile Driving 6-7
6.7.1 Underwater Sound Propagation 6-7
6.7.2 Underwater Noise from Pile Driving 6-7

6.8 Airborne Sound Propagation 6-19

6.9 Estimated Duration of Pile Driving 6-20

6.10 Evaluation of Potential Species Presence 6-21

6.11 Estimating Potential Exposures to Pile Driving Noise 6-21
6.11.1 Approach to Estimating Abundance of Marine Mammals Exposed to Noise 6-21
6.11.2 Assumptions 6-22
6.11.3 Avoidance of Level A Exposure 6-23

6.12 Exposure Estimates 6-24
6.12.1 Humpback Whale 6-24
6.12.2 Bottlenose Dolphin 6-24
6.12.3 Harbor Porpoise 6-26
6.12.4 Harbor Seal 6-26
6.12.5 Gray Seal 6-27

7 Impacts to Marine Mammal Species or Stocks 7-1

7.1 Potential Effects of Pile Driving on Marine Mammals 7-1
7.1.1 Potential Effects Resulting from Underwater Noise 7-1
7.1.2 Potential Effects Resulting from Airborne Noise 7-4

7.2 Conclusions Regarding Impacts to Species or Stocks 7-5

8 Impacts to Subsistence Use 8-1

9 Impacts to the Marine Mammal Habitat and the Likelihood of Restoration 9-1

9.1 Effects from Human Activity and Noise 9-1

9.2 Impacts on Prey Base 9-1
9.2.1 Water Quality 9-2
9.2.2 Underwater Noise Impacts on Prey Base 9-2

9.3 Likelihood of Habitat Restoration 9-3

10 Impacts to Marine Mammals from Loss or Modification of Habitat 10-1

11 Means of Effecting the Least Practicable Adverse Impacts 11-1

11.1 General Construction Best Management Practices 11-1

11.2 Pile Repair, Removal, and Installation Best Management Practices 11-1
11.2.1 Creosote Pile Removal 11-1
11.2.2 General Pile Removal and Replacement 11-2

11.3 Minimization Measures for Marine Mammals and Other Protected Species 11-2
11.3.1 Coordination 11-2
11.3.2 Limits on Changes to Structure Footprint 11-2
11.3.3 Soft Start 11-3
11.3.4 Species Monitoring and Shutdown 11-3
11.3.5 Mitigation Effectiveness 11-4

12 Effects on Arctic Subsistence Hunting and Plan of Cooperation 12-1

13 Monitoring and Reporting Efforts 13-1

13.1 Coordination 13-1

13.2 Monitoring Plans 13-1
13.2.1 Visual Monitoring 13-1

13.3 Reporting 13-4

14 Research Efforts 14-1

15 References 15-1

List of Tables

Table ES-1 Total Underwater Exposure Estimates by Species by Year ES-1
Table 1-1 Fender Piles to Be Replaced at NAVSTA Norfolk Piers, DFSP Craney Island, and Lambert's Point 1-4
Table 1-2 Load-Bearing Piles to be Installed at MWR Marina and V-Area 1-7
Table 1-3 Fender/Guide Piles to be Installed at MWR Marina and V-Area 1-7
Table 3-1 Marine Mammals Potentially Present Within the Lower Chesapeake Bay 3-2
Table 5-1 Total Underwater Exposure Estimates by Species 5-1
Table 6-1 Representative Levels of Underwater Anthropogenic Noise Sources 6-2
Table 6-2 Hearing Ranges for Marine Mammal Functional Hearing Groups and Species Potentially Within the MPU Project Area 6-3
Table 6-3 Injury and Disturbance Threshold Criteria for Underwater and Airborne Noise 6-4
Table 6-4 Underwater Noise Source Levels Modeled for Underwater Impact and Vibratory Pile Driving 6-8
Table 6-5 Calculated Areas of Zones of Influence for Underwater Sound from MPU – Impact Pile Driving 6-17
Table 6-6 Calculated Areas of Zones of Influence for Underwater Sound from MPU – Vibratory Pile Driving 6-18
Table 6-7 Airborne Noise Source Levels from Impact and Vibratory Pile Driving (dB) 6-19
Table 6-8 Calculated Distances to Threshold for Phocids and Areas of Zones of Influence for Airborne Sound from MPU Impact Pile Driving[1] 6-20
Table 6-9 Pile Driving Duration Summary 6-20
Table 6-10 Underwater Exposure Estimates by Species 6-24
Table 6-11 Bottlenose Dolphin Seasonal Densities and Level B Take Estimates 6-25

List of Figures

Figure 1-1 Location 1-2
Figure 1-2 NAVSTA Norfolk Piers, MWR Marina, and V-Area 1-5
Figure 1-3 Craney Island Fuel Depot and Lambert's Point Deperming Station 1-6
Figure 6-1 Pier 3 Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-9
Figure 6-2 Pier 12 Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-10
Figure 6-3 MWR Marina Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-11

Figure 6-4 MWR Marina Concrete Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-12
Figure 6-5 V-Area Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-13
Figure 6-6 V-Area Concrete Predicted Pile Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving Marine Mammals 6-14
Figure 6-7 Lambert's Point Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-15
Figure 6-8 Craney Island Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving 6-16
Figure 13-1 Proposed Protected Species Observer Locations 13-3

List of Appendices

Appendix A Pile Installation and Removal by Location and Year A-1
Appendix B Acoustic Transmission Loss Modeling and Take Analysis Methods for Marine Structure Maintenance, Pile Replacement, and Select Waterfront Improvements B-1

Abbreviations and Acronyms

Acronym	*Definition*
ACZA	ammoniacal copper zinc arsenate
avg	average
BMP	best management practice
CBBT	Chesapeake Bay Bridge Tunnel
CCA	copper chrome arsenic
CV	coefficient of variation
dB	decibel
dB re 1 µPa	decibels referenced to 1 micropascal
dB re 1 $\mu Pa^2 sec$	decibels referenced to 1 micropascal-squared second
dB RMS SPL re 1 µPa	decibels root mean square sound pressure level referenced to 1 micropascal
dB RMS SPL re 20 µPa	decibels root mean square sound pressure level referenced to 20 micropascal
dBA	A-weighted sound level
DFSP	Defense Fuel Supply Point
DO	dissolved oxygen
ELIPH	Lower Elizabeth Polyhaline
ES	Estuarine System
ESA	Endangered Species Act
FR	Federal Register
GPS	Global Positioning System
HDPE	high-density polyethylene
HF	high-frequency
Hz	hertz
in	inch/inches
JEBLC	Joint Expeditionary Base Little Creek
JMSPH	James River at Hampton Roads Harbor Polyhaline
kHz	kilohertz
km	kilometer
L_{eq}	equivalent continuous sound level
LF	low-frequency
L_{max}	maximum sound level
LMR	Living Marine Resources
LOA	Letter of Authorization
m	meter
MF	mid-frequency
MLW	mean low water
MMPA	Marine Mammal Protection Act
MPU	marine structure maintenance, pile replacement, and upgrades
MWR	morale, welfare, and recreation
N/A	not applicable
n/a	not available
No.	number

Acronym	***Definition***
NAVBASE	Naval Base
NAVSTA	Naval Station
Navy	U.S. Department of the Navy
NC	North Carolina
NM	Northern Migratory
NMFS	National Marine Fisheries Service
PCB	polychlorinated biphenyl
PSO	protected species observers
PTS	permanent threshold shift
R&D	research and development
re 20 µPa	referenced to 20 micropascal
RMS	root mean square (sound pressure level)
SEL	sound exposure level
SEL_{CUM}	cumulative sound exposure level
SM	Southern Migratory
SMC	Southern Migratory Coastal
SPL	sound pressure level
sq ft	square feet
sq km	square kilometer
TL	transmission loss
TPH	total petroleum hydrocarbons
TTS	temporary threshold shift
UME	unusual mortality event
UNK	unknown
U.S.	United States
USACE	U.S. Army Corps of Engineers
ZOI	zone of influence

This page intentionally left blank.

1 Introduction and Description of Activities

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

1.1 Introduction

The United States (U.S.) Department of the Navy (Navy) is proposing to conduct marine structure maintenance, pile replacement, and upgrades (MPU) activities at waterfront facilities at Naval Station (NAVSTA) Norfolk, Defense Fuel Supply Point Craney Island, and Lambert's Point Deperming Station (Figure 1-1). Repair activities would include extraction of structurally unsound 12-inch dolphin and fender timber piles and installation of 16-inch composite fender piles. These activities would occur over a five-year period (2021 through 2025).

The Proposed Action would also provide upgrades to two waterfront facilities, the Morale, Welfare, and Recreation (MWR) Marina and the V-Area, which are located on NAVSTA Norfolk (Figure 1-2). These projects would include the installation of load-bearing 24-inch pre-stressed concrete piles and 16-inch composite fender piles, as well as subsequent fender pile replacement during ongoing maintenance. The Proposed Action includes individual actions currently planned as well as estimates for emergent requirements.

Under the Marine Mammal Protection Act of 1972, as amended (16 U.S. Code section 1371(a)(5)(D)), the Navy is requesting a Letter of Authorization (LOA) for pile driving and removal activities that are expected to result in the unintentional taking of marine mammals. The 14 specific items required for this application, as set out by 50 Code of Federal Regulations 216.104 Submission of Requests, are provided in Sections 1 through 14 of this application.

This multi-year request for an LOA replaces multiple, project-by-project requests. This approach should result in increased efficiency for National Oceanic and Atmospheric Administration Fisheries, also known as National Marine Fisheries Service, as opposed to processing multiple authorizations for actions that are small in scale, similar in nature, and located within a similar geographic area; provide a detailed discussion of planned or anticipated projects allowing for a better cumulative analysis; and provide a reduction in the preparation and authorization time necessary to obtain individual Marine Mammal Protection Act authorizations.

Because this LOA application contains a number of projects at several different locations, this application provides:

(1) General information common to activities covered under the MPU, such as a general description of activities that could occur at any in-water structure and analysis of general effects to species if exposed to specific activities within the MPU; and

(2) Location-specific information describing site-specific baseline conditions, species occurrence information, and the site-specific potential for species exposure to effects from activities covered under the MPU.

The Navy is concurrently in a consultation for the Proposed Action with the National Marine Fisheries Service and U.S. Fish and Wildlife Service under section 7(a) of the Endangered Species Act of 1973, as amended (16 U.S. Code section 1531 et seq.).

Figure 1-1 Location

1.2 Description of Activities

The Navy's existing waterfront inspection program identifies fender pile system deficiencies and prioritizes, designs, and conducts maintenance and repairs. The inspection program also addresses repairs (emergent projects) required due to unforeseen events such as weather and vessel incidents. Because construction details are unknown for all emergent projects, potential numbers of fender piles to be extracted and installed were estimated by Navy waterfront infrastructure engineers based on historic emergent maintenance pile driving actions and scheduled/forecasted maintenance.

The Proposed Action includes individual projects (where an existing need has been identified) and estimates for emergent or emergency repairs. Potential impacts to marine mammals from MPU activities are only expected from noise produced from vibratory pile extraction and vibratory or impact pile installation.

The Navy proposes to conduct MPU activities over a five-year period. The Navy would also upgrade waterfront facilities at two areas. The methods described in this section are considered representative of typical Navy in-water/overwater construction methods that may be utilized. The actual methods and materials used may differ slightly, depending on the specific project requirements and/or development of new methods and materials representing improvements or advantages to current methods and/or to comply with updated Navy guidance on best management practices (BMPs) or minimization measures related to waterfront infrastructure. Elements of the proposed MPU activities are described below.

1.2.1 Fender Pile Replacement; NAVSTA Norfolk Piers, Craney Island, and Lambert's Point

Most in-water structures are pile-supported; therefore, repair of these structures typically involves removal of existing piles and installation of new piles or repair of existing piles in-place. Fender piles (or guide piles) protect in-water structures from direct contact with vessels and are not load-bearing. A full list of all pile replacement and removal in each year of the overall MPU project is provided in Appendix A. In this portion of the MPU project area, all piles to be replaced are fender piles. In-water piles may be treated timber, pre-stressed concrete, high-density polyethylene (HDPE) plastic, or hollow core fiberglass. Existing timber piles are generally treated with creosote or copper based wood preservatives, (e.g., ammoniacal copper zinc arsenate [ACZA], copper chrome arsenic [CCA]), to preserve the wood.

Existing timber fender piles would be replaced by either composite (HDPE or hollow core fiberglass) or timber fender piles (only installed depending on availability of composite piles). Below is a description of the various pile replacement methods that may be used under the Proposed Action. Table 1-1 provides pile sizes, materials, and estimated numbers to be removed and installed at each location during the five years of proposed MPU activities. Figure 1-2 and Figure 1-3 show the location of these piers.

1.2.2 Waterfront Improvements; MWR Marina and V-Area

The MWR Marina features 200 deep water slips, a boat ramp, and other recreational boating facilities (Figure 1-2). The mission of the MWR is to contribute to the retention, readiness, and mental, physical and emotional well-being of military personnel and to the welfare of their families by providing a varied program of recreational, social, and community activities. Upgrades to the MWR Marina would consist of the replacement of timber load-bearing and guide piles with 24-by-24-inch square pre-stressed concrete and composite or timber fender piles, respectively. A full list of all pile replacement and removal in each year of the overall MPU project is provided in Appendix A.

Table 1-1 Fender Piles to Be Replaced at NAVSTA Norfolk Piers, DFSP Craney Island, and Lambert's Point

Location	*Pier/Bulkhead*	*Existing Pile Numbers and Types to Be Removed*							*Pile Numbers and Types to Be Installed*						
		2021	*2022*	*2023*	*2024*	*2025*	*Total*	*Type*	*2021*	*2022*	*2023*	*2024*	*2025*	*Total*	*Type*
NAVSTA Norfolk Piers	Pier 1	20	20	20	325	0	385	12-inch timber	20	0	0	267	0	287	16-inch composite
	Pier 09	20	20	20	20	453	533	12-inch timber	0	0	0	0	330	330	16-inch composite
	Pier 10	20	20	20	20	455	535	12-inch timber	0	0	0	0	330	330	16-inch composite
	Pier C	172	0	0	0	0	172	12-inch timber	80	0	0	0	0	80	16-inch composite
	Pier D	358	0	0	0	0	358	12-inch timber	108	0	0	0	0	108	16-inch composite
	Pier E	0	275	0	0	0	275	12-inch timber	0	108	0	0	0	108	16-inch composite
	Pier F	0	180	0	0	0	180	12-inch timber	0	88	0	0	0	88	16-inch composite
	Pier 12	20	20	20	20	20	100	12-inch timber	0	0	0	0	140	140	16-inch composite
	Pier 14	20	20	20	20	20	100	12-inch timber	0	0	0	0	45	45	16-inch composite
DFSP Craney Island	Pier Charlie	272	0	0	0		272	12-inch timber	258	0	0	0	0	258	16-inch composite
Lambert's Point Deperming Station	Pier A - Timber Dolphin	17	0	0	0		17	12-inch timber	17	0	0	0	0	17	16-inch composite
	Pier B	12	0	0	0		12	12-inch timber	12	0	0	0	0	12	16-inch composite

Key: DFSP = Defense Fuel Supply Point; NAVSTA = Naval Station.

The V-Area currently features a bulkhead, a breakwater, two floating piers, and a boat ramp (Figure 1-2). The V-Area supports a Navy Coastal Riverine Squadron, whose mission includes: harbor and homeland defense, coastal surveillance, and special missions. Upgrades to this area would include the construction of two additional floating docks, for a total addition of approximately 4,095 square feet (sq ft) of dock space. These docks would be constructed using 24-by-24-inch square pre-stressed concrete for the load-bearing piles and composite or timber fender/guide piles, respectively.

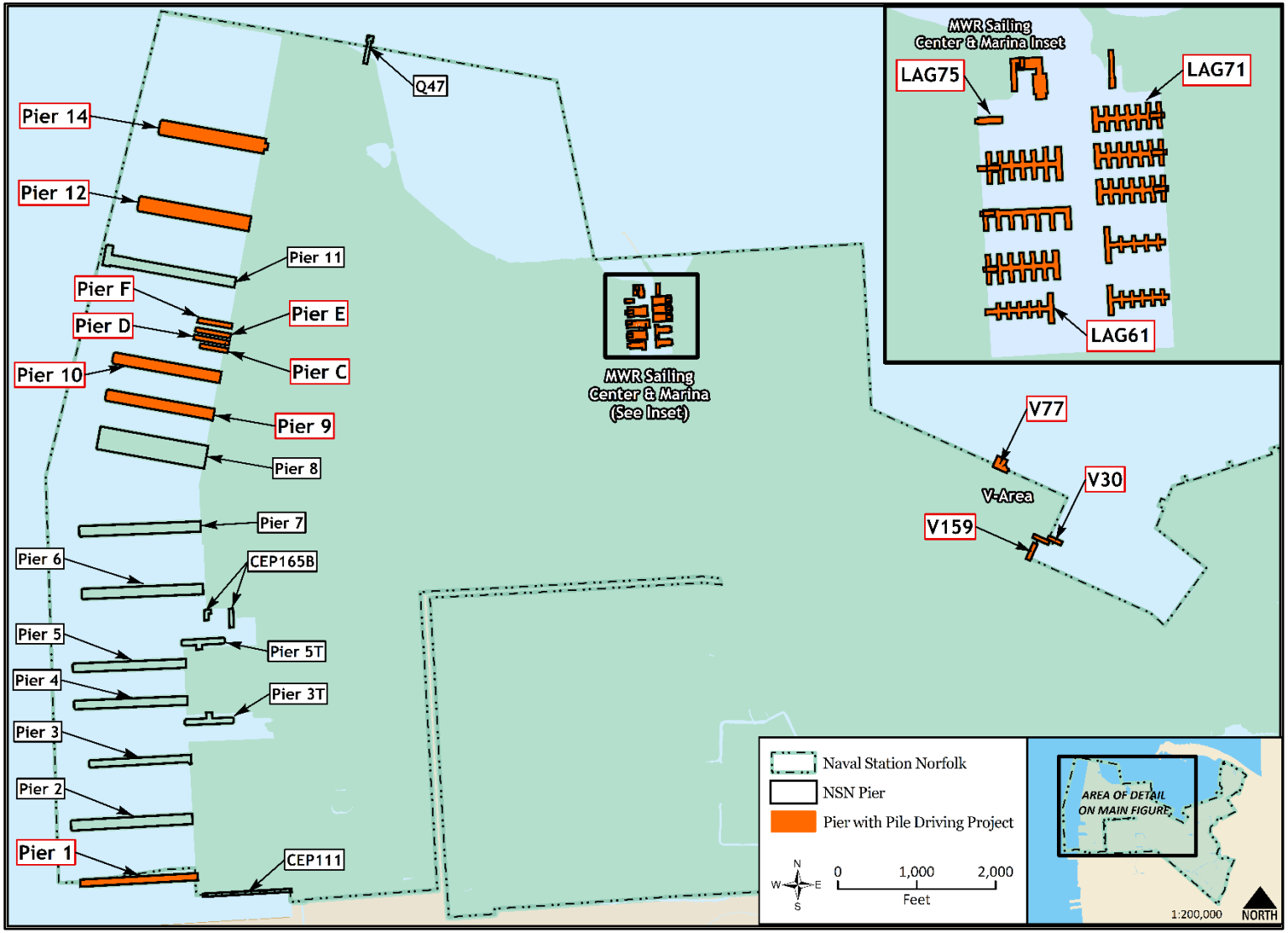

Figure 1-2 NAVSTA Norfolk Piers, MWR Marina, and V-Area

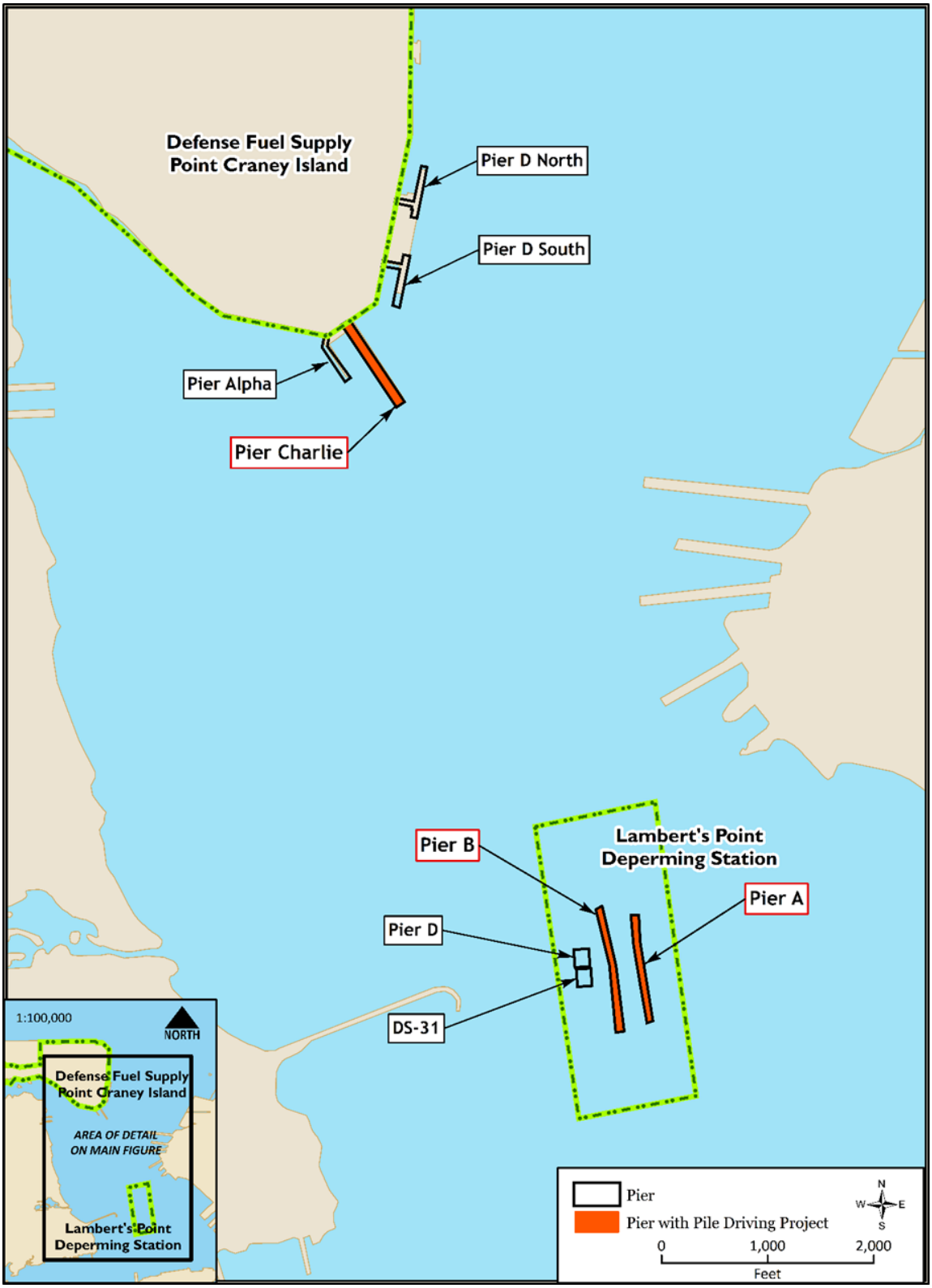

Figure 1-3 Craney Island Fuel Depot and Lambert's Point Deperming Station

For the purposes of this assessment, the upgrades would occur in Project Year One, with maintenance replacements occurring thereafter. Table 1-2 and Table 1-3 below detail the piles for the MWR Marina and the V-Area upgrades. Concrete piles are anticipated to be fully impact driven. Composite piles are anticipated to be impact or vibratory driven depending on pile type—hollow core fiberglass piles can be impact or vibratory driven, while HDPE piles would be impact driven.

Table 1-2 Load-Bearing Piles to be Installed at MWR Marina and V-Area

Location	*Existing Pile Types to Be Removed[1]*		*Pile Types to Be Installed[1]*	
	Number	*Type*	*Number*	*Type*
MWR Marina	50	12-inch timber	50	24-by-24-inch square pre-stressed concrete
V-Area	N/A	N/A	50	24-by-24-inch square pre-stressed concrete

Key: MWR = morale, welfare, and recreation; N/A = not applicable.
Notes:
1. All piles are to be removed/installed in 2021.

Table 1-3 Fender/Guide Piles to be Installed at MWR Marina and V-Area

Location	*Existing Pile Types to Be Removed*		*Pile Types to Be Installed*	
	Number	*Type*	*Number*	*Type*
MWR Marina	50[1]	12-inch timber[1]	50[1]	16-inch composite[1]
	40[2]	16-inch composite[2]	40[2]	16-inch composite[2]
V-Area	N/A[1]	N/A[1]	50[1]	16-inch composite[1]
	40[2]	16-inch composite[2]	40[2]	16-inch composite[2]

Key: MWR = morale, welfare, and recreation; N/A = not applicable.
Notes:
1. Initial upgrade/construction (2021)
2. Maintenance replacements over five-year project span (10 piles per year at each location [2022–2025])

1.2.3 General Description of Pile Removal and Installation Methods

1.2.3.1 Pile Removal

Three methods of pile removal (vibratory extraction, clamshell removal, and direct pull) may be used depending on site conditions.

All materials and waste would be disposed of in accordance with applicable federal and state requirements. Creosote-treated piles would be cut into smaller segments in a manner that precludes further use and disposed of at a facility that is permitted to accept them. With the exception of creosote-treated piles, the Navy would evaluate if it would be possible to reclaim or recycle the materials. The three pile removal methods are described below.

- Vibratory Extraction

Vibratory extraction using a barge-mounted crane with a vibratory driver is a common method for removing all pile types. The vibratory driver is a large mechanical device (5 to 16 tons) suspended from a crane by a cable and positioned on top of a pile. The pile is then loosened from the sediments by activating the driver and slowly lifting up on the driver with the aid of the crane. Once the pile is released from the sediments, the crane continues to raise the driver and pull the pile from the sediment.

The driver is typically shut off once the pile is loosened from the sediments. The pile is then pulled from the water and placed on a barge. Vibratory extraction usually takes between less than 1 minute (for timber piles) to 30 minutes per pile depending on the pile size, type, and substrate conditions.

- Clamshell

In some cases, removal with a vibratory driver is not possible because the pile may break apart from the force of the clamp and the vibration. If piles break or are damaged, a clamshell apparatus may be lowered from the crane in order to remove pile stubs. A clamshell is a hinged steel apparatus that operates similar to a set of steel jaws. The bucket is lowered from a crane and the jaws grasp the pile stub as the crane pulls upward. The use and size of the clamshell bucket would be minimized to reduce the potential for generating turbidity from disturbing and resuspending bottom sediment during pile removal.

- Direct Pull

Based on site conditions, piles may be removed by wrapping the piles with a cable or chain and pulling them directly from the sediment with a crane. In some cases, depending on access and location, piles may be cut at or below the mud-line.

1.2.3.2 Pile Installation

Impact and vibratory hammers may be used to install piles at NAVSTA Norfolk. Impact hammers have guides that hold the hammer in alignment with the pile while a heavy piston moves up and down striking the top of the pile and driving the pile into the substrate from the downward force of the hammer. To drive the pile, a pile is first moved into position and set into the proper location by placing a choker cable around a pile and lifting it into vertical position with the crane. Once the pile is properly positioned, the impact hammer is activated and the pile is driven. Vibratory hammers work by liquefying the substrate next to the pile, resulting in the substrate losing its “grip” on the pile. The pile is then driven downward under the combined weight of the pile and the hammer.

1.2.4 Pile Driving Information by Pile Type

Replacement pile types include 16-inch composite and 24-by-24-inch square pre-stressed concrete, as summarized in Table 1-1 through Table 1-3, and discussed in the following sections.

- Concrete Piles

Fifty 24-by-24-inch square pre-stressed concrete piles would be installed at the MWR Marina, replacing 50 12-inch timber piles, and 50 concrete piles would be installed at the V-Area. All of the concrete piles would be load-bearing at these locations. Concrete piles offer several advantages over timber piles including greater resistance to environmental decay and no creosote or CCA/ACZA treatment. Concrete piles are anticipated to be fully impact driven.

- Composite (Solid HDPE Plastic or Hollow Core Fiberglass) Piles

Twelve-inch timber fender piles would be replaced by 16-inch composite piles at all piers and bulkheads that are a part of the Proposed Action. Composite piles would be either solid HDPE or hollow core fiberglass. Replacement may not be on a strict one for one basis due to different engineering specifications between timber and composite piles. Composite piles demonstrate several advantages over timber piles, such as no creosote or CCA/ACZA treatment, greater energy absorption capabilities,

and greater resistance to environmental decay. Composite piles are anticipated to be impact or vibratory driven, depending on pile type as detailed previously.

- Timber Piles

Although composite piles are preferred over timber piles for the replacement of fender piles, certain supply or funding issues may require the use of CCA/ACZA-treated timber piles at some of the piers. In the event that replacement timber piles are installed, these piles would be impact or vibratory driven.

1.2.5 Marine Structure Maintenance

While the primary focus of the Proposed Action is related to pile driving, the following marine structure maintenance activities, which are performed as needed, are included as essential waterfront maintenance activities.

1.2.5.1 Pile Repair

Several methods of pile repair may be used, including stubbing, wrapping, pile encapsulation, and welding. Pile stubbing is a process in which an existing, damaged length of timber pile above the ground line is removed and replaced with a new length of timber pile. Wrapping may be utilized on existing timber piles to protect against marine borers. Typically, flexible polyvinyl chloride is wrapped around the entire pile from the mud-line to above the water line. Epoxy-grout-filled fiberglass jackets may also be used. With this method, a fiberglass jacket is placed on the pile and is sealed at the bottom. Epoxy-grout is then poured in the annular space between the jacket and pile. There are different methods of pile encapsulation but, in general, encapsulation refers to the process of encasing piles in concrete. Encapsulation is used when a pile is damaged, but still retains some load-bearing capacity. These processes do not involve pile driving.

All of the above repair activities would occur over water or involve only minor in-water work and would be conducted with the appropriate Spill Prevention Control and Countermeasures Plan and other BMPs identified in Section 1.3 (Best Management Practices and Mitigation and Minimization Measures).

1.2.5.2 Demolition of Deck Portions

A wire saw or other equipment would be used to cut timber or concrete decks that are damaged or need replacement into sections. Sections would be removed with a crane. Debris would be captured using debris curtains/sheeting and removed from the project area. Deck pieces would be hauled to a barge and then to an upland disposal site. Large concrete deck areas requiring repair would be cast-in-place with formwork, and repairs of smaller areas would be performed using hand trowels. The concrete debris would be captured using debris curtains/sheeting and removed from the project area.

1.2.5.3 Wetwell Repair

A wetwell is an above water reinforced concrete encasement for a sanitary sewer lift station pump. Repairs would occur by removing failed and delaminated concrete. The reinforced steel substructure would then be repaired and new concrete applied. Large areas requiring concrete would be cast-in-place with formwork, and repairs of smaller areas would be performed using hand trowels. The concrete debris would be captured using debris curtains/sheeting and removed from the project area.

