Request for Authorization for the Incidental Harassment of Marine Mammals Resulting from the Transit Protection Program Pier and Support Facilities at Naval Base Kitsap Bangor, Silverdale, Washington

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Submitted to:

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

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Executive Summary

The U.S. Department of the Navy (Navy) is applying for Incidental Harassment Authorization (IHA) for the incidental take of marine mammals resulting from the proposed construction of the Transit Protection Program Pier at Naval Base (NAVBASE) Kitsap Bangor. NAVBASE Kitsap Bangor is located on Hood Canal, Washington. Vibratory and impact pile driving associated with the proposed construction have the potential to affect marine mammals within marine waters adjacent to this Navy installation and could result in harassment under the Marine Mammal Protection Act (MMPA) of 1972, as amended.

The Navy is requesting two consecutive IHAs in order to complete the project. The IHA inclusive dates for the first year of the project will be July 16, 2021 to July 15, 2022, with pile driving occurring from July 16, 2021 to January 15, 2022. The dates for the second year will be July 16, 2022 to July 15, 2023, with pile driving occurring from July 16, 2022 to January 15, 2023. It is anticipated that the only in-water construction work that will remain at the end of the first in-water work window, January 15, 2022, would be installation of fender and guide piles using methods described in this IHA. However, any work not completed during the first year will be completed during the second year.

Nine species of marine mammals have been documented in Hood Canal: humpback whale (*Megaptera novaeangliae*), Steller sea lion (*Eumetopias jubatus*), California sea lion (*Zalophus californianus*), harbor seal (*Phoca vitulina*), transient killer whale (*Orcinus orca*), gray whale (*Eschrichtius robustus*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), and bottlenose dolphin (*Tursiops truncatus*). Occurrences of all of these species in Washington inland marine waters are summarized in this application, but only five of them (Steller sea lion, California sea lion, harbor seal, transient killer whale, and harbor porpoise) are carried forward in the analysis in this IHA application based on the potential for exposure to Level A or B harassment from noise associated with vibratory and impact pile driving during project construction. With the exception of transient killer whale, all of these species are regularly detected in Hood Canal near NAVBASE Kitsap Bangor. Transient killer whales were observed for lengthy periods in Hood Canal in 2003 (59 days) and 2005 (172 days) between the months of January and July (London, 2006), and brief periods during 2016, 2017, and 2018 (Orca Network, 2016, 2019). Because some of these occurrences involved lengthy stays by several individuals, this stock is included in the analysis for this IHA application. Occurrences of the remaining species are described but not analyzed for noise exposure, based on the following:

- Humpback whales have been detected year-round in small numbers in Puget Sound. In Hood Canal, after an absence of sightings for over 15 years an individual was seen over a one-week period in early 2012, with additional sightings in 2015, 2016, and 2017 (Orca Network, 2019). Because these sightings are exceptions to the normal occurrence of the species in Washington inland waters, the species is not included in the analysis for this IHA application.
- Dall's porpoise has only been documented twice in Hood Canal and is not included in the analysis.
- Gray whales have been infrequently documented in Hood Canal waters over the past decade. These sightings are an exception to the normal seasonal occurrence of gray whales in Puget Sound feeding areas. Because these sightings are exceptions to the normal occurrence of the species in Washington inland waters, the species is not included in this analysis.
- The Southern Resident killer whale stock is resident to the inland waters of Washington State and British Columbia; however, it has not been seen in Hood Canal in over 15 years and is therefore excluded from further analysis.

- Bottlenose dolphins were detected in Hood Canal on two occasions in 2018 (Orca Network, 2019). Because detections of this species in Puget Sound waters are very rare, and no previous detections are known in Hood Canal, this species is not included in this analysis.

Pursuant to MMPA Section 101(a)(5)(A), the Navy submits this application to 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 Transit Protection Program between July 16, 2021 to July 15, 2022, and July 16, 2022 to July 15, 2023. The taking will be in the form of non-injurious, temporary harassment and for harbor seals will also include non-serious injury. 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 subsistence use.

To minimize underwater noise impacts on marine species, vibratory pile driving will be the primary pile driving method for steel piles. All steel support piles will be driven with a vibratory pile driver for their initial embedment depths and impact driven for their final 10 to 15 feet (3 to 5 meters) for proofing as needed.[1] Any piles that cannot be driven to their desired depths using the vibratory hammer may need to be impact driven for the remainder of their required driving depth. Noise attenuating devices (i.e., bubble curtain) will be used during impact hammer operations for steel piles. In addition, marine mammal monitoring will be conducted during pile driving.

The Navy used the National Marine Fisheries Service promulgated thresholds for assessing pile driving impacts to marine mammals, and used the practical spreading loss equation and empirically measured source levels from other similar steel pile driving projects to estimate potential marine mammal exposures to pile driving noise. Predicted exposures are described in detail in Section 6 and summarized in Tables ES–1 through ES-3. Level A harassments associated with pile driving activities will be avoided for all species, except for harbor seals, by implementing mitigation measures described in Section 11. 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 IHA application.

[1] "Proofing" is driving the pile the last few feet into the substrate to determine the capacity of the pile. The capacity during proofing is established by measuring the resistance of the pile to a hammer that has a piston with a known weight and stroke (distance the hammer rises and falls) so that the energy on top of the pile can be calculated. The blow count in "blows per inch" is measured to verify resistance, and pile compression capacities are calculated using a known formula.

Table ES-1. Total Underwater Exposure Estimates by Species

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	1,944
Steller sea lion	0	360
California sea lion	0	4,860
Harbor seal	90	3,150

Table ES-2. Underwater Exposure Estimates by Species July 16, 2021 to July 15, 2022

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	1,728
Steller sea lion	0	320
California sea lion	0	4,320
Harbor seal	90	2,800

Table ES-1. Total Underwater Exposure Estimates by Species July 16, 2022 to July 15, 2023

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	216
Steller sea lion	0	40
California sea lion	0	540
Harbor seal	0	350

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Abbreviations and Acronyms

Acronym	Definition
BMP	best management practice
CFR	Code of Federal Regulations
CSL	Cleanup Screening Levels
CV	coefficient of variation
CWA	Clean Water Act
dB	decibel
dBA	A-weighted decibel
EHW-1	Explosive Handling Wharf #1
EHW-2	Explosive Handling Wharf #2
ESA	Endangered Species Act
fc	foot candle
Hz	hertz
IHA	Incidental Harassment Authorization
K/B	Keyport/Bangor
kHz	kilohertz
km	kilometer
L_{eq}	equivalent continuous sound level
L_{max}	maximum sound level
LMR	Living Marine Resources
MHHW	mean higher high water
MLLW	mean lower low water
µPa	micropascal
MMPA	Marine Mammal Protection Act
NAVBASE	Naval Base
NAVSTA	Naval Station
Navy	U.S. Department of the Navy
NMFS	National Marine Fisheries Service
PSAMP	Puget Sound Ambient Monitoring Program
PSB	port security barrier
PTS	permanent threshold shift
R&D	research and development
RMS	root mean square
SEL	sound exposure level
SEL_{CUM}	cumulative sound exposure level
SMS	Sediment Management Standards
SPL	sound pressure level
sq ft	square feet
sq km	square kilometer
SQS	Sediment Quality Standards
SSBN	Fleet Ballistic Missile Submarine
TL	transmission loss

Abbreviations and Acronyms

Acronym	Definition
TMDL	total maximum daily load
TPP	Transit Protection Program
TTS	temporary threshold shift
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VMF	Vessel Maintenance Facility
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology
WRA	Waterfront Restricted Area
ZOI	zone of influence

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 U.S. Department of the Navy (Navy) is proposing to construct and operate a pier for berthing of Transit Protection Program (TPP) blocking vessels, which provide security escort to Fleet Ballistic Missile Submarines (SSBNs) between Naval Base (NAVBASE) Kitsap Bangor (Figure 1-1) and the Straits of Juan de Fuca. These vessels are currently berthed on a space-available basis at various locations at NAVBASE Kitsap Bangor. Under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 United States Code Section 1371(a)(5)(D)), the Navy is requesting an Incidental Harassment Authorization (IHA) for pile driving and vibratory pile extraction, which 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 (CFR) 216.104 Submission of Requests, are provided in Sections 1–14 of this application.