1.2.5.4 Recoat Piles and Mooring Fittings

Piles and mooring fittings would be cleaned prior to coating. All coatings would be applied to dry surfaces and limited to areas above mean sea level (6.5 feet mean lower low water). Coatings would be inorganic, non-toxic, and free of volatile organic compounds.

1.2.5.5 Passive Cathodic Protection System

A passive cathodic protection system is a metallic rod (anode) attached to a metal object to protect it from corrosion. The more easily oxidized metal of the anode corrodes first, protecting the primary structure from corrosion damage.

1.2.5.6 Repair or Replacement of Pile Caps

Pile caps are situated on the tops of piles located directly beneath a structure and function as a load transfer mechanism between the superstructure and the piles. Replacement concrete pile caps may be cast-in-place. Concrete framework may be located below mean higher high water. The concrete debris would be captured using curtains/sheeting and removed from the project area.

1.2.5.7 Concrete Spalling Repairs

Concrete spalling occurs when concrete becomes chipped, scaled or flaked. Repair of spalled concrete involves removal of damaged sections and installation of new concrete. Concrete debris would be captured using curtains/sheeting and removed from the project area.

1.2.5.8 Mooring Foundation and Substructure Repair

Repairs may involve removal and replacement of concrete mooring foundations and concrete substructure on piers, wharfs, and quay walls. Work may include preservation of rebar and injection of epoxy, as required.

1.2.5.9 Repair or Replacement of Components

Structural and non-structural components of waterfront structures would be repaired or replaced as required. Replacement of components would involve removal of existing components and installation of new components. Components may include, but are not limited to the following:

- timber wave breaks
- cross bracing members
- fender components, including but not limited to camels, chocks, and whalers
- hand rails
- splash guards
- safety ladders
- electrical conduit and wiring
- light poles
- guide pile systems for floats (used to secure a floating dock or barge to a pile but allow the floating dock or barge to move up and down with tidal changes)

- brows (small, movable, bridge-like structures used to board or leave a vessel) or gangways

1.2.5.10 Rewrap/Replace Steel Cable Straps on Dolphins

Dolphins are groups of piles used to guide vessels and hold them in place while docked or berthed. Straps are used to hold pile groupings together.

1.2.6 Construction Access and Project Staging

Barges would be used as platforms for conducting in-water work activities and to haul materials and equipment to and from work sites. Barges would be moored with spuds or anchors. Other than barges, no staging sites have been identified. If staging areas for equipment and materials are identified at a future date, they would occur in currently developed lots or managed fields.

1.3 Best Management Practices and Mitigation and Minimization Measures

General BMPs, mitigation, and minimization measures that will be implemented as appropriate for all in-water activities are described in Section 11 (Means of Effecting the Least Practicable Adverse Impacts) of this application. BMPs are routinely used by the Navy during pile installation activities to avoid and minimize potential environmental impacts. Additional minimization measures have been added to protect marine mammals, Endangered Species Act-listed species, and designated critical habitats.

This page intentionally left blank.

2 Dates, Duration, and Location of Activities

The dates and duration of such activity and the specific geographical region where it will occur.

2.1 Dates and Duration of Activities

Pile repair and replacement activities would be conducted from 2021 through 2025. The United States (U.S.) Department of the Navy (Navy) will coordinate with the National Marine Fisheries Service to ensure that impacts to managed and protected species and their habitat are minimized.

No in-water work would begin at a project site until the Navy has received all required permits and approvals.

2.2 Project Location Description

Naval Station (NAVSTA) Norfolk, the center of naval operations on the East Coast, is part of the world's largest naval complex and is the primary homeport of the U.S. Atlantic Fleet. NAVSTA Norfolk supports the operational readiness of the U.S. Atlantic Fleet, providing facilities and services to enable mission accomplishment.

The station occupies 4,600 acres of land on a peninsula known as Sewell's Point in the northwest corner of Norfolk, Virginia, near the mouth of the Chesapeake Bay (Figure 1-1). The station is bordered by the Chesapeake Bay and Willoughby Bay to the north, the Elizabeth River to the west, and the City of Norfolk to the east and south. NAVSTA Norfolk includes Chambers Field (formerly known as Naval Air Station Norfolk), Fleet Industrial Supply Center, Naval Facilities Engineering Command Mid-Atlantic, Fleet Training Center, and numerous other tenants. The station is home to 59 ships (including five aircraft carriers), 187 aircraft, 18 aircraft squadrons, and 326 tenant commands. Waterfront structures include 13 large piers, numerous small piers, and bulkheads.

Craney Island Fuel Depot, also known as Defense Fuel Supply Point (DFSP) Craney Island, is the Navy's largest fuel facility (874 acres) (Figure 1-2) in the United States and is the primary fueling facility on the East Coast. DFSP Craney Island is located in the city of Portsmouth, Virginia, at the confluence of the Elizabeth River (to the west of the fuel depot) and Hampton Roads (a subpart of the Chesapeake Bay where ships can be anchored, to the north). Craney Island is primarily man-made from dredged river sediments. To the south, DFSP Craney Island is bounded by Craney Island Creek, across from a U.S. Coast Guard station, and to the west by Churchland Middle and High Schools. The western property boundary is also abutted by housing developments. To the north is the U.S. Army Corps of Engineers' (USACE's) Craney Island Dredged Material Management Area.

Lambert's Point Deperming Station provides magnetic silencing for Navy ships (Figure 1-2). This facility is used to reduce a ship's magnetic signature, thereby minimizing vulnerability to magnetic mines. The facility consists of two roughly parallel concrete piers, approximately 1,500 feet long and 240 feet apart, and an adjacent wooden pier. The three piers form two deperming slips. Slip A, between the concrete piers, contains two groups of passive sensors installed in the floor of the riverbed to monitor the magnetic treatment process at deep and medium depths. Slip B, located between the wooden pier and a concrete pier, contains a shallow sensor array.

The Lambert's Point Deperming Station is located farther up the Elizabeth River, adjacent to the Lambert Bend section of the Norfolk Harbor federal navigation channel. This facility is constructed on piles and is entirely within the Elizabeth River. Other ancillary facilities include two operations buildings, a pump house and pump station, a storage building, and two shelters.

2.2.1 Marine and Bathymetric Setting

Both NAVSTA Norfolk and DFSP Craney Island are located within the James River at Hampton Roads Harbor Polyhaline (JMSPH) drainage basin in the Chesapeake Bay. Lambert's Point Deperming Station is within the Lower Elizabeth Polyhaline (ELIPH) watershed basin.

The bathymetry of the Proposed Action area reflects the effects of natural sedimentation and erosion processes combined with modifications from dredging to maintain permitted depths in support of navigational safety, both within the Hampton Roads harbor and in the adjacent portions of the lower James River, ELIPH, and Chesapeake Bay. The tidal range in the area is approximately 2.85 feet. Tides are diurnal with two high tides and two low tides per day (USACE and Port of Virginia, 2017).

Twenty-five significant navigation projects have been constructed within the Norfolk Harbor, ranging in depth from 6 feet to 50 feet when measured at mean low water (MLW). The major deep-draft channels serving Norfolk Harbor are authorized to a depth of 55 feet below MLW. The Norfolk Harbor Reach portion of the Federal Navigation Channel offshore from NAVSTA Norfolk has a permitted dredge depth of -55 feet mean lower low water, but it is maintained at a depth of -50 feet mean lower low water. The Navy deepened the channels from the Craney Island Reach of the Norfolk Harbor and Channels Project through Lambert's Bend and from Lambert's Bend to the Norfolk Naval Shipyard to a depth of 47 feet to meet Navy operational needs. Both of these reaches are maintained with 3 feet of overdredge (USACE and Port of Virginia, 2017). Other deep-draft channels, anchorages, and turning basins in Norfolk Harbor are maintained at depths varying from 24 to 50 feet below MLW.

The annual shoaling rate for NAVSTA Norfolk was estimated as 1 to 2 feet per year (Hoffman, 1980). On average, maintenance dredging of the Navigation Channel occurs every two years (USACE and Port of Virginia, 2018).

2.2.2 Shorelines

The shorelines in the NAVSTA Norfolk area are highly modified with bulkheads to support the infrastructure of the Navy station. Similarly, land use in the vicinity of the Lambert's Point Deperming Station is primarily military and industrial; consequently, the shoreline is mostly bulkheaded with seawalls, wharfs, and pile-supported decks, although some shallow intertidal areas remain (USACE and Port of Virginia, 2017). The shoreline in the vicinity of Piers C and D at DFSP Craney Island has also been modified with bulkheads to support the infrastructure associated with fuel transfer operations (Navy, 2007).

2.2.3 Water Quality

Water quality within the MPU project area reflects the water quality of the Chesapeake Bay mainstem and tributaries, including the Elizabeth River, James River, Lafayette River, Lynnhaven River, and Norfolk Harbor proper, many of which are considered impaired waterways. Water quality at NAVSTA Norfolk also reflects permitted discharges (e.g., stormwater) and periodic maintenance dredging operations. Similarly, water quality in the vicinity of Piers C and D at DFSP Craney Island reflects stormwater

discharges as well as permitted discharges from the Craney Island wastewater treatment plant to the Elizabeth River (Navy, 2007).

In general, water salinities in the Hampton Roads Harbor typically range from 20 to 30 parts per thousand and dissolved oxygen (DO) concentrations meet the criteria for open water designated use (5.0 milligrams per liter) (USACE and Port of Virginia, 2018). Per the Virginia Department of Environmental Quality's 2018 Impairment Summary, waters immediately adjacent to NAVSTA Norfolk are not impaired with respect to DO, chlorophyll a, submerged aquatic vegetation, and benthic community.

However, the JMSPH watershed presently (2018) is not supporting aquatic life, fish consumption, or open water beneficial uses. The Chesapeake Bay and Tidal Tributaries, including portions of the James River, do not support fish consumption because of a fish advisory for elevated polychlorinated biphenyl (PCB) concentrations in anadromous striped bass. The Chesapeake Bay segment of JMSPH is impaired for aquatic life due to estuarine bioassessments (defined as an inadequate benthic community based on the Chesapeake Bay Benthic Index of Biological Integrity). Insufficient information is available to assess impairments related to wildlife use or shellfish.

The Elizabeth River receives point and non-point source loadings from its 300 square-mile drainage area. Due to the relatively poor flushing characteristics caused by low freshwater input and relatively weak tidal currents, watershed loadings of sediment and associated pollutants tend to become trapped within the river system. Water quality is generally better at the mouth of the Elizabeth River which is subject to greater tidal mixing and better flushing. For example, only 0 to 5 percent of the samples collected at two locations in the vicinity of Lambert's Point Deperming Station between 2002 and 2009 exceeded criterion for enterococci bacteria, whereas up to 100 percent of the samples from upstream locations exceeded the criterion (Louis Berger Group, Inc., 2010). Total suspended solids levels in the river are high, resulting in poor water clarity. The ELIPH watershed presently (2018) is impaired and does not support beneficial uses for aquatic life and open water aquatic life due to low DO levels. Exceedances are based on the open water habitat criteria, where most marine life is typically found, whereas the DO criteria for deep water and channel habitat (one milligram DO per liter) is consistently met (USACE and Port of Virginia, 2017). Portions of the Elizabeth River do not support fish consumption use criteria because of a fish advisory for elevated PCB concentrations in anadromous striped bass. A bacterial total maximum daily load was prepared that covered nine segments within the Elizabeth River watershed (Louis Berger Group, Inc., 2010) upstream from the Lambert's Point Deperming Station. A portion of the mouth of the Elizabeth River is on the current (2018) 303(d) list due to impairments for estuarine bioassessments.

2.2.4 Sediments

2.2.4.1 NAVSTA Norfolk

Sediment characterizations at NAVSTA Norfolk have been conducted in support of periodic maintenance dredging operations that are required to maintain permitted depths and ensure navigational safety. NAVSTA Norfolk sediments are dominated by silt-clay size particles (Tetra Tech, Inc., 2016). Elevated concentrations (greater than 500 milligrams per kilogram [or parts per million] of total petroleum hydrocarbons, occurred in sediments from the Tug Basin and the V-50 Fuel Basin. A few of the sediment samples also contained concentrations of one or more metals, polycyclic aromatic hydrocarbon compounds, or total PCBs that exceeded the corresponding sediment quality screening value. Results

from elutriate tests of sediments indicated sporadic copper and nickel concentrations in the elutriate (dissolved) fraction that exceeded the Virginia Water Quality Standards chronic criteria; no results exceeded the acute criteria (CH2M, 2018).

2.2.4.2 Lambert's Point Deperming Station

The sediments in the ELIPH area consist mostly of clays and silts with some sand present. The bottom conditions within the channels consist primarily of fine silts and clays, with a small portion of fine sands, gravel and shell (USACE and Port of Virginia, 2017). Sediment quality at a location near the Lambert's Point Deperming Station in the ELIPH area reflects historical inputs of nutrients and bacteria from municipal waste discharges, inputs of metals (arsenic, cadmium, copper, lead, nickel, zinc) and PCBs from industrial waste discharges, inputs of pesticides from stormwater runoff, and creosote (polycyclic aromatic hydrocarbons) from wood treatment operations. PCB and polycyclic aromatic hydrocarbon levels are particularly high in the sediments throughout the river system. Tributyltin, an active ingredient in antifouling paints applied to boats during past boat maintenance activities, is also present in the sediment (USACE and Port of Virginia, 2017; Navy, 2009).

2.2.4.3 DFSP Craney Island

The sediments in the ELIPH area consist mostly of clays and silts, with some sand present. Sediment quality near the mouth of the Elizabeth River reflects the highly industrialized and densely populated urban areas of the metropolitan Hampton Roads Region. Sediments in the vicinity of DFSP Craney Island Piers C and D likely contain at least trace amounts of pollutants, including metals, pesticide residues, PCBs, polycyclic aromatic hydrocarbons, and organotins, from legacy commercial and military activities that have been reported for upstream portions of the Elizabeth River (Di Giulio & Clark, 2015; Navy, 2009).

2.2.5 Ambient Sound

2.2.5.1 Underwater Sound

Underwater ambient sound in the vicinity of NAVSTA Norfolk is comprised of sounds produced by a number of natural and anthropogenic sources and varies both geographically and temporally. Natural sound sources include wind, waves, precipitation, and biological sources such as shrimp, fish, and cetaceans. These sources produce sound in a wide variety of frequency ranges (Urick, 1983; Richardson et al., 1995) and can vary over both long (days to years) and short (seconds to hours) time scales. In shallow waters, precipitation may contribute up to 35 decibels (dB) to the existing sound level, and increases in wind speed of 5 to 10 knots can cause a 5 dB increase in ambient ocean sound between 20 hertz and 100 kilohertz (Urick, 1983).

Human-generated sound is a significant contributor to the ambient acoustic environment. Normal port activities include vessel traffic from large ships, support vessels and security boats, and loading and maintenance operations, which all generate underwater sound (Urick, 1983). NAVSTA Norfolk is located in close proximity to shipping channels as well as several Port of Virginia facilities that, altogether, have an annual average of 1,459 vessel calls (Port of Virginia, 2019). Other sources of human-generated underwater sound not specific to naval installations include sounds from echo sounders on commercial and recreational vessels, industrial ship noise, and noise from recreational boat engines. Ship and small boat noise comes from propellers and other on-board rotating equipment.

The underwater acoustic environment will vary depending on the amount of anthropogenic activity, weather conditions, and tidal currents. At high-use installations such as NAVSTA Norfolk, anthropogenic noise may dominate the ambient soundscape. In areas with less anthropogenic activity, ambient sound is likely to be dominated by sound from natural sources.

Underwater ambient sound was recorded at 10 meters from pile driving locations prior to and following pile driving events at NAVSTA Norfolk Pier 4 (Illingworth and Rodkin, 2017) in October 2014. Anthropogenic noise resulted primarily from transient vessel traffic and local work-site compressors and generators. During two days of recording, 1-second underwater sound levels averaged 122 and 123 dB root mean square (RMS) sound pressure level (SPL) (range 116–140 dB) and 10-second sound levels averaged 123 and 124 dB RMS SPL (range 118–132 dB).

2.2.5.2 Airborne Sound

Airborne sound is produced by common industrial equipment, including trucks, cranes, compressors, generators, pumps, and other equipment that might typically be employed along industrial waterfronts. Sound levels are highly variable based on the types and operational states of equipment at the recording location, and sound levels may vary within a single installation such as NAVSTA Norfolk, with some piers/wharves very loud and others relatively quiet.

Airborne ambient sound was recorded 15 meters from pile driving locations but outside of pile driving events at NAVSTA Norfolk Pier 4 (Illingworth and Rodkin, 2017) in October 2014. RMS maximum SPL ranged from 72 to 100 A-weighted sound level (dBA) and one-minute equivalent continuous sound level over a period of time ranged from 66 to 88 dBA on one day of monitoring, and on another, maximum sound level ranged from 76 to 85 dBA and the equivalent continuous sound level ranged from 66 to 81 dBA.

This page intentionally left blank.

3 Marine Mammal Species and Numbers

The species and numbers of marine mammals likely to be found within the activity area.

3.1 Marine Mammal Species Likely to be Found within the Activity Area

Five marine mammal species are included in this application for a Letter of Authorization (LOA) because surveys, monitoring, and stranding reports have detected them within the MPU project area (Table 3-1). Reports that were evaluated for this application are listed in Table 3-1 and include nearshore at-sea surveys conducted on behalf of the United States (U.S.) Department of the Navy (Navy) in the mouth of the Chesapeake Bay and the Navy's Virginia Capes training and testing area east of Virginia Beach, marine mammal stranding reports, and pinniped tracking and haulout monitoring in the vicinity of the Chesapeake Bay Bridge Tunnel (CBBT). Sightings of marine mammals in shipboard surveys and haulout monitoring are the most useful evidence of the occurrence of a species in the area, but where sightings are scarce, the summaries below also utilize stranding reports as an indicator of the frequency of occurrence of a species. Appendix B contains additional information on species.

The following sections summarize available data on the occurrence of the potentially affected species in these survey and monitoring areas and describe qualitatively the likelihood of encountering any of these species in the vicinity of the proposed MPU activities. Additional information on population abundance and trends for each marine mammal stock as a whole is also presented below. Section 4 (Affected Species Status and Distribution) contains information on the distribution and status of each potentially affected species.

3.2 Estimates of Abundance within the Activity Area

Estimating potential marine mammal abundance over time and space is challenging because the animals are highly mobile and often difficult to detect. Marine mammal species are not distributed evenly, but occur in groups in areas that are biased towards greater importance, such as areas of high prey abundance, haulout sites, or areas with lower predation risk, etc. Many species are not resident in the area year round, but are occasionally or seasonally present. When they are detected, it may not be clear whether they are seasonally resident, migrating through the area in a predictable manner, or outliers that are not conforming to some pattern. Patterns in the occurrences of many marine mammal species are still being worked out, making it difficult, in a relatively limited area like the MPU project area, to understand how abundant the species may be.

Methods used to estimate marine mammal stock abundance and population trends are described in National Marine Fisheries Service (NMFS) stock assessment reports, and may utilize data from at-sea surveys and monitoring of identifiable individuals, among other methods. Stock assessment reports account for many sources of uncertainty in abundance estimates. For example, surveys generally cannot cover the entire area in which the species may occur at a given time. An additional complication is the overlap of various stocks, such as common bottlenose dolphin, in a survey area.

Table 3-1 Marine Mammals Potentially Present Within the Lower Chesapeake Bay

Species and Stock[1]	*Stock Abundance*	*Relative Occurrence*	*Season(s) of Occurrence*	*Density in the Project Area (individuals/sq km)*
Humpback whale (*Megaptera novaeangliae)* Gulf of Maine stock	896[1]	Likely	Year-round with peak in fall through spring	n/a[2]
Bottlenose dolphin (*Tursiops truncatus*) • Western North Atlantic Northern Migratory Coastal stock • Western North Atlantic Southern Migratory Coastal stock • Northern North Carolina Estuarine System Stock	NM stock: 6,639 (CV = 0.41) SM stock: 3,751 (CV = 0.60) NC ES stock: 823 (CV = 0.06)[3]	• NM stock: Likely • SM stock: Likely • NC ES stock: Rare	Spring to fall (May through October)	Fall: 3.88 Winter: 0.63 Spring: 10 Summer: 3.55[4]
Harbor porpoise (*Phocoena phocoena*) Gulf of Maine/Bay of Fundy stock	79,883 (CV = 0.32)[5]	Rare	Winter to spring	n/a[2]
Harbor seal (*Phoca vitulina*) Western North Atlantic stock	75,834 (CV = 0.15)[5]	Likely	Winter to spring (December through April)	n/a[2]
Gray seal (*Halichoerus grypus*) Western North Atlantic stock	27,131 (CV = 0.19)[5]	Rare	Winter to spring (December through April)	n/a[2]

Key: CV = coefficient of variation; ES = Estuarine System; N/A = not available; NC = North Carolina; NM = Northern Migratory; SM = Southern Migratory; sq km = square kilometers.

Notes:

1. Minimum population estimate (NMFS, 2019a)
2. No density estimates found for Chesapeake Bay. Species assumed to be absent in lower Chesapeake bay in Navy Marine Species Density Database (Navy, 2017).
3. Estimated abundance (NMFS, 2018a)
4. Source: (Engelhaupt et al., 2016)
5. Estimated abundance (NMFS, 2019a)

3.2.1 Humpback Whale

The Navy's nearshore survey effort for humpback whales (Aschettino et al., 2015; 2016; 2017; 2018) has identified high levels of occurrence in waters in and around the mouth of the Chesapeake Bay and the Virginia coast. The number of humpback whales identified in this study reflects the level of effort and study objectives in each field season, among other variables, but the number of unique humpback whales identified each season (31 during the 2014–15 field season, 37 during the 2015–16 field season, 59 during the 2016–2017 field season) indicates the importance of the study area to this species. Several

satellite-tagged humpback whales were detected west of the CBBT, including two individuals with locations near NAVSTA Norfolk and Joint Expeditionary Base Little Creek (JEBLC) (Aschettino et al., 2017). Group size was not reported in these surveys but appears to have been one to two individuals, most of which were juveniles.

Thirty-three humpback whale strandings were reported in Virginia between 1988 and 2013, of which 11 were within the Chesapeake Bay (Barco & Swingle, 2014). Additional strandings have been reported in Virginia in subsequent years (1 in 2015, 4 in 2016, 8 in 2017, 5 in 2018) (Swingle et al., 2017; Swingle et al., 2018; Costidis et al., 2019). Most of these animals showed signs of ship strikes or entanglement. In response to the increasing numbers of humpback whale strandings along the Atlantic coast from Maine through North Carolina, NMFS declared an unusual mortality event (UME) in 2016. Strandings involved primarily juvenile whales and occurred in all seasons, but were most common in the spring.

The 2018 NMFS stock assessment for the Gulf of Maine stock of humpback whales reported a count of 896 individuals as the minimum number alive in 2015 (NMFS, 2019a). A UME was declared following elevated humpback whale mortalities along the Atlantic Coast from Maine to Florida beginning in January 2016 (NOAA Fisheries, 2019). About half of the whales examined showed evidence of vessel strike or entanglement. As of 2019, a total of 103 humpback whale mortalities have been reported, including 19 in Virginia. Current data suggest that the Gulf of Maine humpback whale stock is steadily increasing in numbers (NMFS, 2018a). This is consistent with an estimated average growth trend of 3.1 percent (standard error = 0.005) in the North Atlantic population overall for the period 1979 to 1993 (Stevick et al., 2003).

3.2.2 Bottlenose Dolphin

Bottlenose dolphins are the most abundant marine mammal species encountered in surveys and stranding reports on the coast off Virginia Beach, Virginia, and in the Chesapeake Bay near NAVSTA Norfolk, and JEBLC-Fort Story (Barco & Swingle, 2014; Engelhaupt et al., 2014; 2015; 2016). They occur in greatest numbers in this area annually from May through October. Densities in the nearshore zone were calculated as 3.88 individuals/square kilometer (sq km) in fall, 0.63 individuals/sq km in winter, 10 individuals/sq km in spring, and 3.55 individuals/sq km in summer. Bottlenose dolphins are also the most commonly stranded marine mammal in the state, with strandings mostly occurring from April through October, which corresponds to their abundance in shipboard surveys (Swingle et al., 2015). Barco and Swingle (2014) reported 1,593 strandings from 1988 to 2013, including a UME that peaked in Virginia in 2013. Strandings in subsequent years ranged from 67 to 101 animals (Swingle et al., 2014; 2016; 2017; 2015).

The 2017 NMFS stock assessment for three bottlenose dolphin stocks that may be in the MPU project area reported an estimated abundance of 6,639 (coefficient of variation [CV] = 0.41) for the Northern Migratory Coastal stock, 3,751 (CV = 0.60) for the Southern Migratory Coastal stock, and 823 (CV = 0.06) for the Northern North Carolina Estuarine System stock (NMFS, 2018a). An analysis of trends in abundance for common bottlenose dolphins coast-wide from New Jersey to Florida indicated a statistically significant decline in population size between 2011 and 2016 (Garrison et al., 2017), which may be a result of the UME that occurred during 2013–2015.

3.2.3 Harbor Porpoise

Reports from marine mammal surveys in the Chesapeake Bay in the vicinity of NAVSTA Norfolk and the nearshore off Virginia Beach mention one sighting of a group of two harbor porpoises in 2015 (Engelhaupt et al., 2016), and passive acoustic recorders detected the species in low numbers near NAVSTA Norfolk and JEBLC during winter and spring deployments from August 2012 to September 2013 (Engelhaupt et al., 2014). Stranding reports from 2004 to 2013 cite 89 harbor porpoise strandings along the mouth of the Chesapeake Bay and ocean-facing beaches on the Virginia Beach coastline (Barco & Swingle, 2014). Subsequent stranding reports from Virginia cite from one to five strandings annually from 2014 through 2018 (Swingle et al., 2015; 2016; 2017; 2018; Costidis et al., 2019). All of these reports indicate that harbor porpoises are most likely to be present in the region in winter and spring months, and observations of the species off the coasts of Maryland (Wingfield et al., 2017) and New Jersey (Whitt et al., 2015) support this finding.

The 2018 NMFS stock assessment for the Gulf of Maine/Bay of Fundy stock reported an estimated abundance of 79,883 (CV = 0.32) (NMFS, 2019a). A trend analysis has not been conducted for this stock.

Stranding reports discuss wide historic fluctuations in harbor porpoise strandings in Virginia, ranging from 40 porpoises in 1999 and 30 in 2001 to 2 each in 2011 and 2012 (Costidis et al., 2019), and 5 or fewer from 2014 to 2018 (Swingle et al., 2015; 2016; 2017; 2018; Costidis et al., 2019). These fluctuations in stranding numbers have not been correlated to fluctuations in population or stock abundance, threats such as potential fisheries bycatch, or other factors.

3.2.4 Harbor Seal

Harbor seals are the most common pinnipeds in Virginia, and haul out on rocks around the portal islands of the CBBT and on mud flats on the nearby southern tip of the Eastern Shore from December through April. Surveys at the CBBT haulout sites recorded 112 harbor seal sightings during the 2014–2015 season, 186 sightings during the 2015–2016 season, 308 sightings during the 2016–2017 season, and 340 sightings during the 2017–2018 season (Rees et al., 2016; Jones et al., 2018). The Eastern Shore site had a best total estimate of 105 sightings during the 2015–2016 season and 196 sightings during the 2017–2018 season (Jones et al., 2018).

Harbor seals strand in low numbers on the coast of Virginia and Chesapeake Bay. From 1988 to 2013, 82 strandings were reported (Barco & Swingle, 2014), and in the following years from 1 to 4 stranded harbor seals were reported each year (Swingle et al., 2015; 2016; 2017; 2018; Costidis et al., 2019).

The 2018 NMFS stock assessment for the Western North Atlantic stock reported 75,834 (CV = 0.15) (NMFS, 2019a). This stock is present primarily in U.S. waters. Several researchers consider that harbor and gray seal distribution along the U.S. Atlantic coast appears to be expanding or shifting (DiGiovanni et al., 2011; DiGiovanni et al., 2018; Johnston et al., 2015). This range expansion may be due to rapid growth of gray seal populations in Canada and the Northeastern United States (Cammen et al., 2018). Count trend data for harbor and gray seals in southern New England and Long Island index sites from 1986 to 2011 indicate that harbor and gray seals are showing an increased use of their more southerly range and are extending their time spent at these haulout sites (DiGiovanni et al., 2011).

3.2.5 Gray Seal

Haulout monitoring conducted during 2014–2015 and 2015–2016 at the CBBT reported only one individual for both survey seasons (Rees et al., 2016). Haulout monitoring conducted during 2016–2017 and 2017–2018 at the CBBT and the southern tip of the Eastern Shore of Virginia, reported only one individual at the Eastern Shore for the 2017–2018 season (Jones et al., 2018).

Gray seals strand in low numbers on the coast of Virginia and the Chesapeake Bay. From 1988 to 2013, 15 strandings were reported (Barco & Swingle, 2014), and in the following years from zero to four stranded gray seals were reported each year (Swingle et al., 2015; 2016; 2017; 2018; Costidis et al., 2019).

The 2018 NMFS stock assessment for the Western North Atlantic stock reported 27,131 (CV = 0.19) in U.S. waters (NMFS, 2019a). An additional portion of the stock occurs in Canadian waters. Gray seal abundance is likely increasing in U.S. and Canadian waters (NMFS, 2019a).

This page intentionally left blank.

4 Affected Species Status and Distribution

A description of the status and distribution, including seasonal distribution (when applicable), of the affected species or stocks of marine mammals likely to be affected by such activities.

4.1 Humpback Whale

4.1.1 Status and Management

A recent status review identified 15 distinct population segments globally based primarily on breeding areas (Bettridge et al., 2015). Partially based on this status review, National Marine Fisheries Service (NMFS) issued a final rule to divide the globally listed species into 14 distinct population segments and revise the listing status of each breeding population (81 Federal Register [FR] 62260–62320, September 8, 2016). After evaluating the danger of extinction of each distinct population segment, four distinct population segments (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) are currently listed under the Endangered Species Act (ESA) as endangered and one distinct population segment (Mexico) is listed as threatened. The remaining nine distinct population segments, including the West Indies distinct population segment that occurs within the MPU project area, do not warrant listing under the ESA because they are neither in danger of extinction nor likely to become so in the foreseeable future. All humpback whales feeding in the North Atlantic are considered part of the West Indies distinct population segment (Bettridge et al., 2015), including the Gulf of Maine stock. The West Indies distinct population segment feeding range primarily includes the Gulf of Maine, eastern Canada, and western Greenland (80 FR 22304–22345, April 21, 2015) and breeding grounds include waters of the Dominican Republic and Puerto Rico (81 FR 62260–62320, September 8, 2016).

For management purposes in United States (U.S.) waters, NMFS identified stocks that are based on feeding areas. Although the western North Atlantic population was once treated as a single management stock, the Gulf of Maine stock has been identified as a discrete subpopulation based on strong fidelity of humpbacks feeding in that region (NMFS, 2019a). The Gulf of Maine stock is the only stock of humpbacks in the Atlantic managed under NMFS jurisdiction. However, it should be noted that several other discrete humpback whale subpopulations, based on feeding grounds, are present in the western North Atlantic, including the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland (NMFS, 2019a). The Gulf of Maine stock is designated as Strategic by NMFS.

4.1.2 Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham, P.J. & Mattila, D.K., 1990). Humpback whales of the western North Atlantic are typically found in Labrador Current, North Atlantic Gyre, and Gulf Stream open ocean areas during seasonal migrations from northern latitude feeding grounds, occupied during the summer, to southern latitude calving and breeding grounds occupied in the winter (NMFS, 2019a). The Gulf of St. Lawrence, Newfoundland Grand Banks, West Greenland, and Scotian Shelf are summer feeding grounds for humpbacks (Cetacean and Turtle Assessment Program, 1982; Kenney, Robert D. & Winn, Howard E., 1986; Stevick et al., 2006; Whitehead, 1982). The Gulf of Maine is also one of the principal summer feeding grounds for humpback

whales in the North Atlantic. The largest numbers of humpback whales are present from mid-April to mid-November. Other feeding locations in this ecosystem are Stellwagen Bank, Jeffreys Ledge, the Great South Channel, the edges and shoals of Georges Bank, Cashes Ledge, and Grand Manan Banks (Cetacean and Turtle Assessment Program, 1982; Kenney, Robert D. & Winn, Howard E., 1986; Stevick et al., 2006; Whitehead, 1982). LaBrecque et al. (2015) delineated a humpback whale feeding area in the Gulf of Maine, Stellwagen Bank, and Great South Channel, substantiated through vessel-and aerial-based survey data, photo-identification data, radio-tracking data, and expert judgment. Humpback whales feed in this area from March through December. Humpback feeding habitats are typically shallow banks or ledges with high seafloor relief (Hamazaki, 2002; Payne et al., 1990).

On breeding grounds, females with calves occur in much shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Smultea, 1994; Ersts & Rosenbaum, 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Clapham, 2000; Craig & Herman, 2000; Smultea, 1994).

4.1.3 Site-Specific Occurrence

Although humpback whales are migratory between feeding areas and calving areas, individual variability in the timing of migrations may result in the presence of individuals in high-latitude areas throughout the year (Straley, 1990). Records of humpback whales off the U.S. mid-Atlantic coast (New Jersey to North Carolina) from January through March suggest these waters may represent a supplemental winter feeding ground used by juvenile and mature humpback whales of U.S. and Canadian North Atlantic stocks (LaBrecque et al., 2015).

Humpback whales are most likely to occur near the mouth of the Chesapeake Bay and coastal waters of Virginia Beach between January and March; however, they could be found in the area year-round, based on shipboard sighting and stranding data (Barco & Swingle, 2014; Aschettino et al., 2015; 2016; 2017; 2018). Photo-identification data support the repeated use of the mid-Atlantic region by individual humpback whales. Results of the vessel surveys show site fidelity in the survey area for some individuals and a high level of occurrence within shipping channels—an important high-use area by both the U.S. Department of the Navy and commercial traffic (Aschettino et al., 2015; 2016; 2017; 2018). Nearshore surveys conducted in early 2015 reported 61 individual humpback whale sightings, and 135 individual humpback whale sightings in late 2015 through May 2016 (Aschettino et al., 2016). Subsequent surveys confirmed the occurrence of humpback whales in the nearshore survey area: 248 individuals were detected in 2016–2017 surveys (Aschettino et al., 2017), 32 individuals were detected in 2017–2018 surveys (Aschettino et al., 2018), and 80 individuals were detected in 2019 surveys (Aschettino et al., 2019). Sightings in the Hampton Roads area in the vicinity of Naval Station (NAVSTA) Norfolk were reported in nearshore surveys and through tracking of satellite-tagged whales in 2016, 2017 and 2019. The numbers of whales detected, most of which were juveniles, reflect the varying level of survey effort and changes in survey objectives from year to year, and do not indicate abundance trends over time.

4.2 Bottlenose Dolphin

4.2.1 Status and Management

Along the U.S. East Coast and northern Gulf of Mexico, the bottlenose dolphin stock structure is well studied. There are currently 53 management stocks identified by NMFS in the western North Atlantic

and Gulf of Mexico, including oceanic, coastal, and estuarine stocks (Hayes et al., 2017; Waring et al., 2015; Waring et al., 2016).

There are two morphologically and genetically distinct bottlenose dolphin morphotypes (distinguished by physical differences) described as coastal and offshore forms (Duffield et al., 1983; Duffield, 1986). The offshore form is larger in total length and skull length, and has wider nasal bones than the coastal form. Both inhabit waters in the western North Atlantic Ocean and Gulf of Mexico (Curry & Smith., 1997; Hersh & Duffield, 1990; Mead & Potter, 1995) along the U.S. Atlantic coast. The coastal morphotype of bottlenose dolphin is continuously distributed along the Atlantic coast south of Long Island, New York, around the Florida peninsula, and along the Gulf of Mexico coast. This type typically occurs in waters less than 25 meters deep (Waring et al., 2015). The range of the offshore bottlenose dolphin includes waters beyond the continental slope (Kenney R. D., 1990), and offshore bottlenose dolphins may move between the Gulf of Mexico and the Atlantic (Wells et al., 1999).

Two coastal stocks are likely to be present in the MPU project area: Western North Atlantic Northern Migratory Coastal stock and Western North Atlantic Southern Migratory Coastal stock (SMC), both of which are designated as Strategic and Depleted under the Marine Mammal Protection Act (MMPA). The Northern North Carolina Estuarine System stock may also be present, and is designated as Strategic by NMFS.

4.2.2 Distribution

The bottlenose dolphin occurs in tropical to temperate waters of the Atlantic Ocean as well as inshore, nearshore, and offshore waters of the Gulf of Mexico and U.S. East Coast (Hayes et al., 2017; Waring et al., 2015; Waring et al., 2016). They generally do not range north or south of 45° latitude (Jefferson et al., 2015; Wells & Scott, 2008). They occur in most enclosed or semi-enclosed seas in habitats ranging from shallow, murky, estuarine waters to deep, clear offshore waters in oceanic regions (Jefferson et al., 2015; Wells & Scott, 2008). Open-ocean populations occur far from land; however, population density appears to be highest in nearshore areas (Scott & Chivers, 1990). Bottlenose dolphins occur in the North Atlantic Gyre and Gulf Stream open ocean areas.

4.2.3 Site-Specific Occurrence

Bottlenose dolphins are the most abundant marine mammal along the Virginia coast and within the Chesapeake Bay, typically traveling in groups of 2 to 15 individuals, but occasionally in groups of over 100 individuals (Engelhaupt et al., 2014; 2015; 2016). Several coastal stocks could be present in the MPU project area, overlapping in their distribution in certain seasons (NMFS, 2018a). Bottlenose dolphins of the Western North Atlantic Northern Migratory Coastal stock winter along the coast of North Carolina and migrate as far north as Long Island, New York, in the summer. They are rarely found north of North Carolina in the winter (NMFS, 2018a). The SMC stock occurs in waters of southern North Carolina from October to December, moving south during winter months and north to North Carolina during spring months. During July and August, the SMC stock is presumed to occupy coastal waters north of Cape Lookout, North Carolina, to the eastern shore of Virginia (NMFS, 2018a). It is possible that these animals also occur inside the Chesapeake Bay and in nearshore coastal waters. The North Carolina Estuarine System stock dolphins may also occur in the Chesapeake Bay during July and August (NMFS, 2018a).

Vessel surveys conducted along coastal and offshore transects from NAVSTA Norfolk to Virginia Beach in most months from August 2012 to August 2015 reported bottlenose dolphins throughout the survey

area, including the vicinity of NAVSTA Norfolk (Engelhaupt et al., 2014; 2015; 2016). The final results from this project confirmed earlier findings that bottlenose dolphins are common in the study area, with highest densities in the coastal waters in summer and fall months. Peak estimated abundance in coastal waters of the study area is 1,203 individuals present during the fall (density = 3.88 individuals per square kilometer [sq km]), and 1,101 individuals in summer (density = 3.55 individuals per sq km). However, bottlenose dolphins do not completely leave this area during colder months, with approximately 200–300 individuals still present in winter and spring months (Engelhaupt et al., 2016).

4.3 Harbor Porpoise

4.3.1 Status and Management

The Gulf of Maine-Bay of Fundy stock occurs off the mid-Atlantic states and is the only stock under NMFS management in the region. Harbor porpoises are not listed as depleted under the MMPA, nor are they listed under the ESA.

4.3.2 Distribution

Harbor porpoises inhabit cool temperate-to-subpolar waters, often where prey aggregations are concentrated (Watts & Gaskin, 1985). Thus, they are frequently found in shallow waters, most often near shore, but they sometimes move into deeper offshore waters. Harbor porpoises are rarely found in waters warmer than 63 degrees Fahrenheit (17 degrees Celsius) (Read, 1999) and closely follow the movements of their primary prey, Atlantic herring (Gaskin, 1992).

In the western North Atlantic, harbor porpoise range from Cumberland Sound on the east coast of Baffin Island, southeast along the eastern coast of Labrador to Newfoundland and the Gulf of St. Lawrence, then southwest to about 34 degrees North on the coast of North Carolina (Waring et al., 2016).

Harbor porpoises are seen from the coastline to deep waters (greater than 5,906 feet) (Westgate et al., 1998), although most of the population is found over the continental shelf. During winter (January to March), intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada (Waring et al., 2016). Harbor porpoises sighted off the mid-Atlantic states during winter include porpoises from other western North Atlantic populations (Rosel et al., 1999). There does not appear to be a temporally coordinated migration or a specific migratory route to and from the Bay of Fundy region (Waring et al., 2016). During fall (October to December) and spring (April to June), harbor porpoises are widely dispersed from New Jersey to Maine, with lower densities farther north and south (LaBrecque et al., 2015).

4.3.3 Site-Specific Occurrence

Based on stranding reports, passive acoustic recorders, and shipboard surveys, harbor porpoise occur in coastal waters primarily in winter and spring months, but there is little information on their presence in the Chesapeake Bay. They do not appear to be abundant in the NAVSTA Norfolk area in most years, but this is confounded by wide variations in stranding occurrences over the past decade.

4.4 Harbor Seal

4.4.1 Status and Management

Harbor seals are not listed as depleted under the MMPA, nor are they listed under the ESA. The Western North Atlantic stock occurs in the MPU project area.

4.4.2 Distribution

The harbor seal is one of the most widely distributed seals, found in temperate to polar coastal waters of the northern hemisphere (Jefferson et al., 2015). Harbor seals occur in nearshore waters and are rarely found more than 20 kilometers from shore, where they frequently occupy bays, estuaries, and inlets (Baird, 2001). Individual seals have been observed several kilometers upstream in coastal rivers (Baird, 2001). Haulout sites vary but include intertidal and subtidal rock outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Burns, 2008; Gilbert & Guldager, 1998; Prescott, 1982; Schneider & Payne, 1983; Wilson, 1978). On the western Atlantic coast, their approximate year-round coastal range includes the Gulf of St. Lawrence, Scotian Shelf, Gulf of Maine, Bay of Fundy, and northeast U.S. continental shelf south to the Virginia/North Carolina border.

Harbor seals are found year-round in the coastal waters of eastern Canada and Maine; from September to May they also occur from southern New England to New Jersey (NMFS, 2018a; Katona et al., 1993). A general southward movement from the Bay of Fundy to southern New England waters occurs in autumn and early winter (Barlas, 1999; Jacobs & Terhune, 2000; Rosenfeld et al., 1988; Whitman & Payne, 1990). A northward movement from southern New England to Maine and eastern Canada occurs before the pupping season, which takes place from mid-May through June along the Maine coast (DeHart, 2002; Kenney M. K., 1994; Richardson et al., 1995; Whitman & Payne, 1990; Wilson, 1978). Pupping sites are on the Maine coast, although anecdotal reports suggest that some pupping is occurring at high-use haulout sites off Manomet, Massachusetts, and the Isles of Shoals, Maine (Hayes et al., 2017).

Harbor seal distribution along the U.S. Atlantic coast has shifted in recent years, with an increased number of seals reported from southern New England to the mid-Atlantic region (DiGiovanni et al., 2011; Hayes et al., 2017; Kenney R. D., 2019; Waring et al., 2016). Regular sightings of seals in Virginia have become a common occurrence in winter and early spring (Costidis et al., 2019). Winter haulout sites for harbor seals have been documented in the Chesapeake Bay at the Chesapeake Bay Bridge Tunnel (CBBT), on the Virginia Eastern Shore, and near Oregon Inlet, North Carolina (Waring et al., 2016; Rees et al., 2016; Jones et al., 2018).

4.4.3 Site-Specific Occurrence

Harbor seals regularly haul out on rocks around the portal islands of the CBBT and on mud flats on the nearby southern tip of the Eastern Shore from December through April (Rees et al., 2016; Jones et al., 2018). Seals captured in 2018 on the Eastern Shore and tagged with satellite-tracked tags that lasted from 2 to 5 months spent at least 60 days in Virginia waters before departing the area. All tagged seals returned regularly to the capture site while in Virginia waters, but individuals utilized offshore and Chesapeake Bay waters to different extents (Ampela et al., 2019). The area that was utilized most heavily was near the Eastern Shore capture site, but some seals ranged into the Chesapeake Bay.

4.5 Gray Seal

4.5.1 Status and Management

The Western North Atlantic stock of gray seal occurs in the project area. Gray seals are not listed as depleted under the MMPA, nor are they listed under the ESA.

4.5.2 Distribution

The western North Atlantic stock is centered in the Canadian Maritimes, including the Gulf of St. Lawrence and the Atlantic coasts of Nova Scotia, Newfoundland, and Labrador, Canada, and the northeast U.S. continental shelf (Hayes et al., 2017). However, gray seals range south into the northeastern United States, with strandings and sightings as far south as North Carolina (Hammill et al., 1998; Waring et al., 2004). Gray seal distribution along the U.S. Atlantic coast has shifted in recent years, with an increased number of seals reported in southern New England (DiGiovanni et al., 2011; Kenney R. D., 2019; Waring et al., 2016). Recent sightings included a gray seal in the lower Chesapeake Bay during the winter of 2014 to 2015 (Rees et al., 2016). Along the coast of the United States, gray seals are known to pup at three or more colonies in Massachusetts and Maine.

The gray seal is considered a coastal species and may forage far from shore but does not appear to leave the continental shelf regions (Lesage & Hammill, 2001). Gray seals haul out on land-fast ice, exposed reefs, or beaches of undisturbed islands (Hall & Thompson, 2009; Lesage & Hammill, 2001). Remote uninhabited islands tend to have the largest gray seal haulouts (Reeves et al., 1992).

4.5.3 Site-Specific Occurrence

Gray seals are uncommon in Virginia and in the Chesapeake Bay, based on rare stranding reports and two documented occurrences at the harbor seal haulout sites at the CBBT and Eastern Shore of Virginia.

5 Take Authorization Requested

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury, and/or death), and the method of incidental taking.

5.1 Take Authorization Request

Under Section 101 (a)(5)(A) of the Marine Mammal Protection Act, the United States Department of the Navy (Navy) requests a Letter of Authorization for the incidental take of marine mammals incidental to noise generated during vibratory pile extraction and vibratory and impact pile driving during pile installation activities described in this application. As detailed in Section 6 (Numbers and Species Exposed), the Navy requests a Letter of Authorization for takes of marine mammals listed in Table 5-1 for a period of up to five years, from 2021 through 2025:

Table 5-1 Total Underwater Exposure Estimates by Species

Species	*Level A*	*Level B*					
		2021	*2022*	*2023*	*2024*	*2025*	*Total*
Humpback whale	0	3	2	1	2	4	12
Bottlenose dolphin	0	4,401	1,777	381	1,608	3,977	12,144
Harbor porpoise	0	7	3	1	3	6	20
Harbor seal	0	208	84	18	76	188	574
Gray seal	0	3	2	1	2	4	12

Except with respect to certain activities not pertinent here, the Marine Mammal Protection Act defines ‘‘harassment’’ as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment] (16 United States Code section 1362; see also 50 Code of Federal Regulations part 216.3).

5.2 Method of Incidental Taking

This authorization request considers noise from vibratory pile extraction and installation and impact pile installation as outlined in Section 1 (Introduction and Description of Activities) that has the potential to disturb or displace marine mammals, resulting in Level B harassment as defined above. No Level A takes are requested. The Navy acknowledges that impact pile driving has the potential to produce a permanent threshold shift in the ability of marine mammals to hear, resulting in Level A harassment. However, impact reduction and mitigation measures would be implemented to prevent Level A harassment. The MPU activities are not anticipated to affect the prey base or significantly affect other habitat features of marine mammals that would meet the definition of take. Section 11 (Means of Effecting the Least Practicable Adverse Impacts) provides details on the impact reduction and mitigation measures proposed.

This page intentionally left blank.

6 Numbers and Species Exposed

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking, and the number of times such takings by each type of taking are likely to occur.

6.1 Introduction

In-water pile driving (which includes vibratory extraction) will temporarily increase the local underwater and airborne noise environment near the project area. Research suggests that increased noise may impact marine mammals in several ways depending on many factors, as detailed in Section 7 (Impacts to Marine Mammal Species or Stocks). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic source and the potential effects that sound may have on the physiology and behavior of that marine mammal. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003; 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Furthermore, many other factors besides the received level of sound may affect an animal's reaction, such as the animal's physical condition, behavioral context (i.e., foraging, mating, and migration), prior experience with the sound, and proximity to the source of the sound.

Vibratory pile driving for the Proposed Action described in Section 1 (Introduction and Description of Activities) of this application is not expected to result in Level A exposure of marine mammals as defined under the Marine Mammal Protection Act (MMPA). The methods for estimating the number and types of exposure are summarized below.

Exposure of each species was determined by:

- estimating the area of impact where noise levels exceed acoustic thresholds for marine mammals (Sections 6.2, Description of Noise Sources, and 6.3, Marine Mammal Hearing);
- evaluating potential presence of each species at Naval Station (NAVSTA) Norfolk based on historical occurrence, density, or by site-specific survey as outlined in Section 6.4 (Sound Exposure Criteria and Thresholds); and
- estimating potential harassment exposures by multiplying the density or site-specific abundance, as applicable, of each marine mammal species calculated in the area of impact by their probable duration during construction (Section 6.5, Limitations of Existing Noise Criteria).

6.2 Description of Noise Sources

Ambient sound is a composite of sounds from multiple sources, including environmental events, biological sources, and anthropogenic activities. Physical noise sources include waves at the surface, precipitation, earthquakes, ice, and atmospheric noise, among other events. Biological sources include marine mammals, fish, and invertebrates. Anthropogenic sounds are produced by vessels (small and large), dredging, aircraft overflights, construction activities, geophysical explorations, commercial and military sonars, and other activities. Known noise levels and frequency ranges associated with anthropogenic sources are summarized in Table 6-1. Details of each of the sources are described in the following text.

Table 6-1 Representative Levels of Underwater Anthropogenic Noise Sources

Noise Source	*Frequency Range (Hz)*	*Source Level (dB re 1 µPa RMS SPL)*	*Reference*
Dredging	1–500	161–186 dB RMS SPL re 1 µPa at 1 meter	(Department for Environment, Food and Rural Affairs, 2003; Reine & Dickerson, 2014; Richardson et al., 1995)
Small vessels	860–8,000	141–175 dB RMS SPL re 1 µPa at 1 meter	(Galli et al., 2003; Matzner & Jones, 2011; Sebastianutto et al., 2011)
Large ship	20–1,000	176–186 dB re 1 µPa^{2}sec SEL at 1 meter	(McKenna, 2011)
Tug docking gravel barge	200–1,000	149 dB at 100 meters	(Blackwell & Greene, 2002)

Key: dB = decibel; dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 µPa^{2}sec = decibels referenced to 1 micropascal-squared second; dB RMS SPL re 1 µPa = decibels root mean square sound pressure level referenced to 1 micropascal; Hz = hertz; RMS = root mean square; SEL = sound exposure level; SPL = sound pressure level.

In-water construction activities associated with the Proposed Action include impact and vibratory pile driving. The sounds produced by these activities fall into two sound types: impulsive and non-impulsive (defined below). Impact pile driving produces impulsive sounds, while vibratory pile driving produces non-impulsive sounds. The distinction between these two general sound types is important because they have differing potentials to cause physical effects, particularly with regard to hearing (Ward, 1997).

Impulsive sounds (e.g., explosions, seismic airgun pulses, and impact pile driving), which are referred to as pulsed sounds, are brief, broadband, atonal transients (Harris, 1998) and occur either as isolated events or repeated in some succession (Southall et al., 2007). Impulsive sounds are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures (Southall et al., 2007). Impulsive sounds generally have a greater capacity to induce physical injury compared with sounds that lack these features (Southall et al., 2007).

Non-impulsive sounds (referred to as non-pulsed in Southall (2007)) can be tonal, broadband, or both. They lack the rapid rise time and can have longer durations than impulsive sounds. Non-impulsive sounds can be either intermittent or continuous. Examples of non-impulsive sounds include vessels, aircraft, and machinery operations such as drilling, dredging, and vibratory pile driving (Southall et al., 2007).

In some environments, the duration of both impulsive and non-impulsive sounds can be extended due to reverberations. Appendix B provides additional information on the fundamentals of underwater sound and a review of pile driving sound pressure levels (SPLs) from similar projects as those proposed in this application.

6.3 Marine Mammal Hearing

All marine mammals that have been studied can produce sounds and may use sounds to forage, orient, detect, and respond to predators, and facilitate social interactions (Richardson et al., 1995). Measurements of marine mammal sound production and hearing capabilities provide some basis for assessing whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (Schusterman, 1981; Au, 1993; Wartzok, D. & Ketten, D.R., 1999; Reichmuth et al., 2013; Nachtigall et al., 2007). Behavioral audiograms, which are plots of animals'

exhibited hearing threshold versus frequency, are obtained from captive, trained animals using standard testing procedures with appropriate controls and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity. Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals.

For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on anatomical and physiological structures, the frequency range of the species' vocalizations, and extrapolations from related species.

Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. It has recently been adapted for use on non-humans, including marine mammals (Dolphin, 2000; Wolski et al., 2003; Mulsow et al., 2012; Finneran et al., 2013). For both methods of evaluating hearing ability, hearing response in relation to frequency is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

National Marine Fisheries Service (NMFS) reviewed studies of hearing sensitivity of marine mammals and developed thresholds for use as guidance when assessing the effects of anthropogenic sound on marine mammals, based on measured or estimated hearing ranges (NMFS, 2018b). The guidance places marine mammals into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency (HF) cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), phocid pinnipeds (true seals), and otariid pinnipeds (sea lions and fur seals). Table 6-2 provides a summary of hearing capabilities for marine mammal species assessed in this application.

Table 6-2 Hearing Ranges for Marine Mammal Functional Hearing Groups and Species Potentially Within the MPU Project Area

Functional Hearing Group	*Species*	*Functional Hearing Range*[1,]
Low-frequency cetaceans	Humpback whale	7 Hz to 35 kHz
Mid-frequency cetaceans	Bottlenose dolphin	150 Hz to 160 kHz
High-frequency cetaceans	Harbor porpoise	275 Hz to 160 kHz
Phocid pinnipeds	Harbor seal, gray seal	In-water: 50 Hz to 86 kHz In-air: 75 Hz to 30 kHz

Source: In-water hearing data from (NMFS, 2018b). In-air data from (Schusterman, 1981; Hemilä et al., 2006; Southall et al., 2007)

Key: Hz = hertz; kHz = kilohertz; MPU = marine structure maintenance, pile replacement, and upgrades.

6.4 Sound Exposure Criteria and Thresholds

To date, no studies have been conducted that examine impacts to marine mammals from pile driving sounds from which empirical noise thresholds have been established. NMFS uses underwater sound exposure thresholds to determine when an activity could result in impacts to a marine mammal defined as Level A (injury) or Level B (behavioral disturbance) (Federal Register 70: 1871) (Table 6-3).

Table 6-3 Injury and Disturbance Threshold Criteria for Underwater and Airborne Noise

Marine Mammals	*Airborne Noise (impact and vibratory pile driving) (re 20 µPa)[1]*	*Underwater Vibratory Pile Driving Noise (non-impulsive sounds)[2]*		*Underwater Impact Pile Driving Noise (impulsive sounds)[2]*	
	Disturbance Guideline (haulout)[3]	*Level A Injury (PTS onset) Threshold[4]*	*Level B Disturbance Threshold*	*Level A (PTS onset) Threshold[5,6]*	*Level B Disturbance Threshold*
Low-Frequency Cetaceans	Not applicable	199 dB SEL_{CUM}[7]	120 dB RMS SPL	219 dB Peak SPL[4] 183 dB SEL_{CUM}[7]	160 dB RMS SPL
Mid-Frequency Cetaceans	Not applicable	198 dB SEL_{CUM}[7]	120 dB RMS SPL	230 dB Peak SPL[4] 185 dB SEL_{CUM}[7]	160 dB RMS SPL
High-Frequency Cetaceans	Not applicable	173 dB SEL_{CUM}[7]	120 dB RMS SPL	202 dB Peak SPL[4] 155 dB SEL_{CUM}[7]	160 dB RMS SPL
Phocid pinnipeds	Harbor Seal: 90 dB RMS SPL (unweighted) Other Phocids: 100 dB RMS SPL (unweighted)	201 dB SEL_{CUM}[7]	120 dB RMS SPL	218 dB Peak SPL[4] 185 dB SEL_{CUM}[7]	160 dB RMS SPL

Key: dB = decibel; Peak SPL = peak sound pressure level; PTS = permanent threshold shift; re 20 µPa = referenced to 20 micropascal; RMS SPL = root mean square sound pressure level; SEL_{CUM} = cumulative sound exposure level.

Notes:

1. Airborne disturbance thresholds not specific to pile driver type.
2. Underwater root mean square (RMS) and peak sound pressure levels (SPLs) have a reference value of 1 micropascal. Cumulative sound exposure level (SEL_{CUM}) has a reference value of decibels at 1 micropascal-squared second (1 $\mu Pa^2 sec$).
3. Sound level at which pinniped haulout disturbance has been documented. This is not considered an official threshold, but is used as a guideline.
4. Flat weighted or unweighted peak sound pressure level within the generalized hearing range.
5. Dual metric acoustic thresholds for impulsive sounds: whichever results in the largest isopleth for calculating permanent threshold shift (PTS) onset is used in the analysis.
6. Values presented as the sound exposure level (SEL) threshold are only the values for the species group's best hearing sensitivity because it is frequency weighted. Frequency weighted thresholds are determined from the minimum value of the exposure function and the weighting function at its peak (i.e., area of best sensitivity; equivalent to K+C).
7. Cumulative sound exposure level over 24 hours.

NMFS (2018b) equates the onset of permanent threshold shift (PTS) (i.e., permanent auditory injury) with Level A harassment under the MMPA and "harm" under the Endangered Species Act, and developed acoustic threshold levels for determining the onset of PTS in marine mammals exposed to underwater impulsive and non-impulsive sound sources. The Level A criteria use cumulative sound exposure level metrics and peak pressure rather than the previously used decibel (dB) root mean square (RMS) SPL metric. NMFS also established thresholds for temporary threshold shift (TTS) (i.e., temporary reduced hearing sensitivity following exposure to intense sounds) in the 2018 guidance document. The onset of TTS is a form of Level B harassment under the MMPA and "harassment" under the Endangered Species Act. NMFS did not state the thresholds for other forms of behavioral disturbance in the 2018 guidance document, and thus earlier thresholds for Level B harassment are still accepted. Level B harassment is considered to occur when marine mammals are exposed to impulsive underwater sounds greater than 160 dB RMS SPL referenced to 1 micropascal (re 1 µPa) from impact pile driving and to non-impulsive underwater sounds greater than 120 dB RMS SPL re 1 µPa (70 Federal Register 1871)

(Table 6-3). NMFS does not currently recommend calculations of TTS exposures separate from assessments of Level B harassment using the earlier thresholds for behavioral disturbance (81 Federal Register 51693). Therefore, zones of influence (ZOIs) for TTS were not estimated in this analysis. All forms of harassment, either auditory or behavioral, constitute "incidental take" under these statutes.

NMFS uses generic sound exposure thresholds to determine when an activity in the ocean that produces airborne sound might result in impacts to a marine mammal (70 Federal Register 1871). Construction-period airborne noise would have little impact on cetaceans because they generally do not have their ears in the air and because noise from airborne sources would not transmit as well underwater (Urick, 1983; Richardson et al., 1995). In contrast, pinnipeds spend significant amounts of time out of the water while hauled out. In the water, when not actively diving, they often orient their bodies vertically in the water column and hold their heads above the water surface. Consequently, airborne noise may be a concern for pinnipeds near the MPU project locations. NMFS has identified behavioral harassment threshold criteria for airborne noise generated by pile driving for pinnipeds regulated under the MMPA. Level A injury threshold criteria for airborne noise have not been established. The Level B behavioral harassment threshold for harbor seals is 90 dB RMS SPL referenced to 20 µPa (unweighted), and is 100 dB RMS SPL referenced to 20 µPa (unweighted) for all other phocid seals, including gray seals.

6.5 Limitations of Existing Noise Criteria

The application of the 120 dB RMS SPL re 1 µPa behavioral threshold can sometimes be problematic because this threshold level can be either at or below the ambient noise level of certain locations. The 120 dB RMS SPL re 1 µPa threshold level for non-impulsive noise originated from research conducted by Malme et al. (1984; 1988) for California gray whale response to playbacks of continuous industrial sounds such as drilling operations.[1]

To date, no research or data supports a response by pinnipeds or non-delphinid cetaceans to non-impulsive sounds from vibratory pile driving as low as the 120 dB threshold. Southall et al. (2007) reviewed studies conducted to document behavioral responses of harbor seals and northern elephant seals to non-impulsive sounds under various conditions and concluded that those limited studies suggest that exposures between 90 dB and 140 dB RMS SPL re 1 µPa generally do not appear to induce strong behavioral responses.

A more recent observational study found evidence of weak but statistically significant avoidance behavior of bottlenose dolphins and harbor porpoises in response to estimated received levels of 99 to 132 decibels referenced to 1 micropascal (dB re 1 µPa) during vibratory pile driving (Graham et al., 2017). Branstetter et al. (2018) tested for the effects of vibratory pile driver noise on bottlenose dolphin echolocation by exposing penned dolphins to playback recordings at source levels of 110, 120, 130, and 140 dB re 1 µPa. They found evidence of altered behavior (an almost complete cessation of echolocation clicks) only at the highest source level, for which the received level was roughly estimated as 128 dB re

[1]The 120 dB referenced to 1 µPa non-impulsive sound threshold should not be confused with the species-specific 120 dB pulsed sound criterion established for migrating bowhead whales in the Arctic based on research in the Beaufort Sea (Miller et al., 1999; Richardson et al., 1995).

1 µPa. The effect on behavior diminished significantly, indicating acclimation, as the animals resumed echolocation during subsequent replications.