The proposed action, construction of a TPP Pier at NAVBASE Kitsap Bangor, Washington, will be accomplished over two in-water work seasons. The IHA inclusive dates for the project will be July 16, 2021 to July 15, 2022, with pile driving occurring from July 16, 2021 to January 15, 2022. Any work not completed during this period will be completed during the following in-water work window, July 16, 2022 to January 15, 2023. It is anticipated that the only in-water construction work that will remain at the end of the first in-water work window, January 15, 2022, would be installation of fender and guide piles using methods described in this IHA.

1.2 Description of Activities

The proposed location of the TPP Pier is Keyport/Bangor (K/B) Spit (Figure 1-2). Operations and maintenance will include fueling, provision of utilities (power, potable water, and sanitary and oily waste discharge), and periodic cleaning of pier structures. The design life of the TPP Pier will be 50 years.

1.2.1 Transit Protection Program Pier and Trestle

The proposed pier will consist of an L-shaped pile-supported trestle from shore connecting to a pile-supported main pier section (Figure 1-2). The trestle will be concrete and approximately 114 feet long and 39 feet wide, including a pedestrian walkway. The main pier section will also be concrete and approximately 299 feet long and 69 feet wide. A fender system will be installed along the west face of the pier with two berthing camels where the blocking vessels will tie up to the pier. Each camel will be 65 feet long by 12 feet wide and constructed of grated material. The camels will serve as both a standoff for the blocking vessels and a platform for boarding the blocking vessels. The camels will be accessed via brows down from the main pier deck. The brow platforms and brows will also be constructed of grated material.

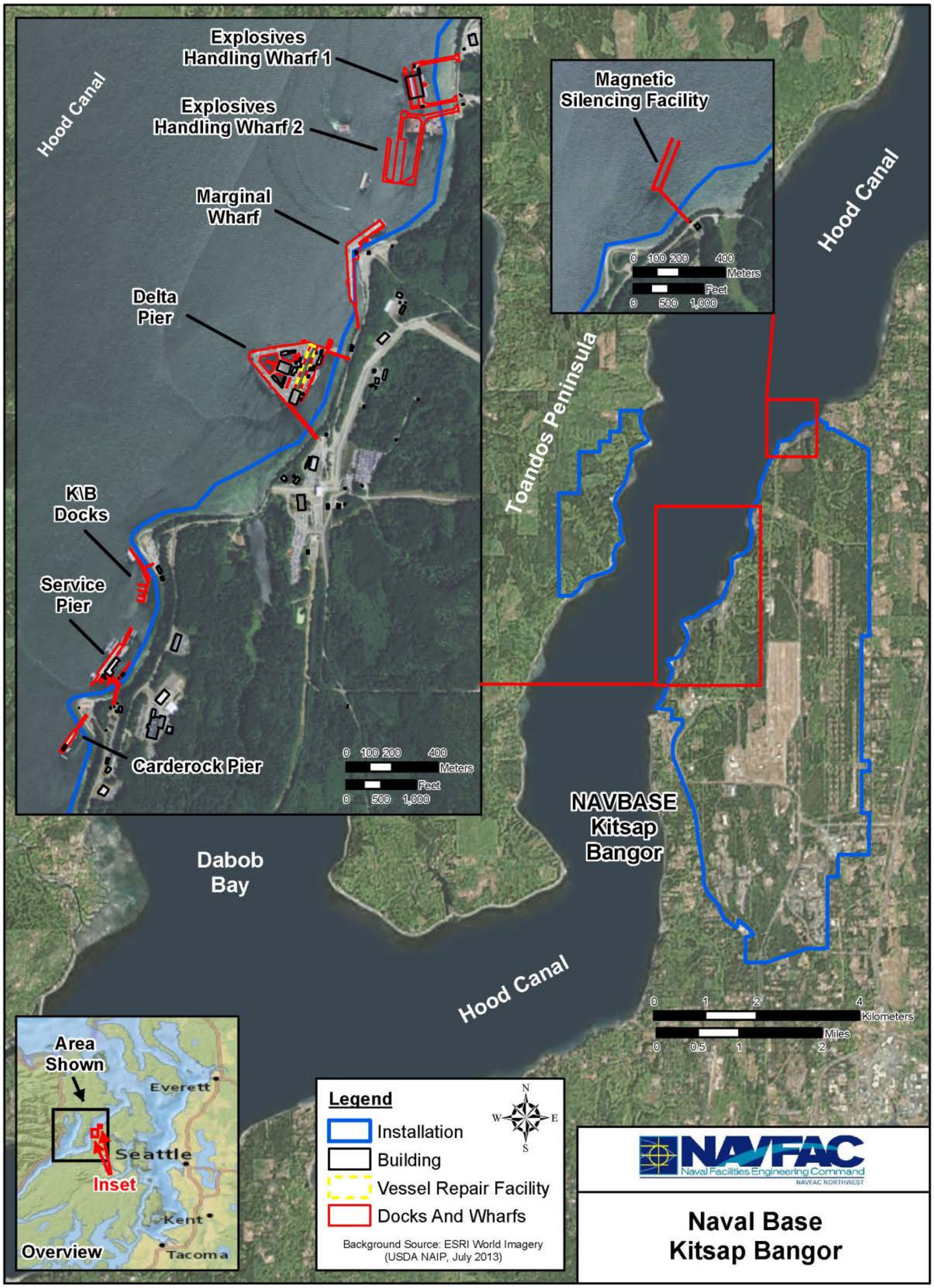

Figure 1-1. Naval Base Kitsap Bangor

Figure 1-2. Proposed TPP Pier Location

Eighty-three light emitting diode (LED) dimming lighting fixtures would be mounted below the trestle in sections between the pile bents. The range of depths where the lighting would be physically placed would be from 5 to 25 feet below mean lower low water (MLLW). This physical placement would illuminate the area between 0 to 30 feet below MLLW. The lighting would mimic natural daylight and be controlled to vary light intensity throughout the day according to the position of the sun and resulting shading conditions.

Two dolphins will be constructed south and north of the pier and used solely for mooring support. The dolphins will support mooring hardware for the bow and stern lines of the blocking vessels and will be centered approximately 46 feet 1 inch off the ends of the pier and approximately 11 feet landward of the front face of the pier. Access to the mooring dolphins will be provided by brows spanning from the pier deck. The structural system for the mooring dolphins will consist of a 12- by 12-foot cast-in-place concrete pile cap and four 36-inch battered steel pipe piles. A shoreline abutment under the pier trestle will be approximately 99 feet 8 inches long and constructed landward of mean higher high water (MHHW). The abutment will be constructed of steel sheet piles.

The trestle, pier, and dolphins will require a total of 124 permanent steel piles that are 24, 30, or 36 inches in diameter, and 60 temporary steel falsework piles that are 36 inches in diameter (Table 1-1). Of these piles, four 36-inch trestle support piles and twenty 36-inch falsework piles will be located above MHHW. The contractor will need to construct a 140-foot by 20-foot temporary work trestle (falsework piles and timber decking). The permanent trestle piles in the intertidal area will be driven from the deck of the temporary work trestle; the trestle will subsequently be removed. The fender piles and camels will be installed on the outer side of the pier to protect it from accidental damage by vessels. Where geotechnical conditions do not allow piles to be driven to the required depth using vibratory methods, an impact hammer may be used to drive some of the 36-inch support piles for part or all of their length. The 24-inch fender piles and 30-inch camel guide piles will not be impact driven.

Table 1-1. Pile Counts for Trestle, Pier, and Dolphins

Pile Type	*Driving Method*	*In-Water*	*On Land*
24-inch steelfender piles	Vibratory only	10	0
30-inch steel guide piles	Vibratory only	10	4
36-inch steel plumb piles	Vibratory with impact proofing of some piles	100	0
36-inch steel falsework piles	Vibratory only	40	20

Pile driving is expected to take place over no more than 90 days total for the project. During the first year, the Navy expects that 80 days will be required to install the steel plumb and falsework piles. 10 days of pile driving is anticipated during year two in order to install the fender and guide piles. Only one pile driver will be used at a time. Under expected conditions, the number of impact hammer strikes per day will not exceed 1,600 in either year.

A total of 787 square feet (sq ft) of seafloor will be occupied by all permanent piles combined; of this, 760 sq ft will be shallower than 30 feet below MLLW. In addition, there will be 283 sq ft of seafloor occupied by the temporary falsework piles (Table 1-1).

The above structures will create 29,451 sq ft of over-water coverage; of this total, 27,382 sq ft will be shallower than 30 feet below MLLW. Approximately 1,900 sq ft will be grated. The pier deck and trestle will slope to drain. The elevation of the bottom of the trestle and pier will be 4 feet 9 inches above

MHHW; the elevation of the top of the trestle will be 17 feet above MHHW at its highest and 12 feet 10 inches at its lowest. The elevation of the bottom of the pier will be 4 feet 2 inches above MHHW at its highest and 1 foot 1 inch at its lowest. The elevation of the top of the pier will be 9 feet 9 inches above MHHW at its highest and 9 feet 5 inches at its lowest. Stormwater from the pier and trestle will be directed to treatment cartridges consistent with a General Use Level Designation from the Washington Department of Ecology (WDOE) prior to discharge of the water to Hood Canal. Stormwater from the floating docks will be routed to a coalescing oil-water separator prior to discharge to Hood Canal.

The shoreline abutment under the pier trestle will be approximately 99 feet 8 inches feet wide and constructed above MHHW. The abutment will be constructed of steel sheet piles.

The trestle will have five 30-foot-high light standards, and the pier will have three 50-foot-high light standards. All of the lights will be LED type lights for which illumination levels at the surface will not exceed 30 foot-candles (fc) at 30 feet, 10 fc at 50 feet, and 5 fc at 100 feet.

Pier and trestle construction will require one derrick barge with a crane and one support/material barge. An average of six barge round trips per month during the in-water work season and two barge round trips per month outside of this period are expected.

The Navy is requesting incidental take, as described in Section 5.2, for pile driving and pile extraction for the TPP Pier.

1.2.2 Utilities and Upland Features

Potable water, power lines, and communication lines will be provided to the berthing areas on the pier and floating docks. All utility lines will be contained in utility trenches built into the concrete trestle and pier decks. Sewage and oily waste will first flow to below-deck holding tanks on the pier and then will be pumped ashore via separate double-contained lines to separate holding tanks on shore (Figure 1-3). Two 20,000-gallon diesel fuel tanks will be installed on shore, and fuel will be pumped to fueling facilities at the small craft floats at the K/B Dock through double-contained, insulated lines with leak and fire detection and alarm systems (Figure 1-3). The facility will include a full loop road for tanker trucks to pull entirely off Sea Lion Road. The diesel fuel line will be installed in a trench running downhill across Sea Lion Road and aligned beneath Shore Boundary Road to the new pier site. All fuel tanks will be enclosed in double-walled secondary containment structures with a capacity of 110 percent of the tank volume.

Other upland facilities to be installed at the site will include an asphalt parking area for approximately five vehicles, an oil-water separator within a 3,000-gallon capacity underground storage tank, one 20,000-gallon sanitary sewer underground storage tank, and a guard station. A 38-foot long roadway will be installed to connect the trestle to the existing roadway. Construction of upland facilities will result in a total surface disturbance of 33,250 sq ft. Of this total, 25,600 sq ft will be located in disturbed areas that do not support native vegetation and 7,650 sq ft would be located in a currently vegetated area.

Construction of the diesel fuel tanks and fueling access point on the east side of Sea Lion Road will require clearing 15,960 sq ft of forested area. Of this total, 2,871 sq ft will be occupied by the new tanks and a fueling access point, 9,889 sq ft will be occupied by a stormwater infiltration pond, and 3,200 sq ft will be revegetated with native forest species. A total of 3,650 sq ft of new impervious surface will be created to support resupplying the tanks with fuel. Upland construction at the pier site will require a maximum of 5,400 cubic yards of excavation and 1,200 cubic yards of fill, including 50 cubic yards of fill behind the abutment and 1,150 cubic yards for the sanitary sewer and oil-water separator systems.

Long-term lighting at the upland site will be provided by high-mast LED pole lights to provide uniform fc illumination.

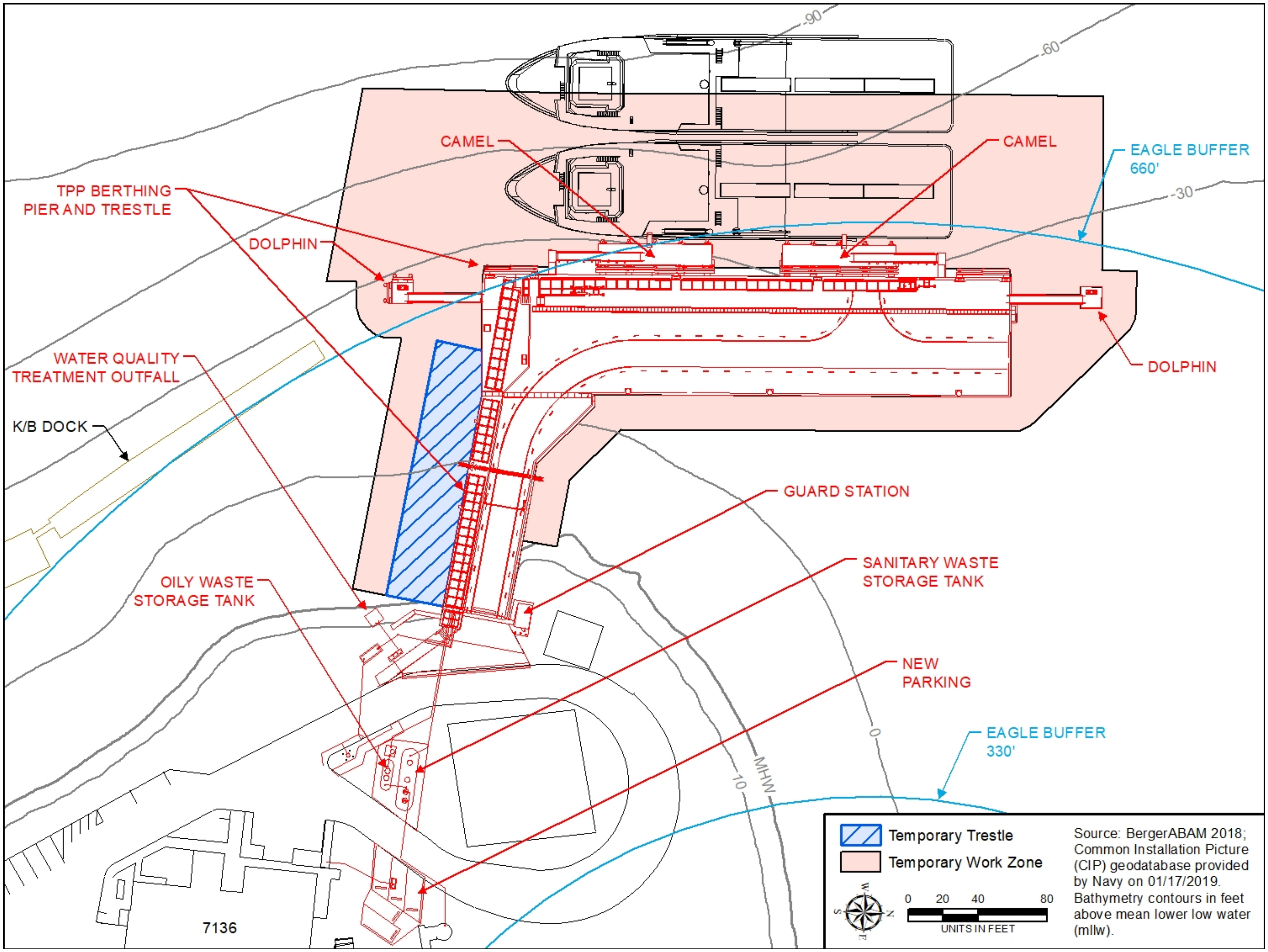

Figure 1-3. Pier Components

1.2.3 Vessel Maintenance Facility

An upland Vessel Maintenance Facility (VMF) with an adjacent storage area will be built at a currently forested upland site located along Sturgeon Street, approximately 4,500 feet south of the proposed pier site (Figure 1-4). The VMF will include utilities for maintaining and cleaning small (trailerable) boats, including water, floor drains with appropriate runoff treatment, and electrical service.