6.6 Auditory Masking

Natural and artificial sounds can disrupt behavior through auditory masking or interference with a marine mammal's ability to detect and interpret other relevant sounds, such as communication and echolocation signals (Wartzok et al., 2004). Masking occurs when both the signal and masking sound have similar frequencies and either overlap or occur very close to each other in time. A signal is very likely to be masked if the noise is within a certain "critical bandwidth" around the signal's frequency and its energy level is similar or higher (Holt, 2008). Noise within the critical band of a marine mammal signal will show increased interference with detection of the signal as the level of the noise increases (Wartzok et al., 2004). For example, in delphinid subjects relevant signals needed to be 17 to 20 dB louder than masking noise at frequencies below 1 kilohertz (kHz) to be detected and 40 dB greater at approximately 100 kHz (Richardson et al., 1995). Noise at frequencies outside of a signal's critical bandwidth will have little to no effect on the detection of that signal (Wartzok et al., 2004).

Additional factors influencing masking are the temporal structure of the noise and the behavioral and environmental context in which the signal is produced. Continuous noise is more likely to mask signals than is intermittent noise of the same amplitude; quiet "gaps" in the intermittent noise allow detection of signals that would not be heard during continuous noise (Brumm & Slabbekoorn, 2005). The behavioral function of a vocalization (e.g., contact call, group cohesion vocalization, echolocation click, etc.) and the acoustic environment at the time of signaling may both influence call source level (Holt et al., 2011), which directly affects the chances that a signal will be masked (Nemeth & Brumm, 2010).

Masking noise from anthropogenic sources could cause behavioral changes if it disrupts communication, echolocation, or other hearing-dependent behaviors. As noted above, noise frequency and amplitude both contribute to the potential for vocalization masking; noise from pile driving typically covers a frequency range of 10 hertz to 1.5 kHz, which is likely to overlap the frequencies of vocalizations produced by species that may occur in the project area. Amplitude of noise from both impact and vibratory pile driving methods is variable and may exceed that of marine mammal vocalizations within an unknown range of each incident pile. Depending on the animal's location and vocalization source level, this range may vary over time.

Although SPLs from impact pile driving are greater, the zone of potential masking effects from vibratory pile driving may be as large or greater due to the duration and continuous nature of vibratory pile driving. The potential for masking differs between species, depending on the overlap between pile driving noise and the animals' hearing and vocalization frequencies. In this respect, harbor porpoises, which use HF sound, are probably less vulnerable to masking from pile driving than pinnipeds. In addition, cetaceans that may be subject to masking are transitory within the vicinity of the Proposed Action area. The animals most likely to be at risk for vocalization masking would be pinnipeds (harbor seals and gray seals). Animals will often compensate for increasing noise levels by increasing the signal level, repetition rate, duration, or changing the frequency, of their vocalizations, a phenomenon termed the "Lombard effect" (Hotchkin & Parks, 2013). Possible behavioral reactions to vocalization masking include changes to vocal behavior (including cessation of calling), habitat abandonment (long- or short-term), and modifications to the acoustic structure of vocalizations (which may help signalers compensate for masking) (Brumm & Slabbekoorn, 2005; Brumm & Zollinger, 2011). The extent to which

the animals' behaviors would mitigate the potential for masking is uncertain, and, accordingly, the United States Department of the Navy (Navy) has estimated that masking as well as compensatory behavioral responses are likely within the zones of behavioral harassment estimated for vibratory and impact pile driving.

6.7 Modeling Potential Noise Impacts from Pile Driving

6.7.1 Underwater Sound Propagation

Pile driving will generate underwater noise that potentially could result in disturbance to marine mammals swimming by the MPU project area. Transmission loss (TL) underwater is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source until the source becomes indistinguishable from ambient sound. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water depth, water chemistry, and bottom composition and topography.

The degree to which underwater noise propagates away from a noise source is dependent on a variety of factors, most notably by the bathymetry and presence or absence of reflective or absorptive conditions including the sea surface and sediment type. The TL model described in Appendix B, which incorporates on-site bathymetry at six representative MPU pile driving locations, was used to calculate the expected noise propagation from both impact and vibratory pile driving. This TL model used representative source levels for previous pile driving projects at NAVSTA Norfolk and other locations to estimate the ZOI, or area exceeding the noise criteria.

6.7.2 Underwater Noise from Pile Driving

The intensity of pile driving sound is greatly influenced by factors such as the type of piles, type of driver, and the physical environment in which the activity takes place. To determine reasonable SPLs from pile driving, studies with similar properties to the Proposed Action were evaluated. Data from prior pile driving projects at the Naval Base Kitsap Bangor waterfront were reviewed in the analysis. The evaluation is presented in Appendix B and the representative SPLs used in the analysis are presented in Table 6-4.

For the analyses that follow, the TL model was used to calculate the expected ZOIs at representative pile driving locations within which pile driving noise would equal or exceed the thresholds for Level A injury (PTS onset) and Level B (behavioral disturbance) for each marine mammal functional hearing group. Representative pile driving locations were chosen to provide the greatest possible affected areas, or "worst-case" scenarios. Typically, these locations are at the seaward end of the selected pier. ZOIs for pile driving at the six representative pile driving locations are depicted in Figure 6-1 through Figure 6-8. ZOIs calculated using the TL model have an irregular outline because they reflect on-site bathymetry, and because they were clipped using geographic information system to indicate where landmasses and structures block underwater sound transmission.

Table 6-4 Underwater Noise Source Levels Modeled for Underwater Impact and Vibratory Pile Driving

Pile Type	*Installation Method*	*Pile Diameter (inches)*	*RMS SPL (dB re 1 µPa)*	*Peak SPL (dB re 1 µPa)*	*SEL (dB re 1 µPa²sec)*
Square pre-stressed concrete	Impact hammer	24	176	189	163
Composite[1]	Impact hammer	16	165	177	157
	Vibratory driver	16	158	N/A	N/A
Timber	Vibratory driver[2]	12	158	N/A	N/A

Source: Concrete: (Illingworth and Rodkin, 2017); Composite impact: (Caltrans, 2015); Composite/timber vibratory: (Illingworth and Rodkin, 2017).

Key: dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 μPa^2sec = decibels referenced to 1 micropascal-squared second; N/A = not applicable; Peak SPL = peak sound pressure level; RMS SPL = root mean square sound pressure level; SEL = sound exposure level.

Notes:

1. Composite piles may be solid high-density polyethylene (HDPE) plastic or hollow core fiberglass.
2. Source level for vibratory installation of timber piles was used for vibratory extraction.
3. For vibratory driving where SEL is not included in the table, SEL_{CUM}= the RMS SPL value + 10log10(time), where time is the nominal duration for vibratory installation.

For impact pile driving, calculated injury ZOIs for the various pile types for mid-frequency cetaceans, high-frequency cetaceans and phocid seals fell within 10 meters of the driven pile (i.e., the distance from proxy piles at which SPLs were measured, based on Illingworth and Rodkin (2017)). Thus, no ZOIs are depicted for these threshold criteria for impact pile driving (Figure 6-1 through Figure 6-8). Instead, a 10-meter radius zone is depicted around each representative pile. The injury ZOI for low-frequency cetaceans exceeds the 10-meter radius and, therefore, is depicted on the figures as a separate polygon. For vibratory pile driving, calculated injury ZOIs for all hearing groups fall within the 10-meter radius, and no ZOIs are depicted for these threshold criteria. Behavioral disturbance ZOIs for all marine mammals for impact and vibratory pile driving fell outside of the 10-meter zone; therefore, they are depicted as separate polygons in these figures. For ZOIs that are larger than the 10-meter radius around representative pile locations, the maximum distance to threshold and size of the areas encompassed within the ZOI were calculated using geographic information system tools. Maximum distance to threshold and ZOI areas within the Level A injury (PTS onset) sound exposure level thresholds and Level B behavioral disturbance RMS SPL thresholds for the various hearing groups are provided in Table 6-5 for impact pile driving. Maximum distance to threshold and ZOI areas within the injury and behavioral noise thresholds are provided in Table 6-6 for vibratory pile driving. Adjusted ZOIs are provided where noise transmission would be truncated by land or a structure. ZOIs for Level A injury thresholds are so small as to be essentially negligible for all pile types and all marine mammal hearing groups; marine mammals are unlikely to be present in these small areas in close proximity to the developed shoreline of NAVSTA Norfolk. Therefore, the Navy is not requesting Level A takes for any species. Similarly, ZOIs for Level B behavioral disturbance thresholds due to impact pile driving are also extremely small for all locations. Therefore, the following analysis focuses on methods for estimating Level B behavioral disturbance takes due to vibratory pile driving.

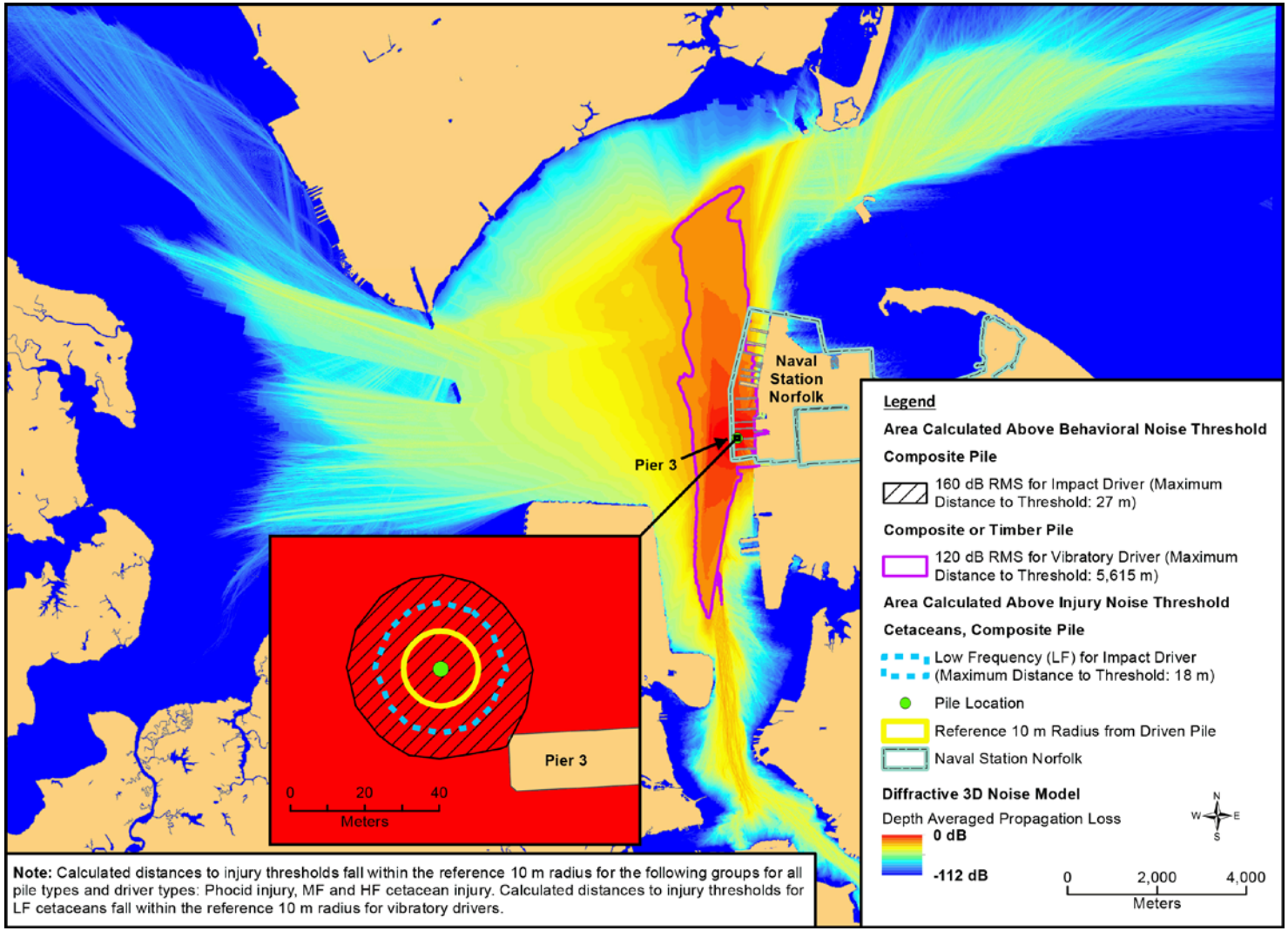

Figure 6-1 Pier 3 Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

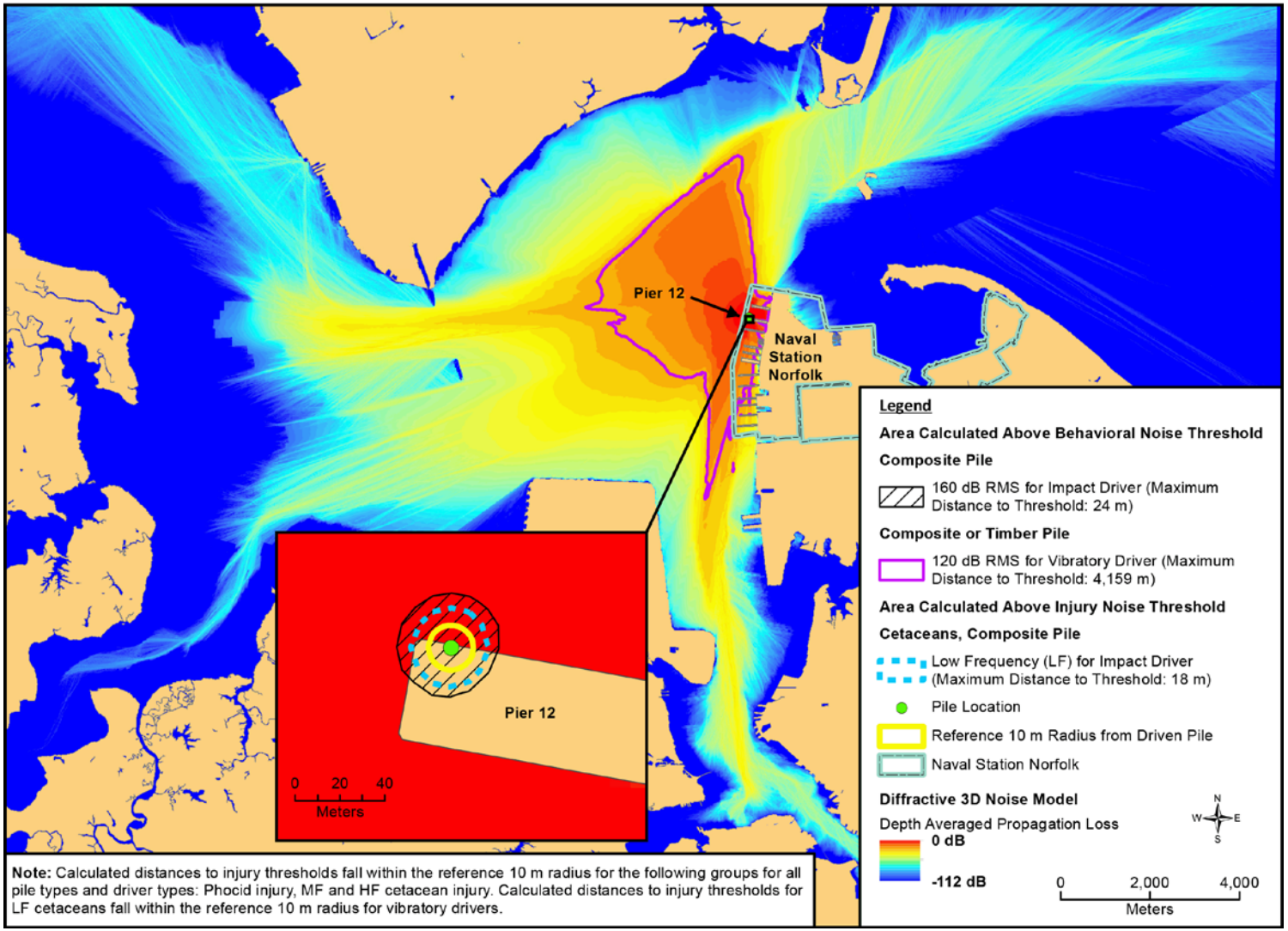

Figure 6-2 Pier 12 Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

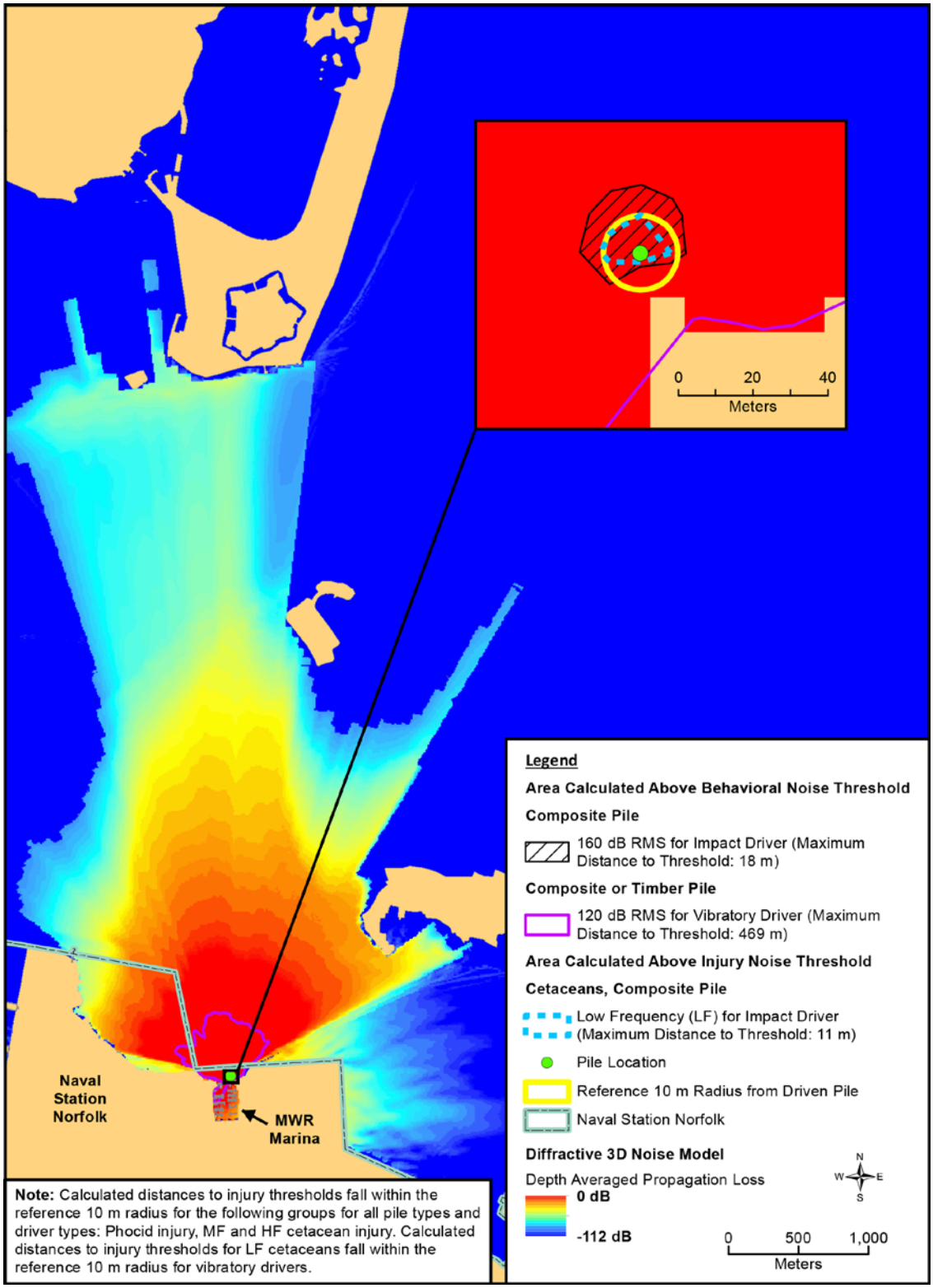

Figure 6-3 MWR Marina Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

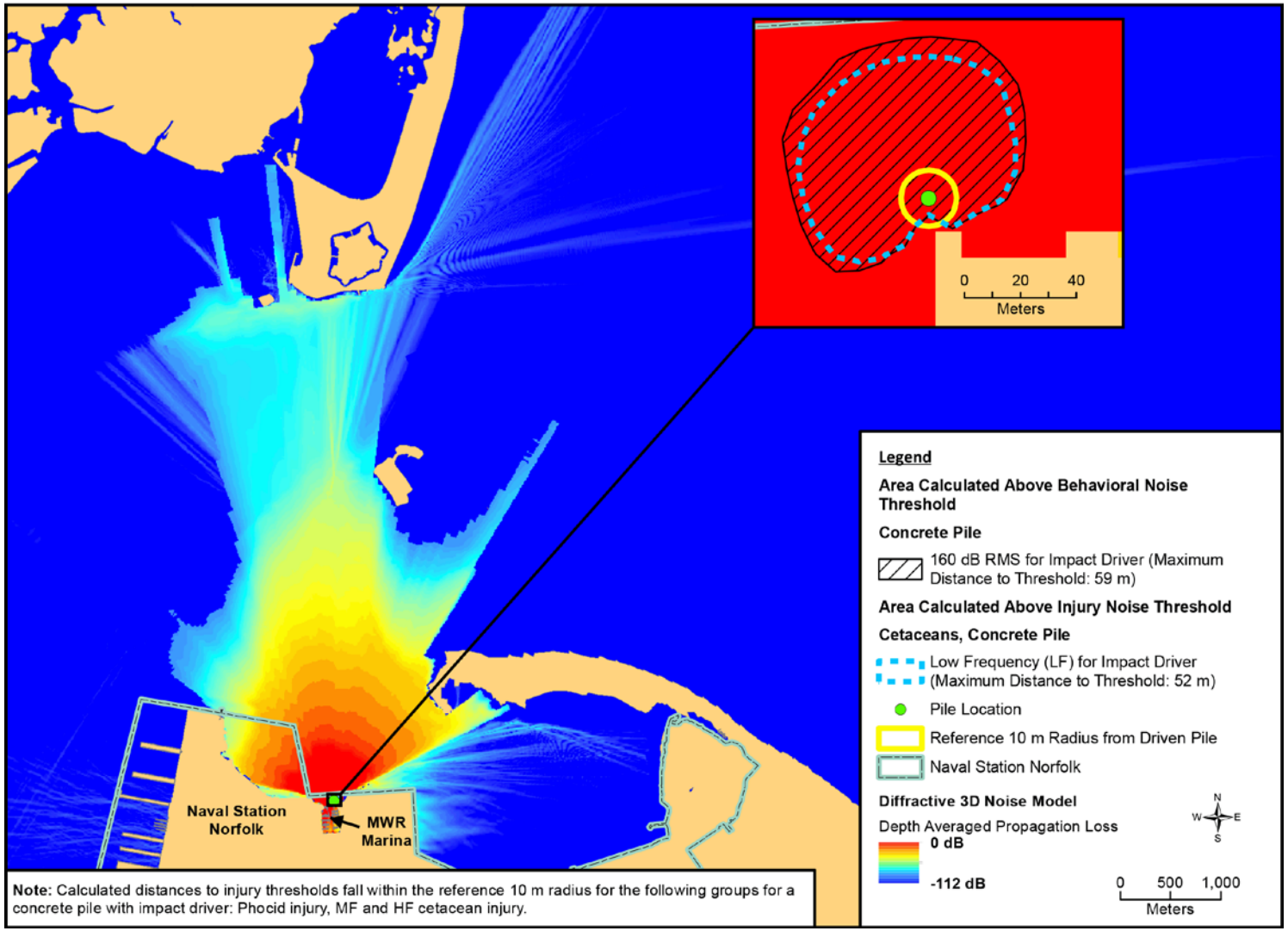

Figure 6-4 MWR Marina Concrete Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

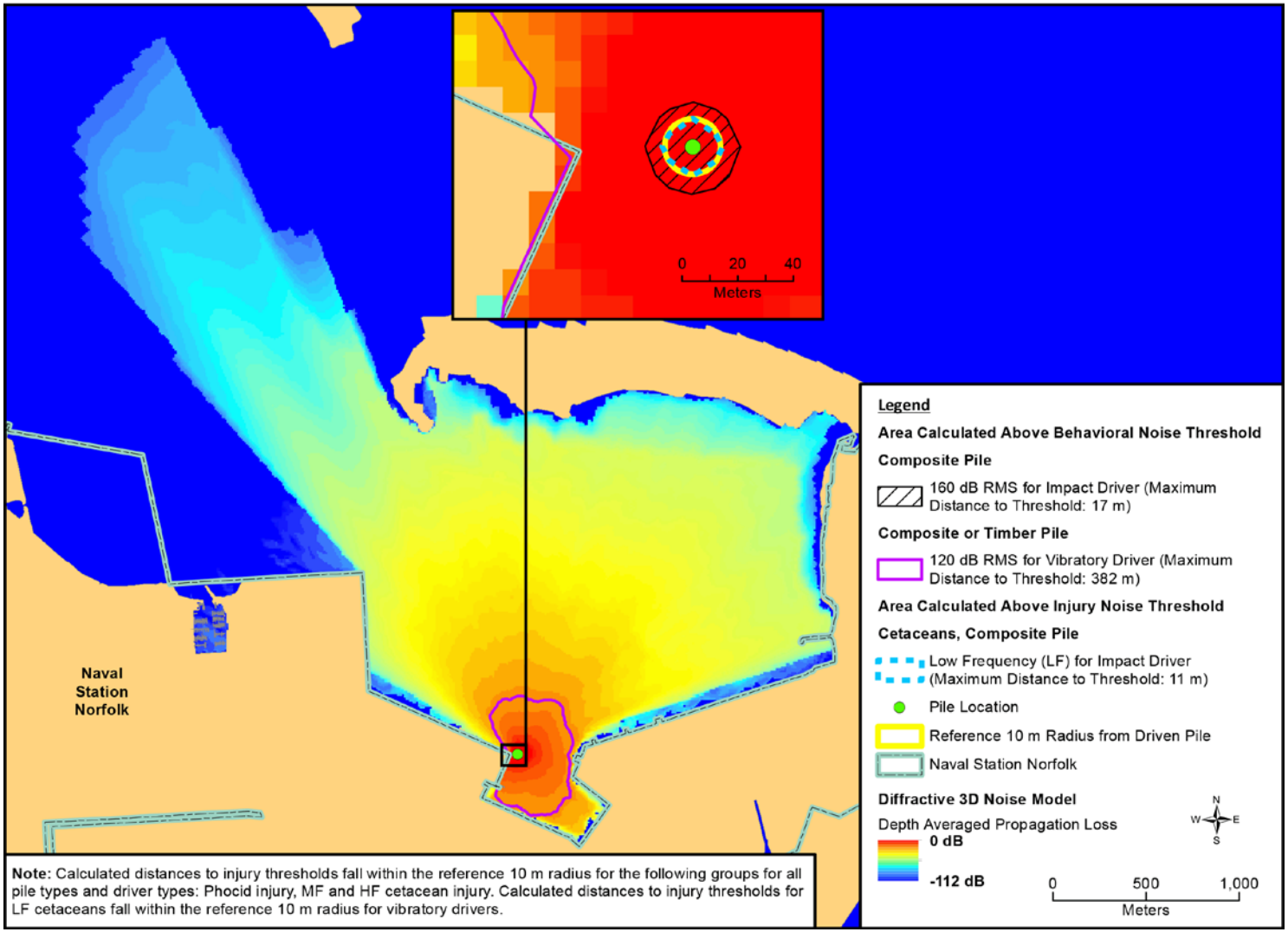

Figure 6-5 V-Area Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

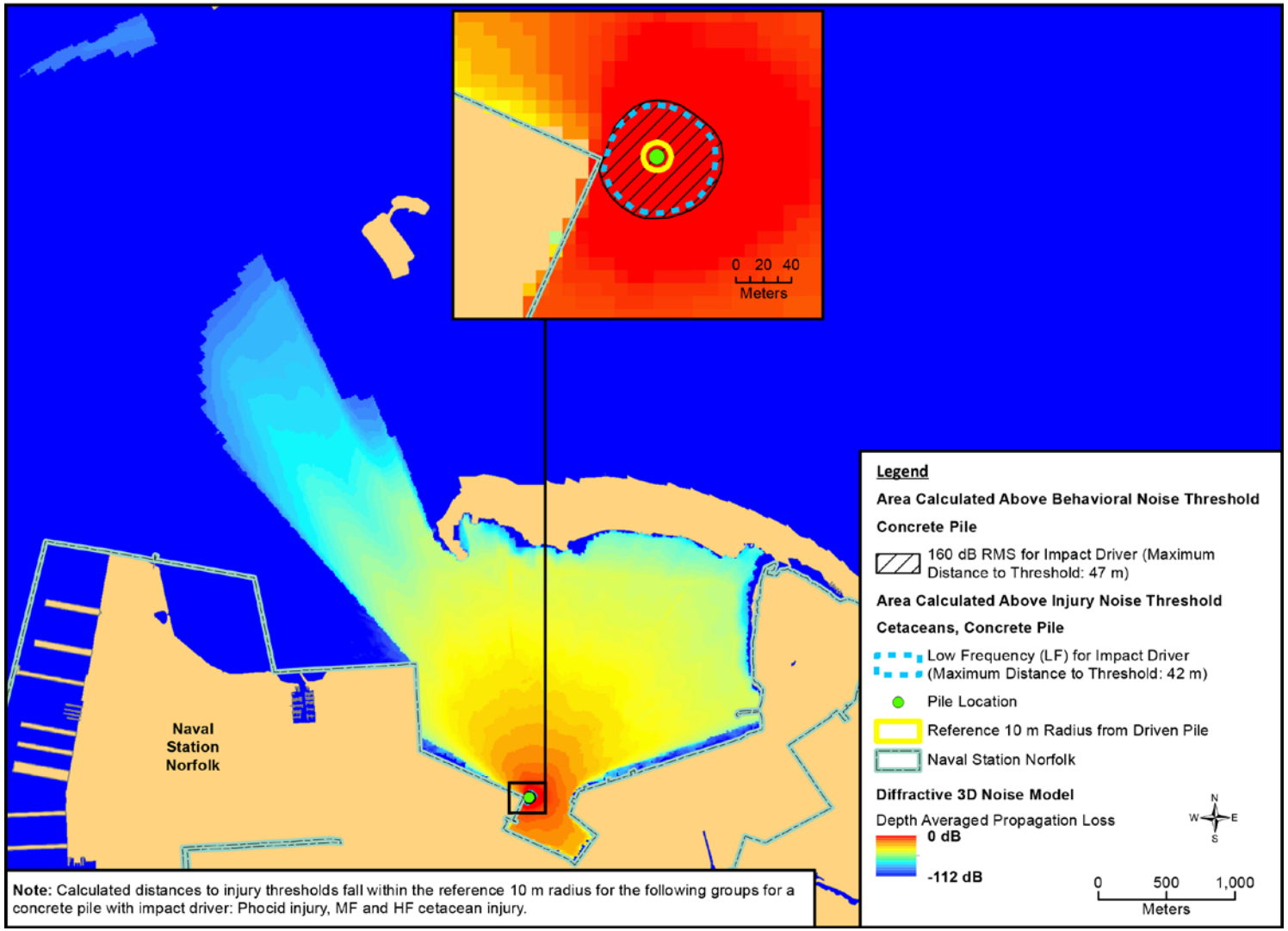

Figure 6-6 V-Area Concrete Predicted Pile Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving Marine Mammals