The Navy is not requesting incidental take for construction of the VMF since there would be no effects to marine species from construction at this site.

1.3 Pile Installation and Removal Methods

Two primary methods of pile installation may be used (vibratory and impact) depending on the pile type and site conditions. These methods are described below.

The vibratory pile driver method is a technique that will be used in pile installation where the substrate allows. Use of this technique may be limited in very hard or liquefiable substrates. This process begins by placing a choker cable around a pile and lifting it into vertical position with a crane. The pile is then lowered into position and set in place at the mudline. The pile is held steady while the vibratory driver installs the pile to the required tip elevation. In some substrates, a vibratory driver may be unable to advance a pile until it reaches the required depth. In these cases, an impact hammer may be used to entirely advance the pile to the required depth. For load-bearing structures, an impact hammer is typically required to strike a pile a number of times to ensure it has met the load-bearing specifications; this is referred to as “proofing.”

Impact hammers may be used to install steel support piles. 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. A vibratory driver may be used to set the pile in place at the mudline. Once the pile is properly positioned, pile installation can typically take a minute or less to 60 minutes depending on pile type, pile size, and conditions (i.e., bedrock, loose soils, etc.) to reach the required tip elevation.

Because impact driving of steel piles can produce underwater noise levels that have been known to be harmful to fish and wildlife, steel support piles will be advanced to the extent practicable with a vibratory driver and only impact driven when required for proofing or when a pile cannot be advanced with a vibratory driver due to hard substrate conditions. When impact driving steel pipe piles, a bubble curtain or other noise attenuation device will be employed for all pile strikes with the possible exception of short periods when the device is turned off to test the effectiveness of the noise attenuation device.[2]

[2] The protocol for monitoring the effectiveness of a bubble curtain is to turn it off periodically during the driving of one or more piles (Fisheries Hydroacoustic Working Group, 2013). However, to protect foraging marbled murrelets, the U.S. Fish and Wildlife Service may require the noise attenuation device to remain on at all times.

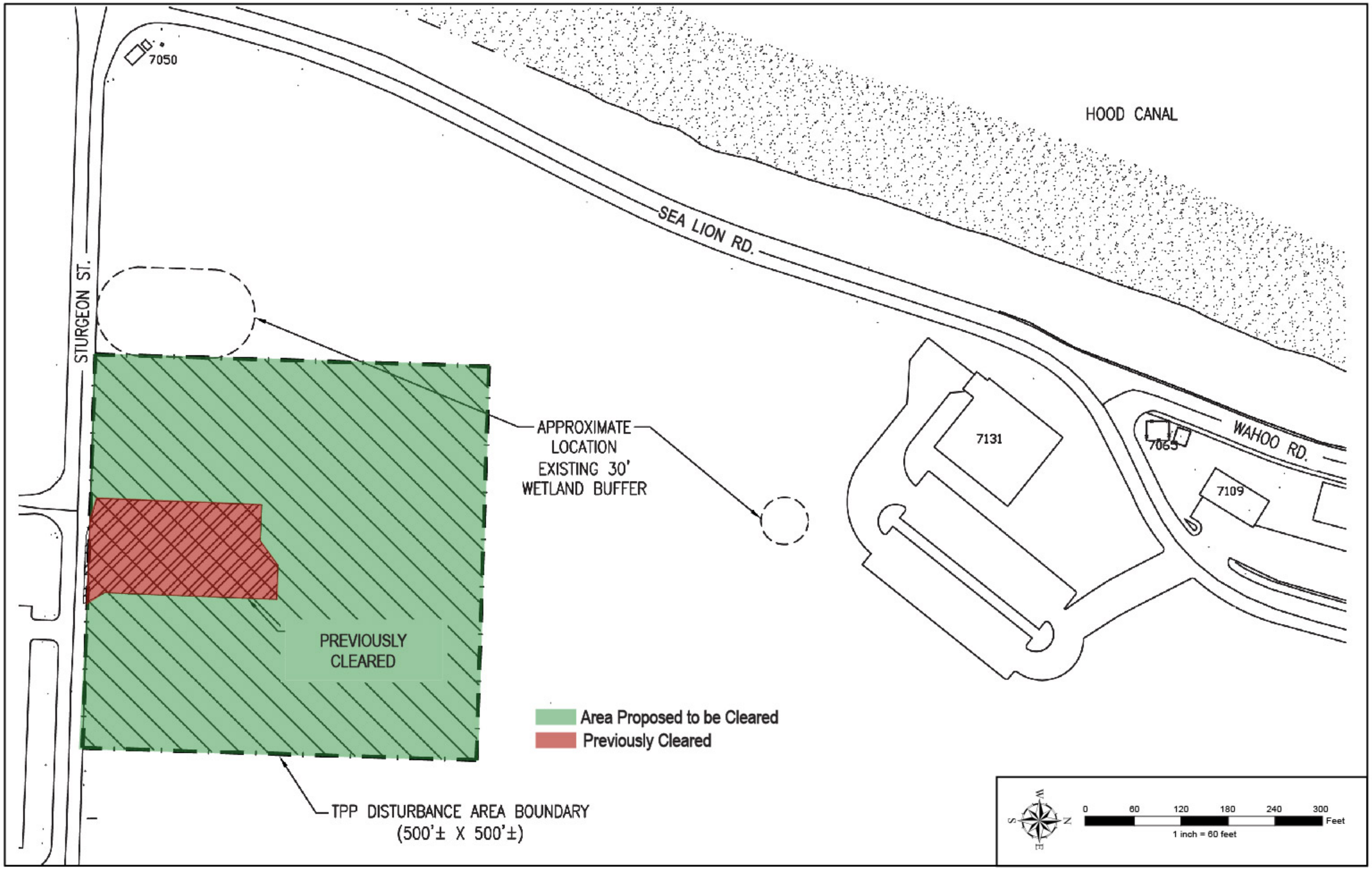

Figure 1-4. Vessel Maintenance Facility

A bubble curtain is usually a ring or series of stacked rings that are placed around a pile along the pile's entire length underwater. The rings are made of tubing that has small puncture holes through which compressed air is pumped. As the compressed air bubbles flow from the tubing, they create an air barrier that impedes the sound produced during pile driving.

During vibratory pile extraction, a barge-mounted crane operates from the water adjacent to the pile during removal activities. A vibratory driver is 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 shut off once the end of the pile reaches the mudline and the pile is pulled from the water and placed on a barge.

1.4 Best Management Practices and Mitigation and Minimization Measures

General Best Management Practices (BMPs), mitigation, and minimization measures that will be implemented as appropriate for all in-water activities are described in Section 11 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 (ESA)-listed species, and designated critical habitats. These measures include vibratory installation of piles where possible, noise attenuation and performance measures for impact pile driving, and marine mammal monitoring as described in Section 11.

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

Completion of all project elements described in Section 1 will require approximately 18 months, and pile driving will require a maximum of 90 in-water pile-driving days. Pile driving will occur between July 2021 and January 2023. Within that period, timing restrictions (or "in-water work windows") typically imposed by the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS) will be in effect at the NAVBASE Kitsap Bangor waterfront to avoid conducting activities in the water when ESA-listed juvenile salmonids are most likely to be present. The in-water work window at NAVBASE Kitsap Bangor is July 16 to January 15. Thus, the IHA inclusive dates for the project will be July 16, 2021 to July 15, 2022, with pile driving occurring from July 16, 2021 to January 15, 2022. Any work not completed during this period will be completed during the following in-water work window, July 16, 2022 to January 15, 2023. It is anticipated that the only in-water construction work that will remain at the end of the first in-water work window, January 15, 2022, would be installation of ten 24" inch steel fender and ten 30" steel guide piles using methods described in this IHA. No in-water work would begin at the installation until the Navy has received all required permits and approvals.

2.2 Project Location Description

NAVBASE Kitsap Bangor is located north of the community of Silverdale in Kitsap County on the Hood Canal. The proposed project area on the Bangor waterfront is within this region (Figure 1-1). NAVBASE Kitsap Bangor is the Pacific homeport for the Navy's SSBN fleet with the mission to support and maintain a SSBN squadron and other ships home-ported or moored at the installation and to maintain and operate administrative and personnel support facilities including security, berthing, messing, and recreational services. NAVBASE Kitsap Bangor is the only naval installation on the west coast with the specialized infrastructure able to support the SSBN program. The specialized infrastructure includes buildings, utilities, and systems used to support missile production shops, missile maintenance, missile component storage, and missile handling cranes, in addition to providing security and operational port facilities. There are eight pile-supported structures at NAVBASE Kitsap Bangor. The proposed location for the TPP Pier is at the tip of K/B Spit, north of the K/B Dock (Figure 1-2).

2.2.1 Marine and Bathymetric Setting

NAVBASE Kitsap Bangor is located on the Hood Canal, a long, narrow, fjord-like basin of western Puget Sound. Oriented northeast to southwest, the portion of the canal from Admiralty Inlet to a large bend, called the Great Bend, at Skokomish, Washington, is 52 miles long. East of the Great Bend, the canal extends an additional 15 miles to Belfair. Throughout its 67-mile length, the width of the canal varies from 1 to 2 miles and exhibits strong depth/elevation gradients.

Hood Canal is characterized by relatively steep sides and irregular seafloor topography. In the entrance to Hood Canal, water depths in the center of the waterway near Admiralty Inlet vary between 300 and 420 feet. As the canal extends southwestward toward the Olympic Mountain Range and Thorndyke Bay, water depth decreases to approximately 160 feet over a moraine deposit. This deposit forms a sill across the canal near Thorndyke Bay, which limits seawater exchange with the rest of Puget Sound. The Bangor waterfront on NAVBASE Kitsap occupies approximately 5 miles of the shoreline within northern Hood

Canal (1.7 percent of the entire Hood Canal coastline) and lies just south of the sill feature. Depths in the center of the waterway off the Bangor waterfront are generally 200 to 400 feet.

2.2.2 Tides, Circulation, and Currents

The tides in Hood Canal are mixed semidiurnal, with one flood and one ebb tidal event with a small to moderate range (1 to 6 feet) and a second flood and second ebb with a larger range (8 to 16 feet) during a 24-hour and 50-minute tidal day (URS & SAIC, 1994; Morris et al., 2008). Hood Canal is subject to one major flushing event per tide day when approximately 1.1326×10^9 cubic yards (or 3 percent of the total canal volume) is exchanged over a 6-hour period. Due to the wide range of tidal heights, the actual seawater exchange volume for Hood Canal ranges from 1 percent during a minor tide to 4 percent during a major tide. At NAVBASE Kitsap Bangor, the majority of the daily volume of seawater exchange flows directly across the waterfront area. As a result, the degree of flushing that occurs is relatively high and the characteristics of this seawater more closely track the physical, chemical, and biological conditions of Puget Sound than southern Hood Canal. Seawater that enters the canal from Admiralty Inlet during an incoming flood tide tends to be cooler, more saline, and well-oxygenated relative to the Hood Canal waters. As a result, the incoming water has a tendency to sink to the bottom of the canal as it flows over the sill and TO move south during each flood tide, while the lower density Hood Canal water tends to remain in the upper water column.

Current flow (speed and direction) along the Bangor waterfront is primarily a function of tidal action based on the phase and range of each tide, and current velocities in the shallower water areas (less than 50 feet) around the project area are variable and complex. The magnitude or instantaneous velocity of these fluctuating water column currents ranges from 0 to 0.88 feet per second within the 30- to 65-feet water depth interval. However, current flow in any one direction is short-lived and inconsistent in magnitude, with relatively few periods of time when sufficient energy (0.7 feet per second) exists to exceed the threshold for re-suspending deposits of unconsolidated material on the seafloor (Boggs, 1995). Statistical summaries show that time-averaged net flow is within the 0.07 to 0.10 feet per second range in the upper water column and less than 0.03 feet per second in proximity to the seafloor.

Nearshore current observations at NAVBASE Kitsap Bangor piers and wharves in the summer of 2006 suggest that tidal currents were inconsistent with water level (tide) measurements. Rather than the typical relationship where maximum current corresponds to mid-flood or mid-ebb in the water level record, maximum flow velocities recorded along the waterfront aligned with water levels at the high and low tide. Furthermore, the direction of nearshore flow often ran counter to expectations in a normal system, with flood tide coinciding with northeastward currents and ebb tide resulting in southwesterly currents (Morris et al., 2008).

The typically light winds afforded by the surrounding highlands (Olympic and Cascade Mountain Ranges) coupled with the fetch-limited environment of Hood Canal result in relatively calm wind conditions throughout most of the year. However, the northern and middle sections of Hood Canal are oriented in the southwest to northeast direction. Therefore, organized coastal storm events that reach land in the late autumn and winter months, as well as fair weather systems in the spring and summer exhibiting wind speeds in excess of 20 knots, have the capability to generate substantial wind waves due to increased fetch and/or alter normal tidal flow within the basin. However, much of the Bangor waterfront area is afforded some protection by the coastline of both Kitsap and Toandos Peninsulas.

2.2.3 Water Quality

The federal Clean Water Act (CWA) requires that all states restore their waters to be "fishable and swimmable." Section 303(d) of the CWA established a process to identify and clean up polluted waters. Every 2 years, all states are required to perform a water quality assessment of the quality of surface waters in the state, including all the rivers, lakes, and marine waters where data are available. The WDOE compiles its own water quality data, and invites other groups to submit water quality data they have collected.

Waters whose beneficial uses—such as for drinking, recreation, aquatic habitat, and industrial use—are impaired by pollutants are placed in the "polluted water" category (Category 5) on the water quality assessment. Categories range from Category 1, corresponding to waters that meet tested standards for clean waters, to Category 5, representing waters that fall short of state surface water quality standards and are not expected to improve within the next 2 years. The 303(d) list is comprised of those waters that have been designated as Category 5, impaired. Waters placed on the 303(d) list require the preparation of a water cleanup plan, like a total maximum daily load (TMDL). The TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. It identifies the maximum amount of a pollutant to be allowed to be released into a water body so that the beneficial uses of the water are not impaired.

The CWA contains the requirements to set water quality standards for all contaminants in surface waters. The U.S. Environmental Protection Agency (USEPA) is the designated regulatory authority to implement pollution control programs and other requirements of the CWA. However, USEPA has delegated regulatory authority for the CWA to WDOE for the implementation of pollution control programs in Washington State, as well as other CWA requirements.

Washington surface water quality standards contained in Washington Administrative Code (WAC) 173-210A provide the basis for protecting and regulating the quality of surface waters in Washington State. The standards implement portions of the federal CWA by specifying the designated and potential uses of water bodies in the state. They set water quality criteria to protect those uses and acknowledge limitations. The standards also contain policies to protect high-quality waters (antidegradation) and specify how criteria are to be implemented.

NAVBASE Kitsap Bangor is located within Hood Canal. WAC 173-201A-612 has established designated uses for Hood Canal as follows: extraordinary (aquatic life uses); primary contact (recreation); shellfish harvesting; and wildlife habitat, commerce/navigation, boating, and aesthetics (miscellaneous uses). The current 303(d) list, approved in 2016, includes two grid segments along the Bangor waterfront impaired by low dissolved oxygen levels. One is to the north, adjacent to Marginal Wharf and Delta Pier; the other is to the south of Service Pier (WDOE, 2017a). Waters of Hood Canal immediately south of the proposed project sites and approximately 0.5 miles north of the base boundary are on the current 303(d) list for low dissolved oxygen. No TMDL has been developed by WDOE for this area. Areas of Hood Canal near the base have also been listed as Category 2, waters of concern, for isolated exceedances of bacteria (fecal coliform) and pH.