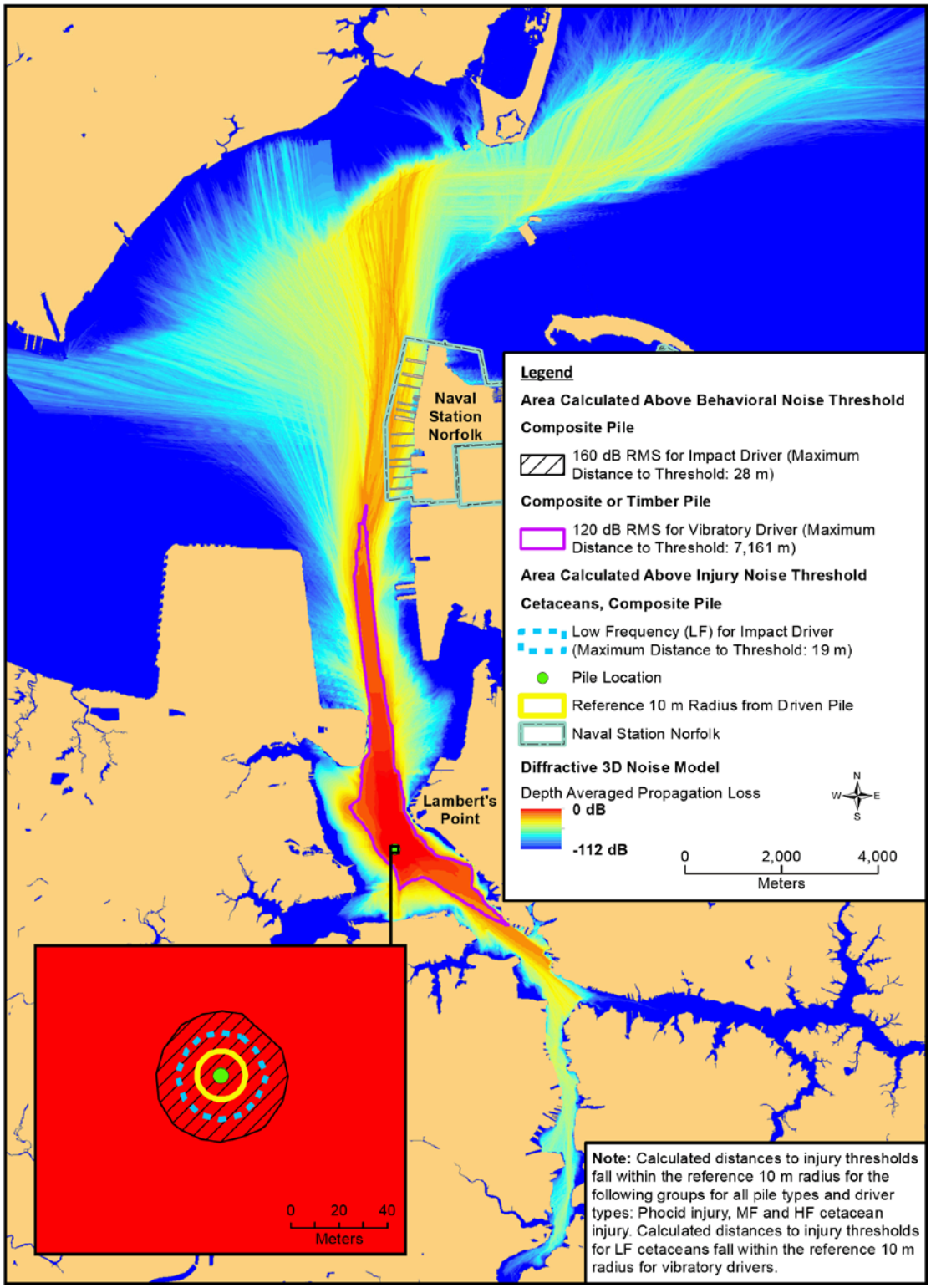

Figure 6-7 Lambert's Point Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

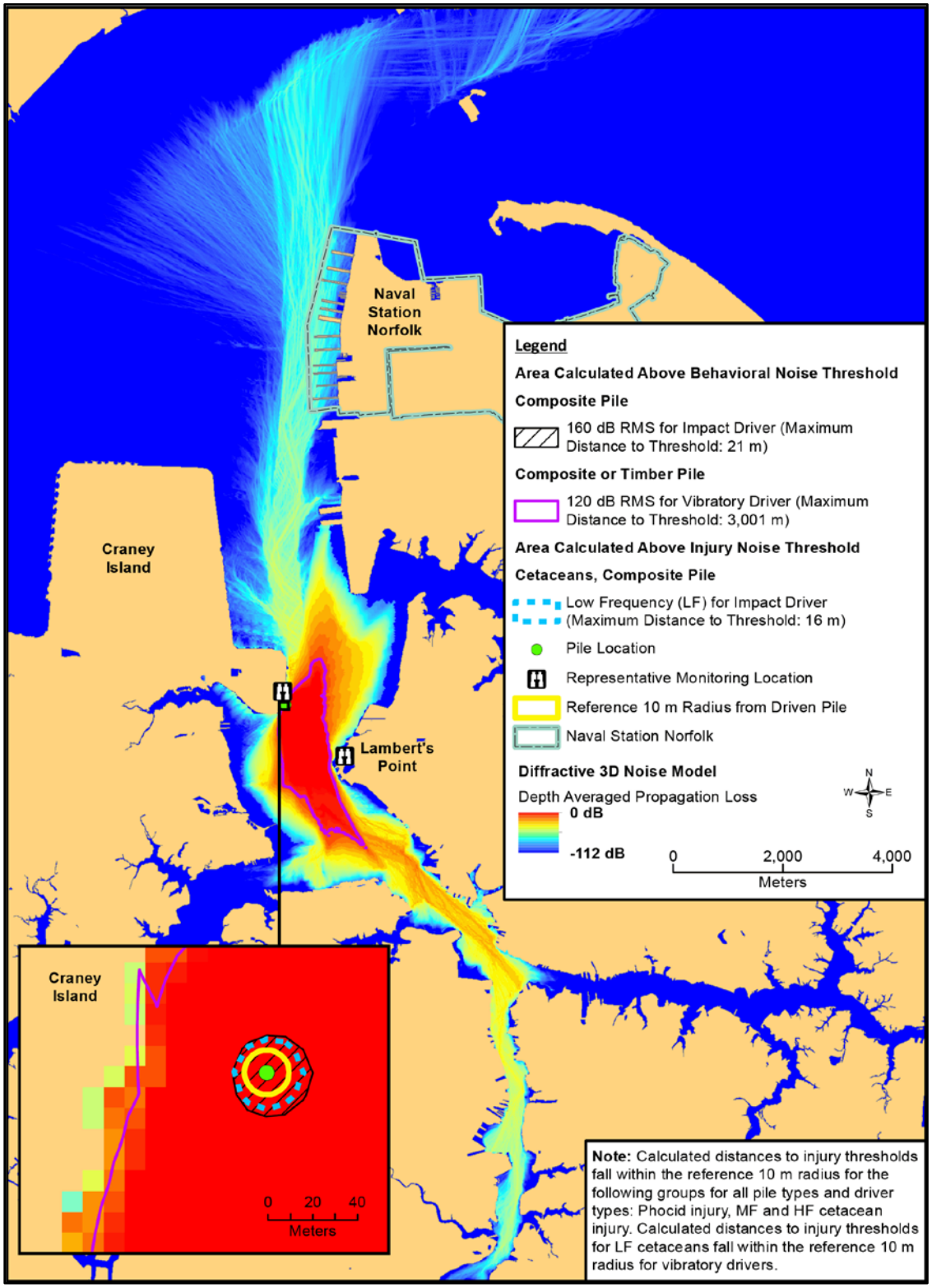

Figure 6-8 Craney Island Timber/Composite Pile Predicted Underwater Sound Pressure Levels (dB re 1µPa) Associated with Impact and Vibratory Pile Driving

Table 6-5 Calculated Areas of Zones of Influence for Underwater Sound from MPU – Impact Pile Driving

Example Pile Driving Site	*Pile Size*	*Total Pile Driving Days*	*Injury (PTS Onset)[1] Level A*				*Behavioral Disturbance[2] Level B*	
			LF Cetacean	*MF Cetacean*	*HF Cetacean*	*Phocid Seal*	*All Species*	
			Maximum Distance to 183 dB SEL_{CUM} Threshold/Area of ZOI[3]	*Maximum Distance to 185 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 155 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 185 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 160 dB RMS SPL Threshold*	*Area of ZOI within 160 dB RMS SPL Threshold*
Pier 3	16-inch composite	68	18 m/909 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	27 m	1,908 m^2
Pier 12	16-inch composite	350	18 m/917 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	24 m	1,623 m^2
MWR Marina	24-inch concrete	53	52 m/4,270 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	59 m	5,367 m^2
	16-inch composite		11 m/145 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	18 m	523 m^2
V-Area	24-inch concrete	43	42 m/4,729 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	47 m	5,642 m^2
	16-inch composite		11 m/274 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	17 m	815 m^2
Craney Island	16-inch composite	53	16 m/712 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	21 m	996 m^2
Lambert's Point	16-inch composite	7	19 m/990 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	28 m	2,266 m^2

Key: < = less than; dB = decibels; LF = low frequency; MF = mid-frequency; MPU = marine structure maintenance, pile replacement, and upgrades; MWR = Morale, Welfare, and Recreation; m = meters, m^2 = square meters; PTS = permanent threshold shift; RMS SPL = root mean square sound pressure level; SEL_{CUM} = cumulative sound exposure level; ZOI = zone of influence.

Notes:

1. Injury thresholds are dB SEL_{CUM}, as listed in Table 6-3; however, all injury ZOIs for cetaceans and phocid seals are smaller than reported sound levels at 10 meters, based on Illingworth and Rodkin (2017).
2, Behavioral disturbance thresholds are dB RMS SPL, as listed in Table 6-3.
3. ZOIs calculated using geographic information system (GIS) data as determined by transmission loss modeling based on bathymetry (details in Appendix B).

Table 6-6 Calculated Areas of Zones of Influence for Underwater Sound from MPU – Vibratory Pile Driving

Example Pile Driving Site	*Pile Size*	*Total Pile Driving Days*	*Injury (PTS Onset)[1] Level A*				*Behavioral Disturbance[2] Level B*	
			LF Cetacean	*MF Cetacean*	*HF Cetacean*	*Phocid Seal*	*All Species*	
			Maximum Distance to 199 dB SEL_{CUM} Threshold/Area of ZOI[3]	*Maximum Distance to 198 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 173 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 201 dB SEL_{CUM} Threshold/Area of ZOI*	*Maximum Distance to 120 dB RMS SPL Threshold*	*Area of ZOI within 120 dB RMS SPL Threshold*
Pier 3	16-inch composite/ 12-inch timber	68	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	5,615 m	10.3 km^2
Pier 12	16-inch composite/ 12-inch timber	350	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	4,159 m	13.1 km^2
MWR Marina	16-inch composite/ 12-inch timber	53	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	469 m	0.2 km^2
V-Area	16-inch composite/ 12-inch timber	43	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	382 m	0.2 km^2
Craney Island	16-inch composite/ 12-inch timber	53	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	3,001 m	2.2 km^2
Lambert's Point	16-inch composite/ 12-inch timber	7	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	< 10 m/< 314 m^2	7,161 m	4.7 km^2

Key: < = less than; dB = decibels; km^2 = square kilometers; LF = low frequency; MF = mid-frequency; MPU = marine structure maintenance, pile replacement, and upgrades; MWR = Morale, Welfare, and Recreation; m = meters, m^2 = square meters; PTS = permanent threshold shift; RMS SPL = root mean square sound pressure level; SEL_{CUM} = cumulative sound exposure level; ZOI = zone of influence.

Notes:

1. Injury thresholds are dB SEL_{CUM}, as listed in Table 6-3; however, all injury ZOIs for cetaceans and phocid seals are smaller than reported sound levels at 10 meters, based on Illingworth and Rodkin (2017).
2. Behavioral disturbance thresholds are dB RMS SPL, as listed in Table 6-3.
3. ZOIs calculated using geographic information system (GIS) data as determined by transmission loss modeling based on bathymetry (details in Appendix B).

6.8 Airborne Sound Propagation

Pile driving can generate airborne noise that could potentially result in disturbance to pinnipeds that are hauled out or swimming or resting at the water's surface. There is no threshold for Level A injury for airborne sound for marine mammals. As a result, the Navy analyzed the potential for seals to be exposed to airborne SPLs that could result in Level B behavioral harassment. The airborne noise threshold for behavioral harassment for harbor seals is 90 dB RMS SPL re 20 µPa (unweighted) and is 100 dB RMS SPL re 20 µPa (unweighted) for gray seals (see Table 6-3). Construction noise behaves as point-source and, thus, propagates in a spherical manner with a 6 dB decrease in SPL over water ("hard-site" condition) per doubling of distance (WSDOT, 2019). The water surface is considered a hard site and acts as a reflective surface. A spherical spreading loss model, assuming average atmospheric conditions, was used to estimate the distance to the 90 dB RMS SPL re 20 µPa (unweighted) airborne threshold. The TL equation is:

$$TL = 20\log_{10}\left(\frac{R_1}{R_2}\right)$$

where:

TL is the transmission loss in dB,

R_1 is the distance of the modeled SPL from the driven pile, and

R_2 is the distance from the driven pile of the initial measurement.

The intensity of pile driving sounds is greatly influenced by factors such as the type of piles, hammers, and the physical environment in which the activity takes place. To determine reasonable airborne source SPLs, source levels were reviewed based on available pile driving in-situ recordings (see analysis in Appendix B). Available data on airborne noise were limited to concrete and timber pile installation (Table 6-7), and source levels for vibratory driving of timber pile were used as a proxy for composite piles.

Table 6-7 Airborne Noise Source Levels from Impact and Vibratory Pile Driving (dB)

Pile Type	*Size (diameter in inches)*	*Installation Method*	
		Impact RMS SPL L_{max} Impact	*Vibratory RMS SPL L_{eq} Vibratory*
Square concrete	24	101 dBA avg L_{max}	N/A
Composite[1, 2]	16	n/a	85 dBA avg L_{eq}
Timber[3]	12	n/a	85 dBA avg L_{eq}

Source: (Illingworth and Rodkin, 2017)
Key: avg = average; dB = decibel; dBA = A-weighted sound level; L_{eq} = equivalent continuous sound level; L_{max} = maximum sound level; N/A = not applicable; n/a = not available; RMS SPL = root mean square sound pressure level.
Notes:
1. Composite piles may be solid high-density polyethylene (HDPE) plastic or hollow core fiberglass.
2. Data not available for vibratory driven composite pile; assumes source level for timber pile.
3. Data not available for impact-driven timber pile.

The distance to the airborne disturbance threshold for phocids was calculated using the airborne TL formula for 24-inch concrete piles with impact driver and for composite or timber piles with vibratory

driver (Table 6-8). No airborne source level data were available for impact installation of composite or timber piles, but these source levels likely would be no greater than source levels for 24-inch concrete piles, and the ZOIs would be smaller because fewer pile strikes are required for composite piles. The exposure analyses that follow use "worst-case" ZOIs; i.e., the ZOIs for behavioral thresholds due to underwater vibratory pile driving (Table 6-6). Because areas affected by airborne noise are smaller than the underwater behavioral threshold zones, a separate analysis of Level B take was not conducted for the airborne zones. Seals in the airborne zones would already be exposed within the corresponding Level B underwater zone; therefore, no additional takes due to exposure to airborne noise are requested.

Table 6-8 Calculated Distances to Threshold for Phocids and Areas of Zones of Influence for Airborne Sound from MPU Impact Pile Driving[1]

Pile Type	*Pile Diameter (inches)*	*Installation Method*	*Radial Distance to Threshold (meters)*	*Area of ZOI (square meters)*
Square Concrete	24	Impact	53	8,825
Composite	16	Vibratory	8	201
Timber	12	Vibratory	8	201

Key: dB = decibels; MPU = marine structure maintenance, pile replacement, and upgrades; RMS SPL = root mean square sound pressure level; ZOI = zone of influence.
Note:
1. Phocid Threshold = 90 dB RMS SPL.

6.9 Estimated Duration of Pile Driving

Pile driving will take place from 2021 through 2025 with the anticipated total number of pile driving days each year, broken down by location and pile type, as shown in Table 6-9. Numbers of pile driving days are based on installation rates indicated in the table; estimates of daily pile driving durations for vibratory drivers and numbers of pile strikes for impact drivers are also provided. The durations of vibratory pile driving and the number of impact pile strikes are averages derived from the Navy's construction projects involving the installation of fender piles and load-bearing piles.

Table 6-9 Pile Driving Duration Summary

Installation Method and Pile Type and Size	*Total Number In-water Work Days by Year*					*Installation Rate*	*Estimated Duration*	
	2021	*2022*	*2023*	*2024*	*2025*		*Vibratory Average Duration/Pile (minutes:seconds)*	*Impact Average Strikes/Day*
NAVSTA Norfolk Piers								
Impact/Vibratory composite 16 in[(a)]	21	20	0	27	85	10 piles/day	7:00	308
Vibratory timber 12 in[(b)]	63	56	10	41	95	10 piles/day	0:40	N/A
DFSP Craney Island								
Impact/Vibratory composite 16 in[(a)]	26	0	0	0	0	10 piles/day	7:00	308
Vibratory timber 12 in[(b)]	27	0	0	0	0	10 piles/day	0:40	N/A
Lambert's Point Deperming Station								

Table 6-9 Pile Driving Duration Summary

Installation Method and Pile Type and Size	*Total Number In-water Work Days by Year*					*Installation Rate*	*Estimated Duration*	
	2021	*2022*	*2023*	*2024*	*2025*		*Vibratory Average Duration/Pile (minutes:seconds)*	*Impact Average Strikes/Day*
Impact/Vibratory composite 16 in[(a)]	3	0	0	0	0	10 piles/day	7:00	308
Vibratory timber 12 in[(b)]	4	0	0	0	0	10 piles/day	0:40	N/A
MWR Marina and V-Area								
Impact pre-stressed concrete 24 in[(c)]	34	0	0	0	0	3 piles/day[(d)]	N/A	1,500
Impact/Vibratory composite 16 in[(a)]	20	8	8	8	8	5 piles/day	7:00	308
Vibratory timber 12 in	10	0	0	0	0	5 piles/day	0:40	N/A
Total pile driving days	208	84	18	76	188			

Key: DFSP = Defense Fuel Supply Point; in = inch/inches; MWR = morale, welfare, and recreation; N/A = not applicable; NAVSTA = Naval Station.

Notes:

(a) All composite piles are fender or guide piles and driven by impact or vibratory driver.

(b) Timber piles include fender piles (all locations except V-Area) and load-bearing piles (MWR Marina only) and driven by impact or vibratory driver.

(c) All concrete piles are load-bearing and driven by impact driver only.

(d) Pile driving daily productivity in the MWR Marina and V-Area is reduced when compared to other areas due to space available to maneuver pile driving equipment efficiently.

6.10 Evaluation of Potential Species Presence

As discussed in Section 3.2 (Estimates of Abundance within the Activity Area), the following species are likely to occur seasonally in the vicinity of NAVSTA Norfolk during the MPU pile driving activities: bottlenose dolphin and harbor seal. In addition, the following rare species may be present intermittently in small numbers: humpback whale, harbor porpoise, and gray seal. The Navy is requesting takes under the MMPA in the event that individuals of these species may be exposed to pile driving noise.

6.11 Estimating Potential Exposures to Pile Driving Noise

6.11.1 Approach to Estimating Abundance of Marine Mammals Exposed to Noise

Density estimates are available for bottlenose dolphins based on shipboard surveys of the mouth of the Chesapeake Bay and Virginia coast (Engelhaupt et al., 2014; Engelhaupt et al., 2015; Engelhaupt et al., 2016). The Navy has developed a Marine Mammal Species Density Database (Navy, 2017) for the East Coast and Atlantic Fleet Training and Testing Study Area, but there are no densities available for the remaining species in the MPU project area. As discussed in Section 3.1 (Marine Mammal Species Likely to be Found within the Activity Area), using a density-based analysis for species that occur intermittently

may not adequately account for their unique temporal and spatial distributions in a limited study area.[2] For rare species, historical occurrence and numbers as well as group size were reviewed to develop a realistic estimate of potential exposure to MPU project impacts.

A density-based analysis for bottlenose dolphin uses the following equation to estimate exposure to noise-relative project impacts[3]:

$$\text{Exposure estimate} = (N \times ZOI) \times \text{maximum days of pile driving}$$

where:

N = seasonal density estimate for the species; and

ZOI = zone of Influence, the area where noise exceeds the noise threshold value.

For the remaining species with no density estimates available for the Chesapeake Bay/Virginia coastline (humpback whale, harbor porpoise, harbor seal, gray seal), the likelihood of occurrence was reviewed based on the information in Sections 3 (Marine Mammal Species and Numbers) and 4 (Affected Species Status and Distribution) and the potential maximum duration of work days and total work days. The rationale for estimating probable abundance and duration is described for each species in Section 6.12 (Exposure Estimates). Results of the calculations for all potentially affected marine mammal species are described in Section 6.12 (Exposure Estimates).

$$\text{(1) Exposure estimate} = \text{Probable abundance during construction} \times \text{Probable duration}$$

where:

Probable abundance = maximum expected group size, and

Probable duration = probable duration of animal(s) presence at construction sites during in-water work.

6.11.2 Assumptions

Cetaceans spend their entire lives in the water and spend most of their time (greater than 90 percent for most species) entirely submerged below the surface. When at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This makes cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, essentially 100 percent of the time because their ears are nearly always below the water's surface.

---

[2]Previously, a density-based exposure analysis was required for these species. The analyses often resulted in zero exposure estimates because of the small size of the affected area and the low densities of most species. Therefore, to obtain Letter of Authorization (LOA) coverage for potential exposure to these animals, the Navy would typically augment the requested take by the typical group size of animals. NMFS has subsequently requested that future Navy LOA applications do not use a density estimate for marine mammal species with a low likelihood of occurrence.

[3]If exposure is greater than or equal to 0.5 animals, the product is rounded up to a whole number.

Pinnipeds spend significant amounts of time out of the water during breeding and molting periods, and while resting at haulout sites. In the water, pinnipeds spend varying amounts of time underwater. When not actively diving, pinnipeds at the surface often orient their bodies vertically or horizontally in the water column and hold their heads above the water surface. Consequently, pinnipeds may not be exposed to underwater sounds to the same extent as cetaceans.

To assess impacts from underwater sound, the Navy assumed that all cetacean and pinniped species spend 100 percent of their time underwater. This approach is conservative because seals spend a portion of their time hauled out and are therefore expected to be exposed to less sound than is estimated by this approach. Some additional assumptions were used to calculate potential exposures to impact and vibratory pile driving noise for each threshold:

- The timeframe for takings would be one potential take (Level B harassment exposure) per individual, per 24 hours.
- The pile type, size, and installation method that produce the largest ZOI were used to estimate exposure of marine mammals to noise impacts. Since vibratory installation of 16-inch composite piles and vibratory extraction of 12-inch timber piles create the largest ZOIs, the exposure analysis calculates marine mammal exposures based on these pile types.
- All piles will have an **underwater** noise disturbance ZOI equal to the pile that causes the greatest noise disturbance (i.e., the pile farthest from shore) installed with the method that has the largest ZOI. If vibratory pile driving would occur, the largest ZOI will be produced by vibratory driving. In this case, the ZOI for an impact hammer will be encompassed by the larger ZOI from the vibratory driver. Vibratory driving was assumed to occur on all days of pile driving where composite piles could be installed and timber piles extracted.
- Exposures to airborne noise were considered included in the larger underwater ZOIs from vibratory driving and, therefore, airborne noise exposures were not calculated for seals. Airborne ZOIs were calculated to determine proximity of haulouts to noise exposure; no haulouts occur within the airborne ZOIs for any MPU projects.
- Days of pile driving (Table 6-9) were based on estimates of average daily production rates provided by NAVSTA Norfolk engineers. Production rates vary among sites due to access and ability to maneuver pile driving equipment (more open areas permit easier maneuvering and greater daily pile production).

6.11.3 Avoidance of Level A Exposure

Of significant note is that successful implementation of mitigation methods (i.e., visual monitoring and the use of shutdown zones) will result in no Level A exposure to any marine mammals. Only the injury ZOI for low-frequency cetaceans exceeds the 10-meter zone around a driven pile, and the areas within this ZOI at the six representative pile locations are too small to have any likelihood of occupation by humpback whales. Moreover, these injury zones are small enough to be fully monitored. Results from the following acoustic impact exposure assessments should be regarded as conservative overestimates that are strongly influenced by limited marine mammal survey data, and the assumption that marine mammals will be present during pile driving.

6.12 Exposure Estimates

Exposure estimates for each species are discussed in the following sections and presented in Table 6-10. Annual reporting requirements will provide details of how many actual and extrapolated animals of each species are exposed to noise levels considered potential Level B harassment.

Table 6-10 Underwater Exposure Estimates by Species

Species	*Level A*	*Level B*					
		2021	*2022*	*2023*	*2024*	*2025*	*Total*
Humpback whale	0	3	2	1	2	4	12
Bottlenose dolphin	0	4,401	1,777	381	1,608	3,977	12,144
Harbor porpoise	0	7	3	1	3	6	20
Harbor seal	0	208	84	18	76	188	574
Gray seal	0	3	2	1	2	4	12

Exposure estimates generally do not differentiate age, sex, or reproductive condition. However, some inferences can be made based on what is known about the life stages of the animals that visit or inhabit nearshore waters. When possible and with the available data, this is discussed by species in the sections that follow.

6.12.1 Humpback Whale

Humpback whales are seen in the mouth of the Chesapeake Bay and nearshore waters of Virginia during winter and spring months. Most detections during shipboard surveys were of one or two juveniles per sighting. Although two individuals were detected in the vicinity of MPU project activities, there is no evidence that they linger for multiple days. Because no density estimates are available for the species in this area, the Navy estimated 1 take for every 60 days of pile driving. The resulting estimate of potential exposures to Level B noise ranges from one to four individuals per year for the duration of the five-year project (Table 6-10). Therefore, the Navy is requesting incidental takes of up to 12 individual whales for Level B harassment due to underwater noise resulting from pile driving. These takes were assigned to the five years in the MPU project in proportion to the number of pile driving days anticipated each year. The majority of affected humpback whales would be juveniles.

To protect humpback whales from injurious noise impacts, the Navy will implement a shutdown if any whales are seen by marine mammal monitors in an injury zone (see mitigation measures in Section 11, Means of Effecting the Least Practicable Adverse Impacts). Therefore, no Level A takes are requested for humpback whales.

6.12.2 Bottlenose Dolphin

Bottlenose dolphins are abundant along the Virginia coast and within the Chesapeake Bay and can be seen annually in Virginia from May through October. Shipboard surveys of marine mammals in the vicinity of NAVSTA Norfolk and nearshore Virginia coast have provided seasonal densities of bottlenose dolphins (Table 6-11). Exposure to Level B behavioral disturbance due to vibratory pile driving was estimated using the equation in Section 6.11 (Estimating Potential Exposures to Pile Driving Noise), in which the inputs are seasonal density, ZOI, and maximum number of pile driving days. ZOIs for the six representative pile driving locations were assumed to apply to all of the MPU project locations indicated in Appendix A as being covered by that representative location. For example, the representative pile at

Lambert's Point Deperming Station Pier A also covers Deperming Station Pier B. It was assumed that pile driving would occur during an equal number of days in all seasons. Therefore, since approximately 574 days of pile driving are anticipated during the 5-year project, 144 pile driving days would be anticipated in each season.

Table 6-11 Bottlenose Dolphin Seasonal Densities and Level B Take Estimates

Season	*Density[1] (individuals/sq km)*	*Representative Pile Driving Locations[1]*	*Largest ZOI for Representative Pile Driving Locations[2] (sq km)*	*Number of Pile Driving Days/Season[3]*	*Number of Estimated Exposures*
Summer	3.55	Pier 3	10.3	17	622
		Pier 12	13.1	88	4,092
		MWR Marina	0.2	13	9
		V-Area	0.2	11	8
		Craney Island	2.2	13	102
		Lambert's Point	4.7	2	33
Fall	3.68	Pier 3	10.3	17	644
		Pier 12	13.1	88	4,242
		MWR Marina	0.2	13	10
		V-Area	0.2	11	8
		Craney Island	2.2	13	105
		Lambert's Point	4.7	2	35
Winter	0.63	Pier 3	10.3	17	110
		Pier 12	13.1	88	726
		MWR Marina	0.2	13	2
		V-Area	0.2	11	1
		Craney Island	2.2	13	18
		Lambert's Point	4.7	2	6
Spring	1.00	Pier 3	10.3	17	175
		Pier 12	13.1	88	1,153
		MWR Marina	0.2	13	3
		V-Area	0.2	11	2
		Craney Island	2.2	13	29
		Lambert's Point	4.7	2	9
				Total, all seasons, all locations	12,144

Key: MWR = morale, welfare, and recreation; sq km = square kilometer; ZOI = zone of influence.
Notes:
1. Density source: (Engelhaupt et al., 2016)
2. Pile driving location ZOIs are assumed to be representative of multiple project locations, as detailed in Appendix A.
3. Pile driving days include all project sites included with representative pile driving locations.

To protect bottlenose dolphins from injurious noise impacts, the Navy will implement a shutdown if any dolphins are observed in an injury zone by marine mammal monitors (see mitigation measures in Section 11, Means of Effecting the Least Practicable Adverse Impacts). Therefore, no Level A takes are requested for bottlenose dolphins.

6.12.3 Harbor Porpoise

Harbor porpoises appear to be rare in the Chesapeake Bay waters in most years, and there is no information about how long, when present, they would linger in the area. For this analysis, it is assumed that any harbor porpoises that occur in the NAVSTA Norfolk vicinity are transiting through the area. Elsewhere in their range they typically occur in groups of 2 to 3 individuals (Carretta et al., 2001; Smultea et al., 2017). Because there are no density estimates for the species in MPU project area, the Navy conservatively estimated 1 exposure of 2 porpoises for every 60 days of vibratory pile driving. The resulting estimate is 20 potential exposures to Level B noise over the 5-year duration of the MPU project (Table 6-10). Therefore the Navy is requesting incidental takes of up to 18 individual harbor porpoises for Level B harassment due to underwater noise resulting from vibratory pile driving. These takes were assigned to the five years in the MPU project in proportion to the number of pile driving days anticipated each year. Animals of any age, sex, or reproductive status could be exposed to elevated underwater noise.