The Navy has sampled the waters off NAVBASE Kitsap Bangor numerous times for water quality parameters (temperature, salinity, dissolved oxygen, and turbidity) (Hafner and Dolan, 2009; Phillips et al., 2009). This sampling has shown that these waters are consistently within the Washington State standards for extraordinary water quality for each of these parameters (Hafner and Dolan, 2009; Phillips et al., 2009). An exception to these findings was temperature, which typically met extraordinary water quality levels in the winter months and excellent water quality standards in the summer months. Waters south of Explosive Handling Wharf #1 (EHW-1) and further offshore showed similar results with the exception of dissolved oxygen, which typically ranged from excellent to extraordinary.

2.2.4 Sediments

The Washington State Sediment Management Standards (SMS) (WAC 173-204) provide the framework for the long-term management of marine sediment quality. The SMS establishes standards for the quality of sediments as the basis for management and reduction of pollutant discharges by providing a management and decision-making process for contaminated sediments.

The marine Sediment Quality Standards (SQS) established by the SMS define the lower limit of sediment quality expected to cause no adverse impacts to biological resources. The SMS Cleanup Screening Levels (CSL) represents cleanup thresholds. Concentrations between the SQS and CSL values require further investigation to determine whether actual adverse impacts exist at the site due to contaminated sediments.

Washington State's Water Quality Assessment and 303(d) list includes an assessment of sediments in the state's water bodies. The current assessment and 303(d) list was approved by USEPA in July 2016 (WDOE, 2017b). Assessed sediments are classified into seven categories:

- Category 5 – Polluted sediments / 303(d) list
- Category 4C – Sediments impaired by a non-pollutant
- Category 4B – Sediments that have a pollution control plan
- Category 4A – Sediments that have a TMDL
- Category 3 – Insufficient data
- Category 2 – Sediments of concern
- Category 1 – Sediments that meet tested standards

Sediment found along the eastern shore of Hood Canal is primarily from natural erosion of bluffs (by wind or wave action). No rivers or large watersheds feed into Hood Canal along the east shore; however, numerous small drainages along the waterfront feed Hood Canal, contributing to a secondary source of sedimentation. Existing marine sediments at the proposed project sites are composed of gravelly sands with some cobbles in the intertidal zone, transitioning to silty sands in the subtidal zone (Hammermeister and Hafner, 2009). The presence of glacial till approximately 6 feet below the mud line in the intertidal zone, increasing to over 10 feet in the subtidal zone was found in subsurface coring studies performed in 1994 (URS, 1994).

NAVBASE Kitsap Bangor sediment composition varies by location along the waterfront. Sediments at the Explosive Handling Wharf #2 (EHW-2) site consist of fine sands and silt/clay with little hydrogen sulfide odor. Sediments north of EHW-1 and at K/B Dock contain medium sand and organic matter with a slight hydrogen sulfide odor. The sediments at the Cattail Lake Delta and at Floral Point are a mix of cobble, sand, and silt/clay. Other sites sampled along the waterfront (at the Magnetic Silencing Facility, Delta Pier, Devil's Hole Delta, and Service Pier) are a mix of fine and medium sands and silt/clay.

NAVBASE Kitsap Bangor has been listed twice on the Comprehensive Environmental Response, Compensation, and Liability Act National Priorities List for investigation and, if necessary, cleanup of past waste disposal sites. In January 1990, the Navy and the USEPA entered into a Federal Facilities

Agreement to ensure that environmental impacts associated with past practices at the base are investigated and remedial actions are completed as needed to protect human health and the environment. As of 2005, all required actions have been completed. WDOE concurred that there was no increasing trend of contaminants of concern and additional sampling was not needed (Madakor, 2005). Results from a 2007 base-wide sediment investigation confirm that, with a few exceptions, sediment quality at NAVBASE Kitsap Bangor is within SQS standards (Hammermeister and Hafner, 2009). None of the subsurface samples collected exceeded the numeric criteria. No marine sediments at or near the Bangor waterfront are currently included on the 303(d) list (WDOE, 2017a).

2.2.5 Ambient Sound

2.2.5.1 Underwater Sound

Underwater ambient sound in Puget Sound 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 (Hz) and 100 kilohertz (kHz) (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). 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 NAVBASE Kitsap Bangor, 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 has been recorded and measured at NAVBASE Kitsap Bangor near Marginal Wharf. The major contributors to the average background noise between 100 Hz and 20 kHz were wind-driven wave action and man-made noise sources from small boat traffic and industrial noise emanating from the waterfront work areas (Slater, 2009). The average broadband (100 Hz–20 kHz) sound level was 114 dB referenced at 1 micropascal (re 1 µPa) root mean square (RMS). Peak spectral noise from industrial activity was noted below 300 Hz, with a maximum level of 110 dB RMS in the 125 Hz band. From 300 Hz to 5 kHz, average received levels ranged between 83 and 99 dB RMS, although small powerboats generated peak narrowband source levels of 150 to 165 dB in the 350 to 1,200 Hz region. Wind-driven wave sound dominated the background sound at 5 kHz and above. In general, ambient noise one-third octave levels flattened above 10 kHz. Precipitation was not noted during this study, but would be expected to increase average broadband noise levels as much as 20 dB above average levels noted in deeper water.

Similar sound levels were recorded near the EHW-1 during the Test Pile Program at NAVBASE Kitsap Bangor in 2011. Average sound levels ranged from 112.4 dB RMS at mid-depth to 114.3 dB RMS at deep depth (Illingworth & Rodkin, 2012). These measurements were made during normal port activities, but did not include noise from construction and pile driving projects. Small-scale geographic variations in ambient sound are to be expected based on land shadowing and other environmental factors, but for analysis purposes the average sound level at this installation was assumed to be 114 dB RMS.

Ambient sound measurements from NAVBASE Kitsap Bangor are well within the range of levels reported for a number of sites within the greater Puget Sound region (95–135 dB RMS) (Carlson et al., 2005; Veirs & Veirs, 2005). Nearshore broadband measurements near ferry terminals in Puget Sound resulted in median sound levels (50 percent cumulative distribution function) between 107 and 133 dB RMS (Laughlin, 2015). Average ambient sound during the Test Pile Program near EHW-1 at NAVBASE Kitsap Bangor was ~114 dB RMS.

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, and airborne sound is produced by other sources such as sea lions. Sound levels are highly variable based on the types and operational states of equipment at the recording location, and sound levels may even vary within a single installation such as NAVBASE Kitsap Bangor, with some piers/wharfs very loud and others relatively quiet. Data from airborne ambient sound measurements are currently only available for a short period at NAVBASE Kitsap Bangor.

Airborne sound measurements were taken at Delta Pier within the waterfront industrial area at NAVBASE Kitsap Bangor during a 2-day period in October 2010. During this period, daytime sound levels ranged from 60 A-weighted decibel (dBA)[3] to 104 dBA, with average values of approximately 64 dBA. Evening and nighttime levels ranged from 64 to 96 dBA, with an average level of approximately 64 dBA. Thus, daytime maximum levels were higher than nighttime maximum levels, but average nighttime and daytime levels were similar (Navy, 2010). More recent measurements, taken during the Navy's Test Pile Program located near EHW-1 at NAVBASE Kitsap Bangor, indicated an average airborne ambient sound level of 55 dBA (Illingworth & Rodkin, 2012). Maximum sound levels from the 2010 recordings were produced by a combination of sources including heavy trucks, forklifts, cranes, marine vessels, mechanized tools and equipment, and other sound-generating industrial/military activities. Maximum sound levels were intermittent in nature and not present at all times. Based on the sound levels measured at the highly industrial location at Delta Pier, the Navy estimated that maximum airborne sound levels at pier locations with a high level of industrial activity may reach as high as 104 dBA due to trucks, forklifts, cranes, and other industrial activities. Sound levels vary by time and location, but average background sound levels are expected to range from approximately 55 dBA (average from Test Pile Program at NAVBASE Kitsap Bangor) to 64 dBA (average levels measured at Delta Pier at NAVBASE Kitsap Bangor) (Navy, 2010; Illingworth & Rodkin, 2012).

[3] A-weighted sound (dBA) is measured using a filter that de-emphasizes the low and high frequency components of the sound in a manner similar to the frequency response of the human ear. A-weighted sound measurements correlate well with subjective human reactions to noise.

3 Marine Mammal Species and Numbers

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

Five marine mammal species managed by NMFS have a reasonable potential to occur within Hood Canal (Table 3-1). A reasonable potential was defined as species with any regular occurrence in Puget Sound since 1995. The likelihood of encountering each of these species is presented qualitatively in Table 3-2. Stock abundance and ESA status of these species are listed in Table 3-1. Section 3.1 provides a description of each of the species and their population abundance. Section 4 contains life history information for each species.

Table 3-1. Marine Mammals Potentially Present Within Hood Canal

Species and Stock	*Stock Abundance[1]*	*ESA Status*
Killer whale (*Orcinus orca*) West Coast Transient	243[2]	None
Harbor porpoise (*Phocoena phocoena*) Washington Inland Waters	11,233[3] (CV = 0.37)	None
Steller sea lion (*Eumetopias jubatus*) Eastern United States/Distinct Population Segment	52,139[4]	None
California sea lion (*Zalophus californianus*) United States	296,750[5]	None
Harbor seal (*Phoca vitulina*) Hood Canal	2,009[6] (CV = 0.07)	None

Key: CV = coefficient of variation; ESA = Endangered Species Act **Sources:** 1.National Marine Fisheries Service marine mammal stock assessment reports at http://www.nmfs.noaa.gov/pr/sars/species.html 2.Allen and Angliss, 2011, as presented in Muto et al., 2018. 3.Smultea et al., 2015, as cited in Carretta et al., 2017. 4. Muto et al., 2018 5.Carretta et al., 2016. 6. Jefferson et al. 2017

Table 3-2. Relative Occurrence of Marine Mammals at NAVBASE Kitsap Bangor

Species	*Relative Occurrence*	*Analysis Method*
Transient killer whale	Rare	Historical occurrence
Harbor porpoise	Likely	Density
Steller sea lion	Seasonal: September–May Haulout on site	Site-specific abundance
California sea lion	Seasonal: late August–mid-June Haulout on site	Site-specific abundance
Harbor seal	Year-round Haulout on site	Site-specific abundance

Notes:

Rare = The distribution of the species is near enough to the area that the species could occur there, or there are a few confirmed sightings.

Likely = Confirmed and regular sightings of the species occur in the area year-round.

Seasonal = Confirmed and regular sightings of the species occur in the area on a seasonal basis.

Year-round = Confirmed and regular sightings of the species occur in the area year-round.

The following marine mammal species have been documented in Hood Canal but are not likely to be found in the activity area and therefore are not analyzed for noise exposure:

- Humpback whales (*Megaptera novaeangliae*) have been detected year-round in small numbers in Puget Sound. In Hood Canal, after an absence of sightings for over 15 years, an individual was seen over a 1-week period in early 2012, with additional sightings lasting 1 day in 2015, 2016, and 2017 (Orca Network, 2019). Because these sightings are exceptions to the normal occurrence of the species in Washington inland waters, the species is not included in the analysis for this application.
- Gray whales (*Eschrichtius robustus*) have been infrequently documented in Hood Canal waters over the past decade. There was five sightings in 2017 and one in 2018 (Orca Network, 2017, 2019). These sightings are an exception to the normal seasonal occurrence of gray whales in Puget Sound feeding areas. Because these sightings are exceptions to the normal occurrence of the species in Washington inland waters, the species is not included in this analysis.
- The Southern Resident killer whale stock is resident to the inland waters of Washington state and British Columbia; however, it has not been seen in Hood Canal in over 15 years and was therefore excluded from further analysis.
- Dall's porpoise (*Phocoenoides dalli*) was documented once in Hood Canal in 2009 and more recently once in 2018 (Orca Network, 2019). Because Dall's porpoises are unlikely to be present in Hood Canal, the species is not included in the analysis.
- Bottlenose dolphin (*Tursiops truncatus*) was documented in Hood Canal twice in 2018 (Orca Network, 2019). Because bottlenose dolphins are unlikely to be present in Hood Canal, the species is not included in this analysis.

3.1 Estimates of On-Site Abundance

Estimating potential marine mammal occurrence over time and space can be challenging. Prior Navy marine mammal IHA applications in Puget Sound relied on density estimates for some or all species exposure estimates. Analyses based on species density assume that marine mammals are uniformly distributed within a given area at any given point in time. This assumption is rarely true for marine mammal species in Puget Sound because many of the species are not resident, but occasionally or seasonally transient through portions of Puget Sound (Table 3-2). Additionally, most species are not distributed evenly, but occur clumped in groups. Distribution of individuals or groups does not occur uniformly in space but is biased toward areas of greater importance, such as areas of high prey abundance, haulout sites, or areas with lower predation risk, etc. For example, density estimates near haulouts or foraging location would be expected to be a function of distance from the attracting haulout and number of animals utilizing the haulout or foraging location.

To characterize potential species occurrence, this application utilized density information available for Puget Sound and recent research and survey information conducted on-site that provides, for some species, actual abundances of animals. The Navy also discussed species occurrence with local species experts and reviewed incidental sighting reports from the Orca Network for verified or reasonably verified species presence, as well as information on seasonal, intermittent, or unusual species occurrences. Based on a review of this information, the Navy separated species into three groups to predict numbers present at NAVBASE Kitsap Bangor during the in-water work period:

- Species with rare or infrequent occurrence in Hood Canal

- Species with routine occurrence, but no site-specific survey information
- Species with site-specific survey information

In the case of species with rare or infrequent occurrence in Hood Canal, the Navy reviewed historical temporal and spatial distribution to predict potential numbers of animals during the in-water work period. For example, in Hood Canal, the presence of transient killer whales is considered rare. Therefore, a methodology that assumes at any point in time animals are present or uniformly distributed, either in time or space, would have little chance of predicting actual occurrence. Therefore, for these types of species, a historical temporal and spatial distribution was used to estimate potential occurrence during the in-water work window.

For harbor porpoise, which has regular occurrence but no site-specific species surveys, the Navy assumed that individuals are relatively uniformly distributed within the affected area and used densities within the in-water work period from the Navy Marine Species Density Database (Navy, 2015) to estimate number of individuals potentially present. This database contains density values used in Navy MMPA permit applications for at-sea training and testing in Puget Sound

Finally, where a reasonable assessment of marine mammal abundance could be determined from on-site surveys, survey numbers and trends were the best predictor of abundance. For example, survey information is available for California sea lions hauled out at NAVBASE Kitsap Bangor and therefore estimated abundance of California sea lions is derived from the survey data.

3.2 Species Abundance

3.2.1 Killer Whale, West Coast Transient Stock

A minimum abundance estimate for the West Coast Transient stock is 243 animals based on photographic data (Fisheries and Oceans Canada, 2009; Allen & Angliss, 2015). This estimate is considered conservative and does not include whales from southeastern Alaska and California that are provisionally classified as part of the stock (Allen & Angliss, 2015).

3.2.2 Harbor Porpoise

Aerial surveys of the inland marine waters of Washington were conducted throughout the year from 2013 to 2015, and in the Strait of Juan de Fuca and the San Juan Islands (and some adjacent Canadian waters) in April 2015 (Jefferson et al., 2016; Smultea et al., 2017). These surveys encompassed waters inhabited by the Washington Inland Waters stock of harbor porpoise, as well as, harbor porpoises from British Columbia. Overall, estimated abundance for the Washington Inland Waters stock was 11,233 porpoises (coefficient of variation [CV] = 37%, 95% CI=9,616–13,120); estimated abundance for Puget Sound was 2,387 (CV=39%; 95% CI=1,942–2,935) (Smultea et al., 2017). The highest densities were detected in North Puget Sound (Admiralty Inlet and South Whidbey regions) and the lowest in south Puget Sound, Vashon and Bainbridge areas, and Hood Canal.