To protect harbor porpoises from injurious noise impacts, the Navy will implement a shutdown if harbor porpoises are seen by marine mammal monitors in an injury zone (see mitigation measures in Section 11, Means of Effecting the Least Practicable Adverse Impacts). Therefore, no Level A takes are requested for harbor porpoise.

6.12.4 Harbor Seal

Harbor seals regularly haul out on rocks around the portal islands of the Chesapeake Bay Bridge Tunnel (CBBT) (between approximately 15 and 23 kilometers from the nearest pile driving location [V-Area]) and on mud flats on the nearby southern tip of the Eastern Shore (over 32 kilometers from nearest pile driving location [V-Area]) (Rees et al., 2016; Jones et al., 2018), and some individuals regularly range into the Chesapeake Bay. Their occurrence is seasonal, from November to April. Although density estimates are not available for this area, haulout survey data can be used to estimate exposure to pile driving noise at MPU project locations. The maximum seal count on a single survey day during 4 survey seasons at CBBT was 45 and during 2 survey seasons at the Eastern Shore haulout site the maximum count was 69 (Rees et al., 2016; Jones et al., 2018). Animals move between haulout sites; therefore, the highest maximum count at the Eastern Shore haulout was used to estimate exposures of harbor seals. Tracking of seven satellite-tagged harbor seals that were captured in the winter at the Eastern Shore haulout site revealed that four seals made trips into the Chesapeake Bay, including one seal that stayed in the bay until it migrated from the area (Ampela et al., 2019). Tracking data indicate that one of these seals entered Hampton Roads Harbor, transited past NAVSTA Norfolk and on to the Warwick River, a minor tributary of James River located approximately 24 kilometers northwest of NAVSTA Norfolk. None of the other seals entered Hampton Roads Harbor. Three tagged seals never entered the Chesapeake Bay. All tagged seals migrated from the area by mid-April. The tagged seals made a total of 56 trips, defined as travel greater than 10 kilometers away from the capture site, while in Virginia waters, of which 36 percent were within the Chesapeake Bay.

Based on these results and lacking more extensive data on occurrence in the Chesapeake Bay, the maximum survey count obtained in the 2017–2018 field season was multiplied by 36 percent, corresponding to the proportion of tagged seals that utilized the Chesapeake Bay during the tracking study. As a result, it is anticipated that up to 25 seals from the population that uses the CBBT and Eastern Shore haulout sites may utilize the Chesapeake Bay at some point from November to April

during the MPU project. Since at least some seals remain in the bay for extended periods, the Navy assumes that two harbor seals may be exposed to elevated noise levels per pile driving day. If half of the total 574 pile driving days occur during the 6-month period when harbor seals are present, then 574 exposures would result. Therefore the Navy is requesting incidental takes of up to 574 individual harbor seals for Level B harassment due to underwater noise resulting from vibratory pile driving. These takes were assigned to the five years in the MPU project in proportion to the number of pile driving days anticipated each year. Animals of any age or sex could be exposed to elevated underwater noise.

To protect harbor seals from injurious noise impacts, the Navy will implement a monitoring plan/shutdown plan if harbor seals are seen by marine mammal monitors in an injury zone (see mitigation measures in Section 11, Means of Effecting the Least Practicable Adverse Impacts). Therefore, no Level A takes are requested for harbor seals.

6.12.5 Gray Seal

Very little information is available about the occurrence of gray seals in the Chesapeake Bay and coastal waters. Although the population of the United States may be increasing, there are only a few records at known haulout sites in Virginia used by harbor seals, strandings are rare, and they have not been reported in shipboard surveys. Assuming that they may utilize the Chesapeake Bay waters, the Navy conservatively estimates that 1 gray seal may be exposed to elevated noise levels for every 60 days of vibratory pile driving during the six month period when they are most likely to be present. Therefore, the Navy is requesting incidental takes of up to 12 gray seals for Level B harassment due to underwater noise resulting from vibratory pile driving. These takes were assigned to the five years in the MPU project in proportion to the number of pile driving days anticipated each year. Animals of any age or sex could be exposed to elevated underwater noise. To protect gray seals from injurious noise impacts, the Navy will implement a monitoring plan/shutdown plan if gray seals are seen by marine mammal monitors in an injury zone (see mitigation measures in Section 11, Means of Effecting the Least Practicable Adverse Impacts). Therefore, no Level A takes are requested for gray seals.

This page intentionally left blank.

7 Impacts to Marine Mammal Species or Stocks

The anticipated impact of the activity upon the species or stock of marine mammals.

7.1 Potential Effects of Pile Driving on Marine Mammals

7.1.1 Potential Effects Resulting from Underwater Noise

Potential impacts to marine species can be caused by physiological responses to both the type and strength of the acoustic signature (Viada et al., 2008). Behavioral impacts may also occur, though the type and severity of these effects are more difficult to define due to limited studies addressing the behavioral effects of impulsive sounds on marine mammals. Potential effects from impulsive sound sources can range from Level B effects such as brief behavioral disturbance, tactile perception, and physical discomfort, to Level A impacts, which may include slight injury of the internal organs primarily within air spaces (e.g., lungs, sinuses, ears, and gastrointestinal tract) and the auditory system, and possible death of the animal (Yelverton et al., 1973; O'Keeffe & Young, 1984; Ketten, 1995; Navy, 2001; Dahl et al., 2015; Finneran, 2015; Kastelein et al., 2016; Kastelein et al., 2018).

7.1.1.1 Physiological Responses

Direct tissue responses to impact/impulsive sound stimulation may range from mechanical vibration or compression with no resulting injury to tissue trauma (injury). Because the ears are the most sensitive organ to pressure, they are the organs most sensitive to injury (Ketten, 2000). Sound-related trauma can be lethal or sub-lethal. Lethal impacts are those that result in immediate death or serious debilitation in or near an intense source (Ketten, 1995). Sub-lethal damage to the ear from a pressure wave can rupture the tympanum, fracture the ossicles, and damage the cochlea; it can also cause hemorrhage, and cause leakage of cerebrospinal fluid into the middle ear (Ketten, 2004). Sub-lethal impacts also include hearing loss, which is caused by exposure to perceptible sounds. Moderate injury implies partial hearing loss. Permanent hearing loss (also called permanent threshold shift [PTS]) can occur when the hair cells of the ear are damaged by a very loud event, as well as by prolonged exposure to noise. Instances of temporary threshold shifts and/or auditory fatigue are well documented in marine mammal literature as being one of the primary avenues of acoustic impact. Temporary loss of hearing sensitivity has been documented in controlled settings using captive marine mammals exposed to strong sound exposure levels at various frequencies (Ridgway et al., 1997; Kastak et al., 1999; Finneran et al., 2005; Mooney et al., 2009; Kastelein et al., 2015; Finneran, 2015). While injuries to other sensitive organs are possible, they are less likely since pile driving impacts are almost entirely acoustically mediated, versus explosive sounds that also include a shock wave that can result in damage. Based on the mitigation measures outlined in Section 11 (Means of Effecting the Least Practicable Adverse Impacts) and the conservative modeling assumptions discussed in Section 6 (Numbers and Species Exposed), Level A harassment is not expected to any marine mammals in the MPU project area.

7.1.1.2 Behavioral Responses

Behavioral responses to sound can be highly variable. For each potential behavioral change, the magnitude of the change ultimately determines the severity of the response. A number of factors may influence an animal's response to noise, including its previous experience, auditory sensitivity, biological and social status (including age and sex), and behavioral state and activity at the time of exposure.

Habituation occurs when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok et al., 2004). Animals are most likely to habituate to sounds that are predictable and unvarying. The opposite process is sensitization—when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at a lower level of exposure. Behavioral state or differences in individual tolerance levels may affect the type of response as well. For example, animals that are resting may show greater behavioral change in response to disturbing noise levels than animals that are highly motivated to remain in an area for feeding (National Research Council, 2003; Wartzok et al., 2004; Southall et al., 2007; Richardson et al., 1995). Indicators of disturbance may include sudden changes in the animal's behavior or avoidance of the affected area. A marine mammal may show signs that it is startled by the noise and/or it may swim away from the sound source and avoid the area. Increased swimming speed, increased surfacing time, and cessation of foraging in the affected area would indicate disturbance or discomfort. Pinnipeds may increase their haulout time, possibly to avoid in-water disturbance.

Controlled experiments with captive marine mammals showed pronounced behavioral reactions, including avoidance of loud sound sources (Ridgway et al., 1997; Finneran et al., 2003). Observed responses of wild marine mammals to loud pulsed sound sources (typically seismic guns or acoustic harassment devices and including pile driving) have been varied, but often consist of avoidance behavior or other behavioral changes suggesting discomfort (Morton & Symonds, 2002; Gordon et al., 2004; Wartzok et al., 2004; Nowacek et al., 2007). Some studies of acoustic harassment and acoustic deterrence devices have found habituation in resident populations of seals and harbor porpoises (see review in Southall et al. (2007)). Blackwell et al. (2004) found that ringed seals exposed to underwater pile driving sounds in the 153–160 decibel (dB) root mean square range tolerated this noise level and did not seem unwilling to dive. One individual was as close as 63 meters from the pile driving.

Responses of harbor seals to impact pile driving at the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project were mixed (California Department of Transportation, 2001; Thorson & Reyff, 2006; Thorson, 2010). Harbor seals were observed in the water at distances of approximately 400 to 500 meters from the pile driving activity and exhibited no alarm responses, although several showed alert reactions, and none of the seals appeared to remain in the area. It is likely that seals were transiting through the pile driving area to the haulout site or feeding areas despite pile driving noise. One of these harbor seals was even seen to swim to within 150 meters of the pile driving barge during pile driving.

Telemetry studies and modeling of harbor seal usage of offshore wind farm sites in Britain showed significant displacement of harbor seals during periods when impact pile driving was taking place (up to 25 kilometers from the center of the wind farm), but use of the area resumed during breaks in pile driving greater than two hours (Russell et al., 2016). Another telemetry study conducted in the Wadden Sea found that reactions to pile driving were diverse. Reactions included altered surfacing or diving behavior and changes in swim direction, including swimming away from the source, heading into shore or travelling perpendicular to the incoming sound, coming to a halt, and slowing descent speed (suggesting a transition from foraging to more horizontal movement). Additionally, seals within 33 kilometers of the pile driving were more likely to swim away (Aarts et al., 2017).

Studies of marine mammal responses to continuous noise, such as vibratory pile driving, are limited. Observations of marine mammals on Naval Base (NAVBASE) Kitsap Bangor during a test pile installation/removal project concluded that pinniped (harbor seal and California sea lion) foraging

behaviors decreased slightly during construction periods involving impact and vibratory pile driving, and both pinnipeds and harbor porpoise were more likely to change direction while traveling during construction (HDR Inc., 2012). Pinnipeds were more likely to dive and sink when closer to pile driving activity, and a greater variety of other behaviors were observed with increasing distance from pile driving. Most harbor porpoises were observed swimming or traveling through the project area and no obvious behavioral changes were associated with pile driving. As detailed in Section 6.5, Branstetter et al. (2018) found evidence of altered behavior resulting from vibratory pile driving in bottlenose dolphins (an almost complete cessation of echolocation clicks) only at the highest source level (roughly estimated as 128 dB re 1 µPa), however the effect on behavior diminished significantly, indicating acclimation.

A total of three years of marine mammal monitoring were conducted during vibratory and impact pile driving for the construction of Explosives Handling Wharf-2 at NAVBASE Kitsap Bangor in Washington (Hart Crowser, Inc., 2013; 2014; 2015). Results from monitoring varied slightly year to year, but in general it was found that harbor seals were most frequently observed having no motion to the construction zone during vibratory pile driving, and during impact driving, seals were most frequently observed moving away from the pile. Harbor porpoises were only observed at a greater distance from the construction area than seals, where the predominant behavior during construction (vibratory pile driving) was swimming or traveling through the project area. Harbor porpoise foraging was reported during pre-construction monitoring, but not during pile driving. Marine mammal observers did not detect adverse reactions to these construction activities at NAVBASE Kitsap Bangor that would be consistent with distress, injury, or high speed withdrawal from the area, nor did they report obvious changes in less acute behaviors.

Marine mammal monitoring at the Port of Anchorage marine terminal redevelopment project in Alaska found no response by marine mammals swimming within the threshold distances to noise impacts from construction activities including pile driving (both impact hammer and vibratory driving). Most marine mammals observed during the two lengthy construction seasons were beluga whales while harbor seals, harbor porpoises, and Steller sea lions were observed in smaller numbers. Background noise levels at this port are typically at 125 dB.

A comprehensive review of acoustic and behavioral responses to noise exposure by Nowacek et al. (2007) concluded that one of the most common behavioral responses is displacement. To assess the significance of displacements, it is necessary to know the areas to which the animals relocate, the quality of that habitat, and the duration of the displacement in the event that they return to the pre-disturbance area. Short-term displacement may not be of great concern unless the disturbance happens repeatedly. Similarly, long-term displacement may not be of concern if adequate replacement habitat is available. Modeling of population-level impacts of pile driving noise for offshore wind farm development suggests that behavioral displacement could lead to reduced reproductive success of displaced female harbor seals during construction years. However, the common pattern at the population level was short-term reductions in abundance during and immediately after the construction period, followed by recovery with no observable long-term consequences (Thompson et al., 2013).

Marine mammals encountering pile driving operations over a project's construction timeframe would likely avoid affected areas in which they experience noise-related discomfort, limiting their ability to forage or rest there. As described in the section above, individual responses to pile driving noise are expected to be variable. Some individuals may occupy a project area during pile driving without apparent discomfort, but others may be displaced with undetermined effects. Avoidance of the affected

area during pile driving operations would reduce the likelihood of injury impacts, but would also reduce access to foraging areas. Noise-related disturbance may also inhibit some marine mammals from transiting the area. Given the duration of the in-water construction period, there is a potential for displacement of marine mammals from affected areas due to these behavioral disturbances during the in-water construction season. However, in some areas habituation may occur resulting in a decrease in the severity of response. Since pile driving will only occur during daylight hours, marine mammals transiting a project area or foraging or resting in a project area at night will not be affected. Effects of pile driving activities will be experienced by individual marine mammals, but will not cause population-level impacts or affect the continued survival of the species because the effects are temporary, highly localized in a peripheral portion of their range, and likely would affect a small portion of the stock.

7.1.2 Potential Effects Resulting from Airborne Noise

Pinnipeds that occur in the project area could be exposed to airborne sounds associated with pile driving that have the potential to cause behavioral harassment, depending on their distance from pile driving activities. Airborne pile driving noises are expected to have very little impact to cetaceans because most noise from atmospheric sources does not transmit well through the air-water interface (Urick, 1972; Richardson et al., 1995); consequently, cetaceans are not expected to be exposed to airborne sounds that will result in harassment as defined under the Marine Mammal Protection Act. Airborne noise will primarily be an issue for pinnipeds that are swimming or hauled out within the range of impact as defined by the acoustic criteria discussed in Section 6 (Numbers and Species Exposed). Most likely, airborne sound will cause behavioral responses similar to those discussed above in relation to underwater noise. For instance, anthropogenic sound could cause hauled-out pinnipeds to exhibit changes in their normal behavior, such as reduction in vocalizations, or cause them to temporarily abandon their usual or preferred locations and move farther from the noise source. Pinnipeds swimming near pile driving may avoid or withdraw from the area, or may show increased alertness or alarm (e.g., heading out of the water, and looking around). However, studies of ringed seals by Blackwell et al. (2004) and Moulton et al. (2005) indicate a tolerance or lack of response to unweighted airborne sounds as high as 112 dB peak pressure and 96 dB root mean square, which suggests that habituation occurred.

California sea lions and harbor seals were present during impact installation and vibratory extraction of piles at NAVBASE Kitsap Bremerton in February 2014 and November 2014 to February 2015 (Northwest Environmental Consulting, 2014; 2015). In February 2014, California sea lions were observed basking on the port security barrier within the underwater behavioral disturbance zone (117 meters from the driven pile) and no behavioral harassment takes were documented because they did not enter the water. California sea lions and harbor seals were observed in the water during vibratory driver activity. Marine mammal observers detected 160 individuals during vibratory pile extraction within the 1,600-meter vibratory disturbance zone, resulting in exposure to noise levels above the Level B threshold. Marine mammal observers detected 125 individuals during impact pile driving within the 117-meter impact disturbance zone, resulting in exposure to noise levels above the Level B threshold. There were no shutdowns of pile driving activity because pinnipeds never entered the injury zones. No visible behaviors indicating a reaction to noise disturbance were observed. Behaviors observed included hauling-out (resting), foraging, milling, and traveling.

Based on these observations, marine mammals in the zones of influence (ZOIs) for airborne noise may exhibit temporary behavioral reactions to airborne pile driving noise. These exposures may have a temporary effect on seals, but this level of exposure is very unlikely to result in population-level impacts

because the effects are temporary, highly localized, and relatively few harbor and gray seals occur in the project area. In particular, the closest known haulout sites for seals in the vicinity of Naval Station Norfolk are the Chesapeake Bay Bridge Tunnel portal islands (located approximately 15 to 23 kilometers from the nearest pile driving location [V-Area]) and the mud flats on the nearby southern tip of the Eastern Shore (more than 30 kilometers from nearest pile driving location [V-Area]), which rules out the possibility of behavioral disturbance to hauled out seals due to pile driving noise.

7.2 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to increased sound pressure levels during pile driving operations, which may result in Level B behavioral harassment. Any marine mammals that are exposed (harassed) may change their normal behavior patterns (i.e., swimming speed, foraging habits, etc.) or be temporarily displaced from the area of construction. Any exposures to Level B harassment will likely have only a minor effect on individuals and no effect on the population. To avoid injurious exposure to pile driving noise, a shutdown zone will be implemented that will encompass the Level A zones. For the MPU projects, the injury ZOIs resulting from both impact and vibratory pile driving are negligible (less than 10 meters from the driven pile; Table 6-5); ZOIs exceed 10 meters only for low frequency cetaceans exposed to impact pile driving. Pile driving noise will not result in injury to marine mammals because the areas where injury could potentially occur are small and will be fully monitored, and pile driving will shut down if marine mammals are seen approaching these zones. Exposure to Level B behavioral disturbance is possible at the MPU project area, as discussed in Section 6 (Numbers and Species Exposed). However, this level of effect is not anticipated to have any adverse impact to population recruitment, survival, or recovery because the effects are temporary, highly localized in a peripheral portion of their range, and would potentially affect a small portion of the stock. No major feeding or reproductive areas, or pinniped haulout sites would be affected by MPU activities.

This page intentionally left blank.

8 Impacts to Subsistence Use

The anticipated impact of the activity on the availability of the species or stock of marine mammals for subsistence uses.

There are no known active ceremonial or subsistence hunts for marine mammals in the vicinity of Naval Station Norfolk. Therefore, the Proposed Action will not affect availability of marine mammals for ceremonial or subsistence use.

This page intentionally left blank.

9 Impacts to the Marine Mammal Habitat and the Likelihood of Restoration

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

Impacts to habitat will be temporary and include increased human activity and noise levels, localized, minor impacts to water quality, and changes in prey availability near the individual project sites. Since the focus of the Proposed Action is pile driving, no habitat loss or permanent modification is expected.

9.1 Effects from Human Activity and Noise

Existing human activity and underwater noise levels, primarily due to industrial activity and vessel traffic, could increase above baseline temporarily during pile installation and removal activities.

Marine mammals in the Proposed Action area and surrounding areas encounter vessel traffic associated with both Navy and non-Navy activities.

Behavioral changes in response to vessel presence include avoidance reactions, alarm/startle responses, temporary abandonment of haulouts by pinnipeds, and other behavioral and stress-related changes (such as altered swimming speed, direction of travel, resting behavior, vocalizations, diving activity, and respiration rate) (Watkins, 1986; Würsig et al., 1998; Terhune & Verboom, 1999; Foote et al., 2004; Bejder et al., 2006; Nowacek et al., 2007; Mocklin, 2005). Some dolphin species approach vessels and are observed bow riding or jumping in the wake of vessels (Norris & Prescott, 1961; Shane et al., 1986; Würsig et al., 1998; Ritter, 2002). In other cases, neutral behavior (i.e., no obvious avoidance or attraction) has been reported (review in Nowacek et al. (2007)). Little is known about the biological importance of changes in marine mammal behavior under prolonged or repeated exposure to high levels of vessel traffic, such as increased energetic expenditure or chronic stress, which can produce adverse hormonal or nervous system effects (Reeder & Kramer, 2005).

During MPU construction activities, additional vessels may operate in project areas, but will operate at low speeds within the relatively limited construction zone and access routes during the in-water construction period. The presence of vessels will be temporary and occur at current Navy facilities that have some level of existing vessel traffic. Therefore, effects are expected to be limited to short-term behavioral changes and are not expected to rise to the level of take or harassment as defined under the Marine Mammal Protection Act.

Additional noise could be generated by barge-mounted equipment, such as cranes and generators, but this noise will typically not exceed existing underwater noise levels resulting from existing routine waterfront operations. While the increase may change the quality of the habitat, it is not expected to exceed the Level A or B harassment thresholds and impacts to marine mammals from these noise sources are expected to be negligible.

9.2 Impacts on Prey Base

Pile installation and removal will impact marine habitats used by fish and benthic invertebrate species, which comprise the prey base for marine mammals. Marine habitats used by prey species that occur in the MPU project area include nearshore intertidal and subtidal habitats, including marine vegetation

and piles used for structure and cover. The greatest impact to prey species during pile installation will result from behavioral disturbance due to pile driving noise. Secondary impacts include temporary benthic habitat displacement and re-suspension of sediments.

9.2.1 Water Quality

Temporary and localized reduction in water quality will occur because of in-water construction activities. Most of this effect will occur during the installation and removal of piles when bottom sediments are disturbed. The installation of piles will disturb bottom sediments and may cause a temporary increase in suspended sediment in the project area. Using available information collection from a project in the Hudson River, pile driving activities are anticipated to produce total suspended sediment concentrations of approximately 5.0 to 10.0 milligrams per liter above background levels within approximately 300 feet (91 meters) of the pile being driven (NMFS, 2017). This estimate was based on information collected from similar activities conducted in the Hudson River, which has a high percentage of silt and clay in bottom sediments (NYSDEC, 2000). During pile extraction, sediment attached to the pile moves vertically through the water column until gravitational forces cause it to slough off. The small resulting sediment plume is expected to settle out of the water column within a few hours. Studies of the effects of turbid water on fish suggest that concentrations of suspended sediment can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton, 1993). The total suspended sediment levels expected for pile driving or removal (5.0 to 10.0 milligrams per liter) are below those shown to have adverse effects on fish (580.0 milligrams per liter for the most sensitive species, with 1,000.0 milligrams per liter more typical) and benthic communities (390.0 milligrams per liter (EPA, 1986)). Turbidity within the water column has the potential to reduce the level of oxygen in the water and irritate the gills of prey fish species in the construction area. However, turbidity plumes would be temporary and localized, and fish in the construction area would likely move away from the affected areas. Therefore, it is expected that the impacts on fish species from turbidity and therefore on marine mammals, would be minimal and temporary.

Piling extraction and installation may have impacts on benthic invertebrate species primarily associated with disturbance of sediments that may cover or displace some invertebrates. The impacts will be temporary and highly localized, and no habitat will be permanently displaced by construction. Therefore, it is expected that impacts on foraging opportunities for marine mammals due to MPU activities would be minimal.

9.2.2 Underwater Noise Impacts on Prey Base

Calculated distances to injury thresholds fall within the reference 10-meter radius for fish with and without swim bladders, eggs and larvae. Given the small size of the potentially affected area, the injury zones of influence (ZOIs) will be negligible for all life stages of fish, and by extension the impact on marine mammal predators will be negligible. Impact pile driving is likely to exceed the established underwater noise temporary threshold shift (TTS) thresholds for fish with swim bladders. TTS ZOIs will be greatest during impact driving of concrete piles, which is proposed only at the V-Area and MWR Marina; for example, installation of concrete piles at the V-Area will result in a ZOI of approximately 4.1 square kilometers (sq km) during 17 days of pile driving (Appendix A). ZOIs for TTS resulting from impact installation of composite or timber piles will be smaller. Given that marine mammals have not been reported to forage in the ZOIs calculated for the MPU project locations, and also the relatively

small size of these ZOIs, adverse impacts on prey availability for marine mammals are negligible and do not rise to the level of Marine Mammal Protection Act take.

9.3 Likelihood of Habitat Restoration

The impacts of the Proposed Action on marine habitats will be temporary and highly localized; therefore, no habitat restoration is planned.

This page intentionally left blank.

10 Impacts to Marine Mammals from Loss or Modification of Habitat

The anticipated impact of the loss or modification of the habitat on the marine mammal population involved.

The Proposed Action is not expected to have any habitat-related effects that could cause significant or long-term consequences for populations of marine mammals because all activities will be temporary. The Proposed Action will affect marine mammal habitats indirectly through temporary, localized impacts on prey abundance and availability. The most important impacts on marine fish species consumed by marine mammals will result from potential temporary threshold shift effects on fish during pile driving. Temporary threshold shift is a behavioral disturbance that is, by definition, temporary, and any impacts to the marine mammal prey base will cease upon completion of construction. As discussed in Section 9 (Impacts to the Marine Mammal Habitat and the Likelihood of Restoration), there will be no permanent loss or modification of habitat.

This page intentionally left blank.

11 Means of Effecting the Least Practicable Adverse Impacts

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance

General best management practices (BMPs), mitigation and minimization measures that may be implemented for all in-water repair and replacement activities are presented in the following subsections. These BMPs are routinely used by the Navy during marine structure maintenance, repair, and pile replacement activities. BMPs are intended to avoid and minimize potential environmental impacts. BMPs are included in construction contract plans and specifications for individual projects and become requirements that the contractor must implement.

11.1 General Construction Best Management Practices

- The Navy will adhere to performance conditions imposed as part of the Clean Water Act, Section 404, Permit and Section 401, Water Quality Certification. No in-water work will be conducted until the Clean Water Act authorization process has been completed.
- An Environmental Protection Plan will be prepared prior to the start of construction activities. The plan will identify construction planning elements and recognize spill sources at the sites. The plan will outline BMPs, responsive actions in the event of a spill or release, and notification and reporting procedures. The plan will also outline contractor management elements such as personnel responsibilities, project site security, site inspections, and training.
- No petroleum products, fresh cement, lime, fresh concrete, chemicals, or other toxic or harmful materials will be allowed to enter surface waters.
- Wash water resulting from washdown of equipment or work areas will be contained for proper disposal, and will not be discharged.
- Equipment that enters surface water will be maintained to prevent any visible sheen from petroleum products.
- No oil, fuels, or chemicals will be discharged to surface waters, or onto land where there is a potential for re-entry into surface waters. Fuel hoses, oil drums, oil or fuel transfer valves, fittings, etc., will be checked regularly for leaks. Materials will be maintained and stored properly to prevent spills.
- No cleaning chemicals or solvents will be discharged to ground or surface waters.

11.2 Pile Repair, Removal, and Installation Best Management Practices

11.2.1 Creosote Pile Removal

- A containment boom surrounding the work area will be used during creosote-treated pile removal to contain and collect any floating debris and sheen. In some cases, the boom may be lined with oil-absorbing material to absorb released creosote.
- Oil-absorbent materials will be used in the event of a spill if any oil product is observed in the water.

- All creosote-treated material and associated sediments will be disposed of in a landfill approved for this type of waste.
- Used creosote piles will be cut into 4-foot lengths to prevent reuse.

11.2.2 General Pile Removal and Replacement

- Removed piles and associated sediments (if any) will typically be contained on a barge. If a barge is not utilized, piles and sediments may be stored in a containment area near the construction sites.
- Piles that break or are already broken below the waterline may be removed by pulling them directly from the sediment with a crane. If this is not possible, piles will be removed with a clamshell bucket. To minimize disturbance to bottom sediments and splintering of piling, the contractor will use the minimum size bucket required to pull out piles based on pile depth and substrate. The clamshell bucket will be emptied of piling and debris on a contained barge before it is lowered into the water. If the bucket contains only sediment, the bucket will remain closed and be lowered to the mud-line and opened to redeposit the sediment. In some cases (depending on access, location, etc.), piles may be cut below the mud-line.
- Any floating debris generated during removal or installation will be retrieved. Any debris in a containment boom will be removed by the end of the work day or when the boom is removed, whichever occurs first. Retrieved debris will be disposed of at an upland disposal site.
- Whenever activities that generate sawdust, drill tailings, concrete fragments, or wood chips from treated timbers are conducted, tarps or other containment material will be used to prevent debris from entering the water.
- If excavation around piles to be repaired or replaced is necessary, hand tools or a siphon dredge will be used to excavate around piles. If siphon dredges are used, any contaminated sediment must be accounted for as waste and disposed of properly.

11.3 Minimization Measures for Marine Mammals and Other Protected Species

The following mitigation measures will be implemented during pile driving to avoid marine mammal exposure to Level A injurious noise levels generated from impact pile driving and to reduce to the lowest extent practicable exposure to Level B disturbance noise levels.

11.3.1 Coordination

The Navy will conduct briefings between construction supervisors and crews, the marine mammal monitoring team, and Navy staff prior to the start of all pile driving activity and when new personnel join the work, to explain responsibilities, communication procedures, marine mammal monitoring protocol, and operational procedures.

11.3.2 Limits on Changes to Structure Footprint

In some cases, piles may not be placed in the same location as the previous pile; however, the overwater coverage (or footprint) of existing structures is not anticipated to change. With the exception of the V-Area improvements, changes to overwater coverage would most likely occur from associated

fender system structures or utility repairs, and would be limited to less than 2 percent of the original overwater coverage of each structure.

11.3.3 Soft Start

The Navy will utilize a "soft start" procedure to provide a warning and/or give animals in proximity to pile driving the opportunity to leave the area prior to an impact driver operating at full capacity, thereby exposing fewer animals to loud underwater and airborne sounds. The soft start will be accomplished by providing an initial set of strikes from the impact hammer at reduced energy, followed by a 30-second waiting period, then two subsequent sets. The soft start procedure will be used for impact pile driving at the beginning of each day's in-water pile driving or any time pile driving has ceased for more than 30 minutes.

The reduced energy of an individual hammer cannot be quantified because they vary by individual drivers. Also, the number of strikes will vary at reduced energy because raising the hammer at less than full power and then releasing it results in the hammer "bouncing" as it strikes the pile resulting in multiple "strikes."

11.3.4 Species Monitoring and Shutdown

A Marine Mammal Monitoring Plan will be approved by National Marine Fisheries Service prior to commencement of project activities. At a minimum, the plans will include the following:

- For all impact and vibratory pile driving, a Level A shutdown zone will be monitored by protected species observers (PSOs).
- All disturbance and shutdown zones will initially be based on the zones of influence (ZOIs) around the source predicted for each threshold level, as described in Section 6 (Numbers and Species Exposed).
- The shutdown zone will include all areas where the underwater sound pressure levels are anticipated to equal or exceed the Level A (injury) criteria for marine mammals. Shutdown will be implemented in accordance with procedures stated in final approved monitoring plan.
- The disturbance zone will include all areas where the underwater or airborne sound pressure levels are anticipated to equal or exceed the Level B (disturbance) criteria for marine mammals during impact or vibratory pile driving. The entire Level B disturbance zone for vibratory driving will be monitored for a subset of days, as these areas are large. At least a portion of the Level B disturbance zone (e.g., the visually monitorable area[4]) will be monitored during all pile driving days. PSOs will be located on land-based features such as docks, piers, or bridges, or small craft vessels in order to properly observe the entire shutdown zone(s) and the Level B disturbance zone to the maximum extent practicable. However, due to the large area of the vibratory disturbance zone and limited visibility due to waterfront structures, this zone may be reduced to a visually monitorable disturbance zone area in the final approved monitoring plan.

[4] Due to the large size of the disturbance zones for vibratory pile driving (see Figure 6-1 through Figure 6-8) and depending on the availability of PSOs and other Navy resources, not all portions of these zones would be observable during all vibratory pile driving days.

- A shutdown zone will be implemented to prevent injury from physical interaction of marine mammals with construction equipment. This shutdown zone will always be a minimum of 10-meter (33 feet) radius. Activities covered by this provision could include, but are not limited to: (1) the movement of a barge to the construction site, (2) the removal of a pile from the water column/substrate via a crane (i.e., a "dead pull"), or (3) positioning a pile in the water in preparation to installing it.
- If a marine mammal is seen approaching or entering an injury zone, pile driving operations will be immediately shut down, thereby preventing Level A takes. If a marine mammal is observed in the disturbance zone, but not approaching or entering the shutdown zone, a "take" will be recorded and the work will be allowed to proceed without cessation. Its behavior will be monitored and documented.
- In the event of a shutdown, pile driving will be halted and delayed until either the animal has voluntarily left and been visually confirmed beyond the injury zone, or 30 minutes have elapsed without re-detection of the animal.
- Visual monitoring will be conducted by qualified, trained PSOs. A PSO is a biologist with prior training and experience conducting marine mammal monitoring or surveys, and who has the ability to identify marine mammal species and describe relevant behaviors that may occur in proximity to in-water construction activities.
- Monitoring will take place from 30 minutes prior to initiation through 30 minutes post-completion of pile driving. Prior to the start of pile driving, the shutdown zone and visually monitorable disturbance zone will be monitored for 30 minutes to ensure that the zones are clear of marine mammals. Pile driving will only commence once PSOs have declared the shutdown zone clear of pinnipeds and cetaceans.
- Monitoring will be conducted by, at a minimum, a two-person PSO team designated by the construction contractor. Given the configuration of the ZOIs, which vary greatly depending on pile driver type and location (see Figure 6-1 through Figure 6-8), it is assumed that two PSOs would be sufficient to monitor the ZOIs for impact drivers, and up to four PSOs be sufficient to monitor the ZOIs for vibratory drivers. However, additional monitors may be added if warranted by the level of marine mammal activity in the area. PSOs will be placed at the best vantage point(s) practicable (e.g., from a small boat, construction barges, on shore, or any other suitable location) to monitor for marine mammals and implement shutdown/delay procedures when applicable by calling for the shutdown by the pile driver operator. The marine mammal observers shall have no other construction-related tasks while conducting monitoring. If the shutdown zone is obscured by fog or poor lighting conditions, pile driving will not be initiated until the entire shutdown zone is visible.

11.3.5 Mitigation Effectiveness

All observers utilized for mitigation activities will be experienced biologists with training in marine mammal detection and behavior. Due to their specialized training, the Navy expects that visual mitigation will be highly effective. The observers will be positioned in locations which provide the best vantage point(s) for monitoring. This will probably be an elevated position to provide a better range of viewing angles. In addition, the small radius of shutdown zones makes the likelihood of detecting a marine mammal in this zone extremely high.

12 Effects on Arctic Subsistence Hunting and Plan of Cooperation

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation

The Proposed Action at Naval Station Norfolk will have no effect on Arctic subsistence hunting.

This page intentionally left blank.

13 Monitoring and Reporting Efforts

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking, or impacts on populations of marine mammals that are expected to be present while conducting activities and the suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that will be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

13.1 Coordination

During construction of each MPU project covered by this Letter of Authorization (LOA), the Navy will update National Marine Fisheries Service (NMFS) on the progress of construction bimonthly.

13.2 Monitoring Plans

The following monitoring measures would be implemented along with the mitigation measures (Section 11, Means of Effecting the Least Practicable Adverse Impacts) in order to reduce impacts to marine mammals to the lowest extent practicable during the period of this LOA. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible. A Marine Mammal Monitoring Plan will be developed further and will entail visual observations. The plan will be submitted to NMFS for approval well in advance of the start of construction.

13.2.1 Visual Monitoring

Visual monitoring of the entire Level A shutdown zones will occur for 100 percent of pile driving activities. The Level B disturbance zone will be visually monitored to the extent possible from protected species observers (PSO) locations determined in the final approved monitoring plan. If a marine mammal is observed entering the disturbance zone, an exposure will be recorded and behaviors documented. The Navy will use the data collected during monitoring days to extrapolate and calculate total takes for all pile driving days. All PSOs will be trained in marine mammal identification and behaviors. NMFS requires that the PSOs have no other construction-related tasks while conducting monitoring.

13.2.1.1 Methods of Monitoring

The Navy will monitor the shutdown zone and disturbance zone before, during, and after pile driving activities. Based on NMFS requirements, the Marine Mammal Monitoring Plan will include the following procedures:

- PSOs will be located on land-based features such as docks, piers, or bridges, or small craft vessels in order to properly observe the entire shutdown zone(s).
- There would be a minimum of two PSOs for each pile driving activity. Depending on available resources, and depending on the size of the zone associated with the type of noise-generating activity occurring, more may be utilized as necessary.

- PSOs will be located at the best vantage point(s) to observe the zone associated with behavioral impact thresholds. See Figure 13-1 for example representative monitoring locations using two PSOs. The Marine Mammal Monitoring Plan will contain proposed PSO locations for all pile driving activities.
- During all observation periods, PSOs will use binoculars and the naked eye to search continuously for marine mammals.
- Monitoring distances will be measured with range finders.
- Distances to animals will be based on the best estimate of the PSO, relative to known distances to objects in the vicinity of the PSO.
- Bearing to animals will be determined using a compass.
- In-water activities will be curtailed under conditions of fog or poor visibility that might obscure the presence of a marine mammal within the shutdown zone.
- Pre-Activity Monitoring: The shutdown and disturbance zones will be monitored for 15 minutes prior to in-water construction/demolition activities. If a marine mammal is present within the shutdown zone, the activity will be delayed until the animal(s) leave the shutdown zone. Activity will resume only after the PSO has determined that, through sighting or by waiting approximately 15 minutes, the animal has moved outside the shutdown zone. If a marine mammal is observed approaching the shutdown zone, the PSO who sighted that animal will notify the shutdown PSO of its presence.
- During Activity Monitoring: If a marine mammal is observed entering the disturbance zone, that pile segment will be completed without cessation, unless the animal enters or approaches the shutdown zone, at which point all pile driving activities will be halted. If an animal is observed within the shutdown zone during pile driving, then pile driving will be stopped as soon as it is safe to do so. Pile driving can only resume once the animal has left the shutdown zone of its own volition or has not been re-sighted for a period of 15 minutes.
- Post-Activity Monitoring: Monitoring of the shutdown and disturbance zones will continue for 30 minutes following the completion of the activity.

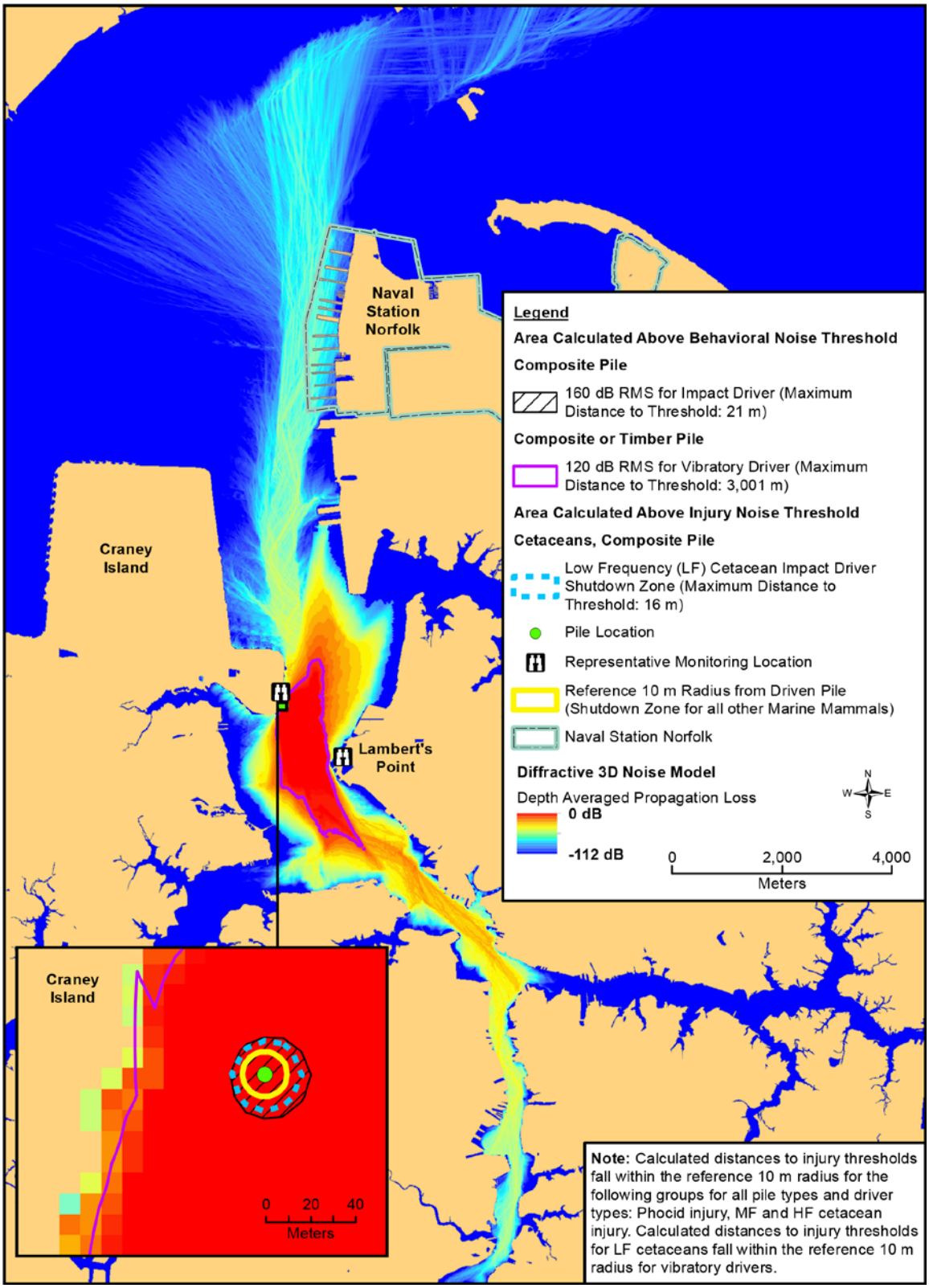

Figure 13-1 Proposed Protected Species Observer Locations

13.2.1.2 Data Collection

NMFS requires that at a minimum, the following information be collected on the sighting forms:

- Date and time that pile removal or installation begins and ends
- Construction activities occurring during each observation period
- Weather parameters identified in the acoustic monitoring (e.g., rain, fog, percent cloud cover, visibility)
- Water conditions (e.g., sea state, tidal state [incoming, outgoing, slack, low, and high])
- Species, numbers, and, if possible, sex and age class of marine mammals
- Marine mammal behavior patterns observed, including bearing and direction of travel, and, if possible, the correlation to SPLs
- Distance from pile removal and installation activities to marine mammals and distance from the marine mammal to the observation point
- Estimated amount of time that a marine mammal spends within the Level A or Level B harassment zones while pile driving is underway
- Locations of all marine mammal observations
- Other human activity in the area

The Navy will note in behavioral observations, to the extent practicable, if an animal has remained in the area during construction activities. Therefore, it may be possible to identify if the same animal or different individuals are being taken.

13.3 Reporting

A draft report will be submitted to NMFS within 45 work days of the completion of required monitoring for each MPU project. The report will detail the monitoring protocol, summarize the data recorded during monitoring, and estimate the number of marine mammals that may have been harassed. A final report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS. The Marine Mammal Monitoring Plan will contain detailed reporting measures.

14 Research Efforts

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

The United States Department of the Navy (Navy) is one of the world's leading organizations in assessing the effects of human activities in the marine environment including marine mammals. From 2004 through 2019, the Navy has funded more than $240 million specifically for marine mammal research. Navy scientists work cooperatively with other government researchers and scientists, universities, industry, and non-governmental conservation organizations in collecting, evaluating, and modeling information on marine resources. They also develop approaches to ensure that these resources are minimally impacted by existing and future Navy operations. It is imperative that the Navy's research and development (R&D) efforts related to marine mammals are conducted in an open, transparent manner with validated study needs and requirements. The goal of the Navy's R&D program is to enable collection and publication of scientifically valid research as well as development of techniques and tools for Navy, academic, and commercial use. Historically, R&D programs are funded and developed by the Navy's Chief of Naval Operations Energy and Environmental Readiness and Office of Naval Research, Code 322 Marine Mammals and Biological Oceanography Program. Primary focus of these programs since the 1990s is on understanding the effects of sound on marine mammals, including physiological, behavioral, and ecological effects.

The Office of Naval Research's current Marine Mammals and Biology Program thrusts include, but are not limited to: (1) monitoring and detection research; (2) integrated ecosystem research including sensor and tag development; (3) effects of sound on marine life (such as hearing, behavioral response studies, physiology [diving and stress], and population consequences of acoustic disturbance); and (4) models and databases for environmental compliance.

To manage some of the Navy's marine mammal research programmatic elements, the Navy developed the Living Marine Resources (LMR) Research and Development Program (http://www.lmr.navy.mil/) in 2011. The goal of the LMR Research and Development Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. Key elements of the LMR program include:

- Providing science-based information to support Navy environmental effects assessments for research, development, acquisition, testing, and evaluation as well as Fleet at-sea training, exercises, maintenance, and support activities;
- Improving knowledge of the status and trends of marine species of concern and the ecosystems of which they are a part;
- Developing the scientific basis for the criteria and thresholds to measure the effects of Navy-generated sound;
- Improving understanding of underwater sound and sound field characterization unique to assessing the biological consequences resulting from underwater sound (as opposed to tactical applications of underwater sound or propagation loss modeling for military communications or tactical applications); and

- Developing technologies and methods to monitor and, where possible, mitigate biologically significant consequences to LMR resulting from naval activities, emphasizing those consequences that are most likely to be biologically significant.

The following marine mammal monitoring activities and contracted studies are being conducted by the Navy in the vicinity of Naval Station Norfolk. To better understand marine mammal presence and habitat use in the region, the Navy has funded and coordinated the following recent major efforts:

- Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia (Aschettino et al., 2015; 2016; 2017; 2018).
- Seal Tagging and Tracking in Virginia (Ampela et al., 2019).
- Haul-out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay and Eastern Shore, Virginia (Jones et al., 2018).
- Haul-out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay, Virginia (Rees et al., 2016).
- Occurrence, Distribution, and Density of Marine Mammals Near Naval Station Norfolk and Virginia Beach (Engelhaupt et al., 2014; 2015; 2016)

The Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include monitoring programs, data sharing with National Marine Fisheries Service from research and development efforts, and current research as previously described.

15 References

Aarts et al. (2017). Aarts, G., Brasseur, S., & Kirkwood, R. *Response of grey seals to pile-driving. Wageningen Marine Research report C006/18*. Wageningen Marine Research (University & Research Centre).

Ampela et al. (2019). Ampela, K., DeAngelis, M., DiGiovanni Jr., R., & Lockhart, G. *Seal Tagging and Tracking in Virginia, 2017-2018*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-15-8006, Task Order 17F4058, issued to HDR, Inc., Virginia Beach, Virginia. March 2019.

Aschettino et al. (2015). Aschettino, J.M., Engelhaupt, A., & Engelhaupt, D. *Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, VA: Annual Progress Report. Draft Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Order 054, issued to HDR Inc., Virginia Beach, Virginia. 18 June 2015.

Aschettino et al. (2016). Aschettino, J. M., Engelhaupt, D., Engelhaupt, A., & Richlen., M. *Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2015/16 Annual Progress Report. Final Report.* Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract Nos. N62470-10-3011, Task Orders 03 and 54, and N62470-15-8006, TO 13, issued to HDR Inc., Virginia Beach, Virginia.

Aschettino et al. (2017). Aschettino, J. M., Engelhaupt, D., Engelhaupt, A., & Richlen, M. *Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2016/17 Annual Progress Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract N62470-15-8006, Task Order 33, issued to HDR, Inc., Virginia Beach, Virginia. August 2017.

Aschettino et al. (2018). Aschettino, J. M., Engelhaupt, D., Engelhaupt, A., Richlen, M., & DiMatteo, A. *Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2017/18 Annual Progress Report. Final Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract N62470-15-8006, Task Order 17F4013, issued to HDR, Inc., Virginia Beach, Virginia. June 2018.

Aschettino et al. (2019). Aschettino, J.M., D. Engelhaupt, A. Engelhaupt, M. Richlen, & M. Cotter. *Mid-Atlantic Humpback Whale Monitoring, Virginia Beach, Virginia: 2018/19 Annual Progress Report.* Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract N62470-15-8006, Task Order 19F4005, issued to HDR, Inc., Virginia Beach, Virginia. July 2019.

Au, W. (1993). *The Sonar of Dolphins.* New York: Springer-Verlag.

Baird, R. W. (2001). Status of harbour seals, Phoca vitulina, in Canada. *The Canadian Field-Naturalist*, 663-675.

Barco, S., & Swingle, W. (2014). *Marine Mammal Species Likely to be Encountered in the Stranding Data. VAQF Scientific Report #2014-07a.* Prepared for the Virginia Department of Mines, Minerals and Energy.

Barlas, M. E. (1999). *The distribution and abundance of harbor seals (Phoca vitulina concolor) and gray seals (Halichoerus grypus) in southern New England, Winter 1998–Summer 1999 (Master's thesis).* Boston: Boston University.

Bejder et al. (2006). Bejder, L., Samuels, A.L., Whitehead, H.; Gales, N.G., Barbara, J.M., Connor, R.T., Heithaus, M., Watson-Capps, J.J., Flaherty, C., & Krützen, M. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, 1791–1798.

Bettridge et al. (2015). Bettridge, Shannon, Baker, C. Scott, Barlow, Jay, Clapham, Phillip J., Ford, Michael, Gouveia, David, Mattila, David K., Richard M. Pace, III, Rosel, Patricia E., Silber, Gregory K., & Wade, Paul R. *Status review of the humpback whale (Megaptera novaeangliae) under the Endangered Species Act. NOAA-TM-NMFS-SWFSC-540*.

Blackwell et al. (2004). Blackwell, S.B., Lawson, J.W., & Williams, M.T. Tolerance by ringed seals (Phoca hispida) to impact pipe-driving and construction sounds at an oil production island. *The Journal of the Acoustical Society of America*, 2346–2357.

Blackwell, S. B., & Greene, C. R. (2002). *Acoustic measurements in Cook Inlet, Alaska during August 2001.* Prepared by Greeneridge Sciences, Inc., Aptos, CA and Santa Barbara, CA. Prepared for National Marine Fisheries Service Protected Resources Division, Anchorage, AK.

Branstetter et al. (2018). Branstetter, B.K., Bowman, V.F., Houser, D.S., Tormey, M., Banks, P., Finneran, J.J; & Jenkins, K. Effects of vibratory pile driver noise on echolocation and vigilance in bottlenose dolphins (Tursiops truncatus). *Journal of the Acoustical Society of America*, 429–439.

Brumm, H., & Slabbekoorn, H. (2005). Acoustic Communication in Noise. In P. J. Slater, C. T. Snowdon, T. J. Roper, H. J. Brockmann, & M. Naguib, *Advances in the Study of Behavior* (pp. 151-209). Academic Press.

Brumm, H., & Zollinger, S. A. (2011). The evolution of the Lombard effect: 100 years of psychoacoustic research. *Behaviour*, 1173-1198.

Burns, J. J. (2008). Harbor seal and spotted seal Phoca vitulina and P. largha. In W. Perrin, B. Wursig, & J. Thewissen, *Encyclopedia of Marine Mammals (Second Edition)* (pp. 533-542). Cambridge: Academic Press.

Burton, W. (1993). *Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources.* Columbia: Versar.

Calambokidis et al. (2001). Calambokidis, J., Steiger, G.H, Straley, J.M, Herman, L.M., Cerchio, S., Salden, D.R.,...Quinn II, T.J. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science*, 769-794.

California Department of Transportation. (2001). *San Francisco - Oakland Bay Bridge East Span seismic safety project. Pile installation demonstration project: marine mammal impact assessment.* California Department of Transportation.

Caltrans. (2015). *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish.* Sacramento, CA: California Department of Transportation Division of Environmental Analysis. (CTHWANP-RT-15-306.01.01). Retrieved from http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf .

Cammen et al. (2018). Cammen, K. M., Schultz, T.F., Bowen, W. Don, Hammill, M.O., Puryear, W.B., Runstadler, J., Wenzel, F.W., Wood, S.A., & Kinnison, M. Genomic signatures of population bottleneck and recovery in Northwest Atlantic pinnipeds. *Ecology and Evolution*, 6599-6614.

Carretta et al. (2001). Carretta, J.V., Taylor, B.L., & Chivers, S.J. Abundance and depth distribution of harbor porpoise Phocoena phocoena) in northern California determined from a 1995 ship survey. *Fisheries Bulletin*, 99:29-39.

Cetacean and Turtle Assessment Program. (1982). *A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Final Report #AA551-CT8-48.* Washington, DC: Bureau of Land Management.

CH2M. (2018). *Final Sampling and Analysis Plan Sediment Sampling to Support Fiscal Year 2019 to Fiscal Year 2021 Maintenance Dredging.* Prepared for Department of the Navy, Naval Facilities Engineering Command Mid-Atlantic.

Clapham, P. (2000). The humpback whale: seasonal feeding and breeding in a baleen whale. In M. J., *Cetacean societies: Field studies of dolphins and whales* (pp. 173-196). Chicago: University of Chicago.

Clapham, P.J. & Mattila, D.K. (1990). Humpback whale songs as indicators of migration routes. *Marine Mammal Science*, 155-160.

Costidis et al. (2019). Costidis, A.M., Swingle, W.M., Barco, S.G., Bates, E.B., Mallette, S.D., Rose, S.A., & Epple, A.L. *Virginia Sea Turtle and Marine Mammal Stranding Network 2018 Grant Report*. Virginia Beach, VA: Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant NA17NOS4190152, Task 49. VAQF Scientific Report 2019-01.

Craig, A., & Herman, L. (2000). Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series*, 209-216.

Curry, B., & Smith., J. (1997). Phylogeographic structure of the bottlenose dolphin (Tursiops truncatus): stock identification and implications for management. In A. Dizon, S. Chivers, & W. Perrin, *Molecular genetics of marine mammals. Spec. Publ. 3* (pp. 327-247). Society for Marine Mammalogy.

Dahl et al. (2015). Dahl, Peter H., Jong, Christ A. F. de, & Popper, Arthur N. The Underwater Sound Field from Impact Pile Driving and Its Potential Effects on Marine Life. *Acoustics Today*, 18-25.

DeHart, P. (2002). *The distribution and abundance of harbor seals (Phoca vitulina concolor) in the Woods Hole region. (Unpublished thesis).* Boston: Boston University.

Department for Environment, Food and Rural Affairs. (2003). *Preliminary investigation of the sensitivity of fish to sound generated by aggregate dredging and marine construction. (Project AE0914 Final Report).* London.

Di Giulio, R., & Clark, B. W. (2015). The Elizabeth River Story: A Case Study In Evolutionary Toxicology. *Journal of Toxicology and Environmental Health, Part B, 18*, 259–298.

DiGiovanni et al. (2011). DiGiovanni, R.A., S.A., Wood, G.T., Waring, A., Chaillet, & Josephson., E. Trends in harbor and gray seal counts and habitat use at southern New England and Long Island index

sites. *Poster presented at the Society for Marine Mammalogy, Tampa, Florida USA, October 2011.*

DiGiovanni et al. (2018). DiGiovanni Jr., R.A.; DePerte, A.; Winslow, H.; Durham, K. Gray seals (Halichoerus grypus) and Harbor Seals (Phoca vitulina) in the endless winter. *Northwest Atlantic Seal Research Consortium Meeting.* New Bedford.

Dolphin, W. F. (2000). Electrophysiological measures of auditory processing in odontocetes. In W. Au, A. Popper, & R. R. Fay, *Hearing by Whales and Dolphins.* New York: Springer-Verlag.

Duffield et al. (1983). Duffield, D.A., Ridgway, S.H., & Cornell, L.H. Hematology distinguishes coastal and offshore forms of dolphins (Tursiops). *Canadian Journal of Zoology*, 930-933.

Duffield, D. (1986). *Investigation of genetic variability in stocks of the bottlenose dolphin (Tursiops truncatus). Final report to the NMFS/SEFSC, Contract No. NA83-GA-00036.*

Engelhaupt et al. (2014). Engelhaupt, A., Richlen, M., Jefferson, T.A., & Engelhaupt, D. *Occurrence, Distribution, and Density of Marine Mammals Near Naval Station Norfolk & Virginia Beach, VA: Annual Progress Report.* Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command (NAVFAC) Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Orders 031 and 043, issued to HDR Inc., Norfolk, Virginia. 22 July 2014.

Engelhaupt et al. (2015). Engelhaupt, A., Aschettino, J., Jefferson, T.A., Richlen, M., & Engelhaupt, D. *Occurrence, Distribution, and Density of Marine Mammals Near Naval Station Norfolk & Virginia Beach, VA: Annual Progress Report. Final Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470- 10-3011, Task Orders 031 and 043, issued to HDR Inc., Virginia Beach, Virginia. 07 August 2015.

Engelhaupt et al. (2016). Engelhaupt, A., Aschettino, J., Jefferson, T.A., Engelhaupt, D., & Richlen, M. *Occurrence, Distribution, and Density of Marine Mammals Near Naval Station Norfolk and Virginia Beach, Virginia: 2016 Final Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10- 3011, Task Orders 03 and 043, issued to HDR Inc., Virginia Beach, Virginia. 12 October 2016.

EPA. (1986). *Quality Criteria for Water. EPA 440/5-86-001.* U.S. Environmental Protection Agency.

Ersts, P. J., & Rosenbaum, H. C. (2003). Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground. *Journal of Zoology, 260*(4), 337-345.

Finneran et al. (2003). Finneran, J., Dear, R., Carder, D. A., & Ridgway, S. H. Auditory and behavioral responses of California sea lions (Zalophus californianus) to single underwater impulses from an arc-gap transducer. *The Journal of the Acoustical Society of America*, 1667-1677.

Finneran et al. (2005). Finneran, J. J., Carder, D. A., Schlundt, C. E., & Ridgway, S. H. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. *The Journal of the Acoustical Society of America*, 2696–2705.

Finneran et al. (2013). Finneran, J. J., Mulsow, J., & Houser, D. S. Auditory evoked potentials in a bottlenose dolphin during moderate-range echolocation tasks. *The Journal of the Acoustical Society of America*, 4532-4547.

Finneran, J. J. (2015). Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. *Journal of the Acoustical Society of America*, 1702–1726.

Foote et al. (2004). Foote, A. D., Osborne, R. W., & Hoelzel, A. R. Environment: whale-call response to masking boat noise. *Nature*, 428(6986), 910.

Galli et al. (2003). Galli, L., Hurlbutt, B., Jewett, W., Morton, W., Schuster, S., & Van Hilsen, Z. *Source-level noise in Haro Strait: relevance to orca whales*. Colorado Springs, CO: Colarado College.

Garrison et al. (2017). Garrison, L.P., Barry, K., & Hoggard, W. *The abundance of coastal morphotype bottlenose dolphins on the U.S. east coast: 2002-2016*. Miami, FL: Southeast Fisheries Science Center, Protected Resources and Biodiversity Division.

Gaskin, D. (1992). Status of the harbour porpoise, Phocoena phocoena, in Canada. *Canadian Field-Naturalist*, 36-54.

Gilbert, J. R., & Guldager, N. (1998). *Status of Harbor and Gray Seal Populations in Northern New England.* Woods Hole: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Gordon et al. (2004). Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal*, 16-34.

Graham et al. (2017). Graham, I.M., Pirotta, E., Merchant, N.D., Farcas, A., Barton, T.R., Cheney, B., Hastie, G.D., & Thompson, P.M. Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. *Ecosphere*, 8(5):e01793. 10.1002/ecs2.1793.

Hall, A., & Thompson, D. (2009). Gray seal, Halichoerus grypus. In W. Perrin, B. Wursig, & J. Thewissen, *Encyclopedia of Marine Mammals (2nd ed.)* (pp. 500-503). Cambridge: Academic Press.

Hamazaki, T. (2002). Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Harteras, North Carolina, USA. to Nova Scotia, Canada) . *Marine Mammal Science*, 920-939.

Hammill et al. (1998). Hammill, M.O., Stenson, G.B., Myers, R.A., & Stobo, W.T. Pup production and population trends of the grey seal (Halichoerus grypus) in the Gulf of St. Lawrence. *Canadian Journal of Fisheries and Aquatic Sciences*, 423-430.

Harris, C. (1998). *Handbook of acoustical measurements and noise control. (3rd ed.).* McGraw Hill.

Hart Crowser, Inc. (2013). *Naval Base Kitsap-Bangor Explosives Handling Wharf 2 Year 1 Marine Mammal Monitoring Report (2012–2013) .* Bangor: Prepared for Naval Facilities Engineering Northwest.

Hart Crowser, Inc. (2014). *Naval Base Kitsap-Bangor Explosives Handling Wharf 2 Year 2 Marine Mammal Monitoring Report (2013–2014).* Bangor: Prepared for Naval Facilities Engineering Northwest.

Hart Crowser, Inc. (2015). *Naval Base Kitsap-Bangor Explosives Handling Wharf 2 Year 3 Marine Mammal Monitoring Report (2014–2015).* Silverdale: Prepared for Naval Facilities Engineering Northwest.

Hayes et al. (2017). Hayes, S.A, Josephson, E., Maze-Foley, K., & Rosel, P.E. *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2016. NOAA Tech Memo NMFS NE*.

HDR Inc. (2012). *Naval Base Kitsap at Bangor Test Pile Program, Bangor, Washington. Final Marine Mammal Monitoring Report.* Silveredale: Prepared for Naval Facilities Engineering Northwest.

Hemilä et al. (2006). Hemilä, S., Nummela, S., Berta, A., & Reuter, T. High-frequency hearing in phocid and otariid pinnipeds: An interpretation based on inertial and cochlear constraints. *The Journal of the Acoustical Society of America*, 3463-3466.

Hersh, S., & Duffield, D. (1990). Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. In S. Leatherwood, & R. Reeves, *The bottlenose dolphin.* (pp. 129-139). San Diego: Academic Press.

Hoffman, J. F. (1980). *Investigation into Deep-Draft Vessel Berthing Problems at Selected U.S. Naval Facilities.* Office for Naval Research and Naval Facilities Engineering Command.

Holt et al. (2011). Holt, M.M., Noren, D.P., & Emmons, C.K. Effects of noise levels and call types on the source levels of killer whale calls. *The Journal of the Acoustical Society of America*, 3100-3106.

Holt, M. (2008). *Sound exposure and Southern Resident killer whales (Orcinus orca): A review of current knowledge and data gaps. NOAA Tech. Memo. NMFS NWFSC-89.* U.S. Department of Commerce.

Hotchkin, C., & Parks, S. (2013). The Lombard effect and other noise-induced vocal modifications: insight from mammalian communication systems. *Biological Reviews*, 809-824.

Illingworth and Rodkin. (2017). *Pile Driving Noise Measurements at Atlantic Fleet Naval Installations: 28 May 2013–28 April 2016.*

Jacobs, S., & Terhune, J. (2000). Harbor seal (Phoca vitulina) numbers along the New Brunswick coast of the Bay of Fundy in autumn in relation to aquaculture. *Northeastern Naturalist*, 289-296.

Jefferson et al. (2015). Jefferson, T.A., Webber, M.A., & Pitman, R.L. *Marine mammals of the world: a comprehensive guide to their identification. 2nd ed.* London: Academic Press.

Johnston et al. (2015). Johnston, David W.; Frungillo, Jaime,...Read, Andrew J. Trends in Stranding and By-Catch Rates of Gray and Harbor Seals along the Northeastern Coast of the United States: Evidence of Divergence in the Abundance of Two Sympatric Phocid Species? *PLoS ONE*, 10(7): e0131660.

Jones et al. (2018). Jones, D.V., Rees, D.R., & Bartlett, B.A. *Haul-out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay and Eastern Shore, Virginia: 2017/2018 Annual Progress Report. Final Report*. Prepared for U.S. Fleet Forces Command, Norfolk, Virginia. 21 December 2018.

Kastak et al. (1999). Kastak, D., Schusterman, R. J., Southall, B. L., & Reichmuth, C. J. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *The Journal of the Acoustical Society of America*, 1142-1148.

Kastelein et al. (2015). Kastelein, R.A., Gransier, R., Marijt, M.A., & Hoek, L. Hearing frequency thresholds of harbor porpoises (Phocoena phocoena) temporarily affected by played back offshore pile driving sounds. *The Journal of the Acoustical Society of America*, 556–564.

Kastelein et al. (2016). Kastelein, R. A., Helder-Hoek, L., Covi, J., & Gransier, R. Pile driving playback sounds and temporary threshold shift in harbor porpoises (Phocoena phocoena): Effect of exposure duration. *The Journal of the Acoustical Society of America, 139*(5), 2842-2851.

Kastelein et al. (2018). Kastelein, R. A., Helder-Hoek, L., Kommeren, A., Covi, J., & Gransier, R. Effect of pile-driving sounds on harbor seal (Phoca vitulina) hearing. *The Journal of the Acoustical Society of America, 143*(6), 3583-3594.

Katona et al. (1993). Katona, S.K., Rough, V., & Richardson, D.T. *Field Guide to Whales, Porpoises, and Seals from Cape Cod to Newfoundland (Fourth ed.)*. Washington, DC: Smithsonian Institution Press.

Kenney, M. K. (1994). *Harbor seal population trends and habitat use in Maine. (Unpublished master's thesis).* Orono: University of Maine.

Kenney, R. D. (1990). Bottlenose dolphins off the northeastern United States. In S. Leatherwood, & R. Reeves, *The bottlenose dolphin* (pp. 369-386). San Diego: Academic Press.

Kenney, R. D. (2019). *Marine Mammals of Rhode Island, Part 5, Harbor Seal*. Retrieved from Rhode Island Natural History Survey: http://rinhs.org/uncategorized/marine-mammals-of-rhode-island-part-5-harbor-seal/. August 5.

Kenney, Robert D. & Winn, Howard E. (1986). Cetacean High-Use Habitats of the Northeast United States Continental Shelf. *Fishery Bulletin*, 345-357.

Ketten, D. R. (1995). Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. In R. A. Kastelein, J. A. Thomas, & P. E. Nachtigall, *Sensory systems of aquatic mammals* (pp. 391-407). Woerden: De Spil Publishers.

Ketten, D. R. (2000). Cetacean ears. In W. L. Au, A. Popper, & R. Fay, *Hearing by whales and dolphins* (pp. 43-108). New York: Springer-Verlag.

Ketten, D. R. (2004). Marine mammal auditory systems: a summary of audiometric and anatomical data and implications for underwater acoustic impacts. *Polarforschung*, 79-92.

LaBrecque et al. (2015). LaBrecque, E.; Curtice, C.; Harrison, J.; Van Parijs, S.M.; & Halpin, P.N. Biologically Important Areas for cetaceans within U.S. waters – East coast region. In S. V. Parijs, C. Curtice, & M. Ferguson, *Biologically Important Areas for cetaceans within U.S. waters. Aquatic Mammals (Special Issue)* (pp. 17-29).

Lesage, V., & Hammill, M. (2001). The status of the grey seal, Halichoerus grypus, in the Northwest Atlantic. *Canadian Field-Naturalist*, 653-662.

Louis Berger Group, Inc. (2010). *Bacteria Total Maximum Daily Load (TMDL) Development for the Elizabeth River.*

Malme et al. (1984). Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P. L., & Bird, J. E. *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. Phase II, January 1984 Migration*. Anchorage: Prepared by Bolt, Beranek, and Newman, Cambridge, MA. Prepared for United States Minerals Management Service, Alaska, OCS Office.

Malme et al. (1988). Malme, C. I., Wursig, B., Bird, J. E., & Tyack, P. L. Observations of feeding gray whale responses to controlled industrial noise exposure. In W. M. Sackinger, M. O. Jefferies, J. L. Imm, & S. D. Treacy, *Port and Ocean Engineering Under Arctic Conditions (Vol. II)* (pp. 55-73). Fairbanks: University of Alaska.

Matzner, S., & Jones, M. E. (2011). Measuring coastal boating noise to assess potential impacts on marine life. *Sea Technology*, 41-44.

McKenna, M. F. (2011). *Blue whale response to underwater noise from commercial ships.* University of California, San Diego.

Mead, J., & Potter, C. (1995). Recognizing two populations for the bottlenose dolphin (Tursiops truncatus) off the Atlantic coast of North America: morphologic and ecologic considerations. *International Biological Research Institute Reports*, 31-43.

Miller et al. (1999). Miller, G. W., Elliott, R. E., Koski, W. R., Moulton, V. D., & Richardson, W. J. Whales. In LGL, & Greeneridge, *Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998.* King City.

Mocklin, J. (2005). *Final report: Research and monitoring needs relevant to decisions regarding increasing seasonal use days for cruise ships in Glacier Bay. Appendix C: Potential impacts of cruise ships on the marine mammals of Glacier Bay.* Glacier Bay Vessel Management Science Advisory Board.

Mooney et al. (2009). Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S., & Au, W. W. Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): The effects of noise level and duration. *The Journal of the Acoustical Society of America*, 1816-1826.

Morton, A. B., & Symonds, H. K. (2002). Displacement of Orcinus orca (L.) by high amplitude sound in British Columbia, Canada. *ICES Journal of Marine Science*, 71-80.

Moulton et al. (2005). Moulton, V. D., Richardson, W. J., Elliott, R. E., McDonald, T. L., Nations, C., & Williams, M. T. Effects of an offshore oil development on local abundance and distribution of ringed seals (Phoca hispida) of the Alaskan Beaufort Sea. *Marine Mammal Science*, 217–242.

Mulsow et al. (2012). Mulsow, J., Reichmuth, C., Houser, D., & Finneran, J. J. Auditory evoked potential measurement of hearing sensitivity in pinnipeds. In A. Popper, & A. Hawkins, *The Effects of Noise on Aquatic Life* (pp. 73-76). Springer.

Nachtigall et al. (2007). Nachtigall, P. E., Mooney, T. A., Taylor, K. A., & Yuen, M. M. L. Hearing and Auditory Evoked Potential Methods Applied to Odontocete Cetaceans. *Aquatic Mammals*, 6-13.

National Research Council. (2003). *Ocean noise and marine mammals.* Washington, DC: The National Academies Press.

National Research Council. (2005). *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects.* Washington, DC: The National Academies Press.

Navy. (2001). *Shock trial of the WINSTON S. CHURCHILL (DDG 81): Final Environmental Impact Statement.* Department of the Navy.

Navy. (2007). *Environmental Assessment for Replacement of Pier D at Defense Fuel Support Point Craney Island .* Norfolk, CA: NAVFAC Mid-Atlantic.

Navy. (2009). *Final Environmental Impact Statement for the Propsed Dredging of Norfolk Harbor Channel Norfolk and Portsmouth, Virginia.* United States Navy.

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.* Norfolk: Naval Facilities Engineering Command Atlantic.

Nemeth, E., & Brumm, H. (2010). Birds and anthropogenic noise: are urban songs adaptive? *American Naturalist*, 465-475.

NMFS. (2017). *Turbidity Table*. Retrieved August 7, 2017, from NOAA Fisheries, Greater Atlantic Region (National Marine Fisheries Service): https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/consultation/turbiditytablenew.html. National Oceanic and Atmospheric Administration Fisheries.

NMFS. (2018a). *TM 245 US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2017 (Second Edition). NOAA Tech Memo NMFS NE-245.*

NMFS. (2018b). *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. NOAA Technical Memorandum NMFS-OPR-59.*

NMFS. (2019a). *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2018.* NOAA Technical Memorandum NMFS-NE-258.

NMFS. (2019b). *Interactive North Atlantic right whale sightings map*. Retrieved from National Marine Fisheries Service: https://www.nefsc.noaa.gov/psb/surveys/. July 11.

NOAA Fisheries. (2019). *2016–2019 Humpback Whale Unusual Mortality Event Along the Atlantic Coast*. Retrieved from NOAA Fisheries: https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2019-humpback-whale-unusual-mortality-event-along-atlantic-coast. September 27.

Norris, K., & Prescott, J. (1961). Observations on Pacific cetaceans of Californian and Mexican waters. *University of California Publications in Zoology*, 291-402.

Northwest Environmental Consulting. (2014). *Replace Fendering System, Pier 6, PSNS & IMF Marine Mammal Monitoring.* Gig Harbor: Prepared for Watts Constructors, LLC.

Northwest Environmental Consulting. (2015). *Naval Base Bremerton Pier 6 Pile Replacement – Marine Mammal Monitoring.* Gig Harbor: Prepared for Watts Constructors, LLC.

Nowacek et al. (2007). Nowacek, D. P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. Responses of cetaceans to anthropogenic noise. *Mammal Review*, 81-115.

NYSDEC. (2000). *Hudson River Sediment and Biological Survey.* New York State Department of Environmental Conservation.

O'Keeffe, D. J., & Young, G. A. (1984). *Handbook on the environmental effects of underwater explosions. (NSWC TR 83-240).* Dahlgren, VA and Silver Spring, MD: Naval Surface Weapons Center.

Payne et al. (1990). Payne, P. Michael, Wiley, David N., Young, Sharon B., Pittman, Sharon, Clapham, Phillip J., & Jossi, Jack W. Recent Fluctuations in the Abundance of Baleen Whales in the Southern Gulf of Maine in Relation to Changes in Selected Prey. *Fishery Bulletin*, 687-696.

Port of Virginia. (2019). *Port Stats*. Retrieved from The Port of Virginia: http://www.portofvirginia.com/about/port-stats/. October 25.

Prescott, R. (1982). Harbor seals: Mysterious lords of the winter beach. *Cape Cod Life*, 24-29.

Read, A. (1999). Harbor porpoise, Phocoena phocoena (Linnaeus, 1758). In S. H. Ridgway, & R. Harrison, *Handbook of Marine Mammals* (pp. 323-355). San Diego: Academic Press.

Reeder, D. M., & Kramer, K. M. (2005). Stress in free-ranging mammals: integrating physiology, ecology, and natural history. *Journal of Mammalogy*, 225-235.

Rees et al. (2016). Rees, D.R., Jones, D.V., & Bartlett, B.A. *Haul-out Counts and Photo-Identification of Pinnipeds in Chesapeake Bay, Virginia: 2015/16 Annual Progress Report. Final Report*. Norfolk: Prepared for U.S. Fleet Forces Command.

Reeves et al. (1992). Reeves, R.R., Stewart, B.S., & Leatherwood, S. *The Sierra Club Handbook of Seals and Sirenians*. San Francisco: Sierra Club Books.

Reichmuth et al. (2013). Reichmuth, C., Holt, M. M., Mulsow, J., Sills, J. M., & Southall, B. L. Comparative assessment of amphibious hearing in pinnipeds. *Journal of Comparative Physiology A*, 491-507.

Reine, K. J., & Dickerson, C. (2014). *Characterization of underwater sounds produced by a hydraulic cutterhead dredge during maintenance dredging in the Stockton Deepwater Shipping Channel, California.* Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Richardson et al. (1995). Richardson, W.J., Greene, Jr., C. R., Malme, C.I., & Thomson, D.H. *Marine Mammals and Noise*. San Diego: Academic Press.

Ridgway et al. (1997). Ridgway, S. H., Carter, D. A., Smith, R. R., Kamolnick, T., Schlundt, C. E., & Elsberry, W. R. *Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, Tursiops truncatus, to 1-second tones of 141 to 201 dB re 1 µPa. (Technical Report 1751)*. San Diego: Naval Command, Control and Ocean Surveillance Center, RDT&E Division.

Ritter, F. (2002). Behavioural observations of rough-toothed dolphins (Steno bredanensis) off La Gomera, Canary Islands (1995–2000), with special reference to their interactions with humans. *Aquatic Mammals*, 46-59.

Rosel et al. (1999). Rosel, P.E., France, S.C., Wang, J.Y., & Kocher, T.D. Genetic structure of harbor porpoise Phocoena phocoena populations in the northwest Atlantic based on mitochondrial and nuclear markers. *Molecular Ecology*, S41-54.

Rosenfeld et al. (1988). Rosenfeld, M., George, M., Terhune, J.M. Evidence of autumnal harbour seal, Phoca vitulina, movement from Canada to the United States. *Canadian Field-Naturalist*, 527-529.

Russell et al. (2016). Russell, D. J., Hastie, G. D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A., Matthiopoulos, J., Jones, E. L., & McConnell, B. J. Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology*, 53(6), 1642-1652.

Schneider, D., & Payne, P. M. (1983). Factors Affecting Haul-Out of Harbor Seals at a Site in Southeastern Massachusetts. *Journal of Mammalogy*, 518-520.

Schusterman, R. (1981). Behavioral Capabilities of Seals and Sea Lions: A Review of Their Hearing, Visual, Learning and Diving Skills. *The Psychological Record*, 125-143.

Scott, M., & Chivers, S. (1990). Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In S.Leatherwood, & R. R. Reeves, *The Bottlenose Dolphin* (pp. 387-402). Cambridge: Academic Press.

Sebastianutto et al. (2011). Sebastianutto, L., Picciulin, M., Costantini, M., & Ferrero, E. A. How boat noise affects an ecologically crucial behaviour: the case of territoriality in Gobius cruentatus (Gobiidae). *Environmental Biology of Fishes*, 207-215.

Shane et al. (1986). Shane, S. H., Wells, R. S., & Würsig, B. Ecology, behavior and social organization of the bottlenose dolphin: A review. *Marine Mammal Science*, 34-63.

Smultea et al. (2017). Smultea, M. A., Lomac-MacNair, K., Campbell, G., Courbis, S., & Jefferson, T. A. *Final Report Aerial Surveys of Marine Mammals Conducted in the Inland Puget Sound Waters of Washington, Summer 2013–Winter 2016*. Preston, WA: Smultea Environmental Sciences, LLC. Prepared for Naval Facilities Engineering Command Pacific, Silverdale, WA.

Smultea, M. A. (1994). Segregation by humpback whale (Megaptera novaeangliae) cows with a calf in coastal habitat near the island of Hawaii. *Canadian Journal of Zoology*, 805-811.

Southall et al. (2007). Southall, B., Bowles, A., Ellison, W., Finneran, J., Gentry, R., Greene, C. Jr., Kastak, D., Ketten, D., Miller, J., Nachtigall, P., Richardson, W., Thomas, J., Tyack, P. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, 411-521.

Stevick et al. (2003). Stevick, P.T.; Allen, J.; Clapham, P. J.; Friday, N.; Katona, S. K.; Larsen, F.; Lien, J.; Mattila, D.K.,...Hammond, P.S. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. *Marine Ecology Progress Series*, 263-273.

Stevick et al. (2006). Stevick, P.T., Allen, J., Clapham, P. J., Katona, S.K., Larsen, F., Lien, J., Mattila, D.K., Palsbøll, P.J., Sears, R.,...Hammond, P.S. Population spatial structuring on the feeding grounds in North Atlantic humpback whales (Megaptera novaeangliae). *Journal of Zoology*, 244 –255.

Straley, J. (1990). Fall and winter occurrence of humpback whales (Megaptera novaeangliae) in southeastern Alaska. *Reports of the International Whaling Commission*, 319-323.

Swingle et al. (2014). Swingle, W. M., Lynott, M. C., Bates, E. B., D'Eri, L.R., Lockhart, G.G., Phillips, K.M., & Thomas, M.D. *Virginia Sea Turtle and Marine Mammal Stranding Network 2013 Grant Report. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA11NOS4190122, Task 49. VAQF Scientific Report 2013-01*. Virginia Beach.

Swingle et al. (2015). Swingle, W. M., Lynott, M.C., Bates, E.B., Lockhar, G.G., Phillips, K.M., Rodrique, K.R., Rose, S.A., & Williams, K.M. *Virginia Sea Turtle and Marine Mammal Stranding Network 2014 Grant Report. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA13NOS4190135, Task 49. VAQF Scientific Report 2015-01*.

Swingle et al. (2016). Swingle, W.M., Barco, S.G., Bates, E.B., Lockhart, G.G., Phillips, K.M., Rodrique, K.R., Rose, S.A., & Williams, K.M. *Virginia Sea Turtle and Marine Mammal Stranding Network 2015 Grant Report Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA14NOS4190141, Task 49. VAQF Scientific Report 2016-01.*

Swingle et al. (2017). Swingle, W.M., Barco, S.G., Costidis, A.M., Bates, E.B., Mallette, S.D., Phillips, K.M., Rose, S.A., & Williams, K.M. *Virginia Sea Turtle and Marine Mammal Stranding Network 2016*

Grant Report. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA15NOS4190164, Task 49. VAQF Scientific Report 2017-01. Virginia Beach.

Swingle et al. (2018). Swingle, W.M., Barco, S.G., Costidis, A.M., Bates, E.B., Mallette, S.D., Rose, S.A., & Epple, A.L. *Virginia Sea Turtle and Marine Mammal Stranding Network 2017 Grant Report. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant NA16NOS4190171, Task 49. VAQF Scientific Report 2018-01*. Virginia Beach.

Terhune, J. M., & Verboom, W. C. (1999). Right whales and ship noise. *Marine Mammal Science*, 256-258.

Tetra Tech, Inc. (2016). *Nearshore Surveys at Naval Station Norfolk (NSN), Final Report.* Norfolk, VA: Naval Facilities Engineering Command Mid-Atlantic.

Thompson et al. (2013). Thompson, P. M., Hastie, G. D., Nedwell, J., Barham, R. Brookes, K. L., Cordes, L. S., Bailey, H., & McLean, N. Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review*, 43, 73-85.

Thorson, P. (2010). *San Francisco-Oakland Bay Bridge east span seismic safety project marine mammal monitoring for the self-anchored suspension temporary towers, June 2008-May 2009.* California Department of Transportation.

Thorson, P., & Reyff, J. (2006). *San Francisco-Oakland Bay bridge east span seismic safety project marine mammals and acoustic monitoring for the marine foundations at piers E2 and T1.* California Department of Transportation.

Urick, R. J. (1972). Noise signature of an aircraft in level flight over a hydrophone in the sea. *The Journal of the Acoustical Society of America*, 939-999.

Urick, R. J. (1983). *Principles of Underwater Sound. 3rd Edition.* New York: McGraw-Hill.

USACE and Port of Virginia. (2017). *Elizabeth River and Southern Branch Improvements Draft General Reevaluation Report and Environmental Assessment.* Norfolk VA: USACE Norfolk District.

USACE and Port of Virginia. (2018). *Norfolk Harbor Navigation Improvements General Reevaluation Report and Environmental Assessment.* U.S. Army Corps of Engineers.

Viada et al. (2008). Viada, S. T., Hammer, R. M., Racca, R., Hannay, D., Thompson, M. J., Balcom, B. J., & Phillips, N.W. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. *Environmental Impact Assessment Review*, 267-285.

Ward, W. D. (1997). Effects of high intensity sound. In M. J. Crocker, *Encyclopedia of acoustics, (Volume III)* (pp. 1497-1507). New York: John Wiley & Sons.

Waring et al. (2004). Waring, G.T., Pace, R.M., Quintal, J.M., Fairfield, C.P., & Maze-Foley, K. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments–2003 (NOAA Technical Memorandum NMFS-NE-182)*. Woods Hole: U.S. Department of Commerce, National Marine Fisheries Service.

Waring et al. (2015). Waring, G. T., Josephson, E., Maze-Foley, K., & Rosel, P.E. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2014. NOAA Tech. Memo. NMFS-NE-231*.

Waring et al. (2016). Waring, Gordon T., Josephson, Elizabeth, Maze-Foley, Katherine, & Rosel, Patricia E. *US Atlantic and Gulf of Mexico marine mammal stock assessments - 2015. NOAA technical memorandum NMFS-NE; 238*.

Wartzok et al. (2004). Wartzok, D., Popper, A. N., Gordon, J., & Merrill, J. Factors affecting the responses of marine mammals to acoustic disturbance. *Marine Technology Society Journal*, 6-15.

Wartzok, D. & Ketten, D.R. (1999). Marine Mammal Sensory Systems. In J. Reynolds III, & S. Rommel, *Biology of Marine Mammals* (pp. 117-175). Washington, DC: Smithsonian Institute Press.

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science*, 251-262.

Watts, P., & Gaskin, D. (1985). Habitat index analysis of the harbor porpoise (Phocoena phocoena) in the southern coastal Bay of Fundy, Canada. *Journal of Mammalogy*, 733-744.

Wells et al. (1999). Wells, R.S., Rhinehart, H.L., Cunningham, P., Whaley, J., Baran, M., Koberna, C., & Costa, D.P. Long distance offshore movements of bottlenose dolphins. *Marine Mammal Science*, 1098-1114.

Wells, R., & Scott, M. (2008). Bottlenose Dolphin, Tursiops truncatus, Common Bottlenose Dolphin. In W. B., T. J.G.M., & K. K.M., *Encyclopedia of Marine Mammals Second Edition* (pp. 249-255). London: Academic Press.

Westgate et al. (1998). Westgate, A.J., Read, A.J., Cox, T.M., Schofield, T.D.; Whitaker, B.R., & Anderson, K.E. Monitoring a rehabilitated harbor porpoise using satellite telemetry. *Marine Mammal Science*, 599-604.

Whitehead, H. (1982). Populations of humpback whales in the northwest Atlantic. *Reports of the International Whaling Commission*, 345-353.

Whitman, A., & Payne, P. (1990). Age of harbour seals, Phoca vitulina concolor, wintering in southern New England. *Canadian Field-Naturalist*, 579-582.

Whitt et al. (2015). Whitt, A.D., Powell, J.A., Richardson, A.G., & Bosyk., J.R. Abundance and distribution of marine mammals in nearshore waters off New Jersey, US. *Journal of Cetacean Research and Management*, 45-59.

Wilson, S. C. (1978). *Social organization and behavior of harbor seals, Phoca vitulina concolor, in Maine. (MMC-76/10).* Prepared by Office of Zoological Research, National Zoological Park, Smithsonian Institution, Washington, DC. Prepared for U.S. Marine Mammal Commission, Washington, DC.

Wingfield et al. (2017). Wingfield, JE, O'Brien, M, Lyubchich, V, Roberts, J.J., Halpin, P.N., Rice, A.N., & Bailey, H. Year-round spatiotemporal distribution of harbor porpoises within and around the Maryland wind energy area. *PLoS ONE*, 12(5): e0176653.

Wolski et al. (2003). Wolski, L. F., Anderson, R. C., Bowles, A. E., & Yochem, P. K. Measuring hearing in the harbor seal (Phoca vitulina): comparison of behavioral and auditory brainstem response techniques. *The Journal of the Acoustical Society of America*, 629-637.

WSDOT. (2019). *Biological Assessment Preparation for Transportation Projects – Advanced Training Manual Chapter 7.0 Construction Noise Impact Assessment. (Version-1-2019).* Olympia: Washington State Department of Transportation.

Würsig et al. (1998). Würsig, B., Lynn, S. K., Jefferson, T. A., & Mullin, K. D. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals*, 41-50.

Yelverton et al. (1973). Yelverton, J. T., Richmond, D. R., Fletcher, E. R., & Jones, R. K. *Safe distances from underwater explosions for mammals and birds*. Albuquerque: Lovelace Foundation.

Appendix A Pile Installation and Removal by Location and Year

Project Location	*Water Depth (feet)*	*Pile Size (inches)*	*Pile Material*	*Pile Type*	*No. of Piles*		*Installation Method*	*Removal Method*	*Average No. of Strikes if Impact / Average Duration if Vibratory*	*No. Piles Per Day*	*In-Water Work Days*	*Representative Pile Driving Location*
					Installed	*Removed*						
2021												
Lambert's Point Deperming Station Pier A – Timber Dolphin	51	12	Timber	Round	0	17	N/A	Vibratory	0:40	10	2	Lambert's Point Deperming Station Pier B
		16	Composite	Round	17	0	Impact/Vibratory	N/A	308/7:00	10	2	
Lambert's Point Deperming Station Pier B	51	12	Timber	Round	0	17	N/A	Vibratory	0:40	10	2	
		16	Composite	Round	12	0	Impact/Vibratory	N/A	308/7:00	10	1	
Craney Island Pier Charlie	45	12	Timber	Round	0	272	N/A	Vibratory	0:40	10	27	Craney Island Pier Delta
		16	Composite	Round	258	0	Impact/Vibratory	N/A	308/7:00	10	26	
Pier 01	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 3
		16	Composite	Round	20	0	Impact/Vibratory	N/A	308/7:00	10	2	
Pier 09	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 12
Pier 10	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier C	25	12	Timber	Round	0	172	N/A	Vibratory	0:40	10	17	
		16	Composite	Round	80	0	Impact/Vibratory	N/A	308/7:00	10	8	
Pier D	25	12	Timber	Round	0	358	N/A	Vibratory	0:40	10	36	
		16	Composite	Round	108	0	Impact/Vibratory	N/A	308/7:00	10	11	
Pier 12	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier 14	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
MWR Marina	10	24	Pre-Stressed Concrete	Square	50	0	Impact	N/A	1500	3	17	MWR Marina
	10	16	Composite	Round	50	0	Impact/Vibratory	N/A	308/7:00	5	10	
	10	12	Timber	Round	0	50	N/A	Vibratory	0:40	5	10	
V-Area	UNK	24	Pre-Stressed Concrete	Square	50	0	Impact	N/A	1,500	3	17	V-Area
	UNK	16	Composite	Round	50	0	Impact/Vibratory	N/A	308/7:00	5	10	

Project Location	*Water Depth (feet)*	*Pile Size (inches)*	*Pile Material*	*Pile Type*	*No. of Piles*		*Installation Method*	*Removal Method*	*Average No. of Strikes if Impact / Average Duration if Vibratory*	*No. Piles Per Day*	*In-Water Work Days*	*Representative Pile Driving Location*
					Installed	*Removed*						
2022												
Pier 01	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 3
Pier 09	47	12	Timber	Round	0	20		Vibratory	0:40	10	2	Pier 12
Pier 10	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier E	25	12	Timber	Round	0	275	N/A	Vibratory	0:40	10	28	
		16	Composite	Round	108	0	Impact/Vibratory	N/A	308/7:00	10	11	
Pier F	25	12	Timber	Round	0	180	N/A	Vibratory	0:40	10	18	
		16	Composite	Round	88	0	Impact/Vibratory	N/A	308/7:00	10	9	
Pier 12	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier 14	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
MWR Marina	10	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	MWR Marina
	10	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
V-Area	UNK	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	V-Area
	UNK	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
2023												
Pier 01	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 3
Pier 09	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 12
Pier 10	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier 12	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier 14	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
MWR Marina	10	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	MWR Marina
	10	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
V-Area	UNK	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	V-Area
	UNK	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
2024												
Pier 01	47	12	Timber	Round	0	325	N/A	Vibratory	0:40	10	33	Pier 3
		16	Composite	Round	267	0	Impact/Vibratory	N/A	308/7:00	10	27	
Pier 09	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	Pier 12
Pier 10	47	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	

Project Location	*Water Depth (feet)*	*Pile Size (inches)*	*Pile Material*	*Pile Type*	*No. of Piles*		*Installation Method*	*Removal Method*	*Average No. of Strikes if Impact / Average Duration if Vibratory*	*No. Piles Per Day*	*In-Water Work Days*	*Representative Pile Driving Location*
					Installed	*Removed*						
Pier 12	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
Pier 14	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
MWR Marina	10	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	MWR Marina
	10	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
V-Area	UNK	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	V-Area
	UNK	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
2025												
Pier 09	47	12	Timber	Round	0	453	N/A	Vibratory	0:40	10	45	Pier 12
		16	Composite	Round	330	0	Impact/Vibratory	N/A	308/7:00	10	33	
Pier 10	47	12	Timber	Round	0	455	N/A	Vibratory	0:40	10	46	
		16	Composite	Round	330	0	Impact/Vibratory	N/A	308/7:00	10	33	
Pier 12	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
		16	Composite	Round	140	0	Impact/Vibratory	N/A	308/7:00	10	14	
Pier 14	52	12	Timber	Round	0	20	N/A	Vibratory	0:40	10	2	
		16	Composite	Round	45	0	Impact/Vibratory	N/A	308/7:00	10	5	
MWR Marina	10	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	MWR Marina
	10	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	
V-Area	UNK	16	Composite	Round	0	10	N/A	Vibratory	0:40	5	2	V-Area
	UNK	16	Composite	Round	10	0	Impact/Vibratory	N/A	308/7:00	5	2	

Key: MWR = morale, welfare, and recreation; N/A = not applicable; No. = number; UNK = unknown.

This page intentionally left blank.

Appendix B Acoustic Transmission Loss Modeling and Take Analysis Methods for Marine Structure Maintenance, Pile Replacement, and Select Waterfront Improvements

This page intentionally left blank.