3.2.3 Steller Sea Lion

The Eastern stock was estimated by NMFS in the Recovery Plan for the Steller sea lion as numbering between 45,000 to 51,000 animals (NMFS, 2008). This stock has been increasing approximately 3 percent per year over the entire range since the late 1970s (NMFS, 2012). The most recent population estimate for the U.S. portion of the Eastern stock based on rookery counts analyzed in 2015 is 52,139, including pups and non-pups (Muto et al., 2018). This count is considered a minimum estimate of population size because it is not corrected for animals that are at sea during surveys.

3.2.4 California Sea Lion

A complete population count of California sea lions is not possible because all age and sex classes are not ashore at the same time during field surveys. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population. The current population estimate for the U.S. stock of California sea lions is 296,750 (Carretta et al., 2016).

3.2.5 Harbor Seal

The harbor seal is the only species of marine mammal that is consistently abundant and considered resident in Hood Canal (Jeffries et al., 2003). Expert review of existing datasets and analytic approaches concluded that Navy-funded line-transect aerial survey data collected from 2013 to 2016 by Smultea Environmental Sciences were the best basis for estimating in-water density of harbor seals (Jefferson et al., 2017). The best estimate of in-water density of harbor seals in Hood Canal was 5.8 seals per square kilometer (sq km), with an estimated abundance of 2,009 seals (CV not including g[0] variance = 6.9%; including g[0] variance = 118.6%)[4]. Highest densities were estimated in the sub-region that includes Dabob Bay; lowest densities were estimated from Hood Canal Bridge southward through the waters adjacent to NAVBASE Kitsap Bangor. Density in the sub-region adjacent to NAVBASE Kitsap Bangor was 1.34 seals per sq km with an abundance of 58 animals. Highest density and abundance were in the spring and lowest were in winter.

[4] Trackline detection probability [g(0)] is a correction factor estimated from dive and surface time data from seal tagging studies, and is used to correct for seals missed on the trackline during surveys.

4 Affected Species Status and Distribution

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.

4.1 Killer Whale, West Coast Transient Stock

4.1.1 Status and Management

Among the genetically distinct assemblages of killer whales in the northeastern Pacific, the West Coast Transient stock, which occurs from California to southeastern Alaska, is one of two stocks that may occur in Puget Sound. The other is the Southern Resident killer whale population, which has not been detected in Hood Canal since 1995. Killer whales belonging to the West Coast Transient stock are protected under the MMPA, but not listed under the ESA.

4.1.2 Distribution

The geographical range of the West Coast Transient stock of killer whales includes waters from California through southeastern Alaska with a preference for coastal waters of southern Alaska and British Columbia (Krahn et al., 2002). Transient killer whales in the Pacific Northwest spend most of their time along the outer coast of British Columbia and Washington, but visit inland waters in search of harbor seals, sea lions, and other prey. Transients may occur in inland waters in any month (Orca Network, 2015), but several studies have shown peaks in occurrence: Morton (1990) found bimodal peaks in spring (March) and fall (September to November) for transients on the northeastern coast of British Columbia, and Baird and Dill (1995) found some transient groups frequenting the vicinity of harbor seal haulouts around southern Vancouver Island during August and September, which is the peak period for pupping through post-weaning of harbor seal pups. However, not all transient groups were seasonal in these studies and their movements appeared to be unpredictable. During the period 2004–2010, transient killer whales occurred in Washington inland waters most frequently in August–September with a strong second peak in April–May (Houghton et al., 2015)

The number of West Coast Transient killer whales in Washington inland waters at any one time was considered likely to be fewer than 20 individuals (Wiles, 2004). Recent research suggests that the transient killer whales use of inland waters increased from 2004 through 2010, with the trend likely due to increasing prey abundance (Houghton et al., 2015). Many of the West Coast Transients in Washington inland waters have been catalogued by photo identification.

4.1.3 Site-Specific Occurrence

Transient killer whales were observed for lengthy periods in Hood Canal (Figure 1-1) in 2003 (59 days) and 2005 (172 days) between the months of January and July (London, 2006), but were not observed again until March 2016 (Orca Network, 2016). Transient killer whales were observed in Hood Canal on 2 days in March 2016, 1 day in April, 8 consecutive days in May 2016, 1 day in 2017, 11 consecutive days in April 2018, and 1 day on two additional occasions in 2018. Some of the sightings in 2016 and 2018 were in Dabob Bay (Orca Network, 2017, 2019). Killer whales were historically documented in Hood Canal by sound recordings in 1958 (Ford, 1991), a photograph from 1973, sound recordings in 1995 (Unger, 1997), and anecdotal accounts of historical use. Long-term use of Hood Canal is likely anomalous, and the more typical use of Hood Canal appears to be short-term occupancy for foraging in a small area, followed by departure from Hood Canal.

West Coast Transient killer whales most often travel in small pods of up to four individuals (Baird & Dill, 1996). Houghton et al. (2015) reported that the group size most often observed in the Salish Sea was four whales for 2004–2010, is larger than the size most often observed from 1987–1993, and that group size appeared to be increasing from 2004–2010. According to unpublished data (Houghton, 2012), the most commonly observed group size in Puget Sound[5] from 2004 to 2010 was 6 whales (mode = 6, mean = 6.88).

4.2 Harbor Porpoise

4.2.1 Status and Management

Harbor porpoises are protected under the MMPA, but not listed under the ESA. NMFS conservatively recognizes two stocks in Washington waters: the Oregon/Washington Coast stock and the Washington Inland Waters stock (Carretta et al., 2013). Individuals from the Washington Inland Waters stock are expected to occur in Puget Sound.

4.2.2 Distribution

In Washington Inland waters, harbor porpoise are known to occur in the Strait of Juan de Fuca and the San Juan Island area year-round (Calambokidis & Baird, 1994; Osmek et al., 1996; Carretta et al., 2012). Harbor porpoises were historically one of the most commonly observed marine mammals in Puget Sound (Scheffer & Slipp, 1948); however, there was a significant decline in sightings beginning in the 1940s (Everitt et al., 1979; Calambokidis et al., 1992). Only a few sightings were reported between the 1970s and 1980s (Calambokidis et al., 1992; Osmek et al., 1996; Suryan & Harvey, 1998), and no harbor porpoise sightings were recorded during multiple ship and aerial surveys conducted in Puget Sound (including Hood Canal) in 1991 and 1994 (Calambokidis et al., 1992; Osmek et al., 1996). Incidental sightings of marine mammals during aerial bird surveys conducted as part of the Puget Sound Ambient Monitoring Program (PSAMP) detected few harbor porpoises in Puget Sound between 1992 and 1999 (Nysewander et al., 2005). However, these sightings may have been negatively biased due to the low elevation of the plane that may have caused an avoidance behavior. Since 1999, PSAMP data, stranding data, and aerial surveys conducted from 2013 to 2015 documented increasing numbers of harbor porpoise in Puget Sound (Nysewander, 2005; WDFW, 2008; Jeffries, 2013; Jefferson et al., 2016; Smultea et al., 2017).

4.2.3 Site-Specific Occurrence

Sightings in Hood Canal (Figure 1-1) north of the Hood Canal Bridge have increased in recent years (Calambokidis, 2010). During line-transect vessel surveys conducted in the Hood Canal in 2011 for the Test Pile Program near NAVBASE Kitsap Bangor and Dabob Bay (HDR, 2012), an average of six harbor porpoises were sighted per day in the deeper waters. Group sizes ranged from 1 to 10 individuals (HDR, 2012). Raum-Suryan and Harvey (1998) reported a mean group size of 1.9 (range 1–8 individuals) in the San Juan Islands. Aerial surveys conducted throughout 2013 to 2015 in Puget Sound indicated density in Puget Sound was 0.91 individuals/sq km) (95% CI = 0.72–1.10, all seasons pooled) and density in

[5] Puget Sound is defined as waters east of Admiralty Inlet (including Hood Canal) through South Puget Sound and north to Skagit Bay.

Hood Canal was 0.44/sq km (95% CI = 0.29–0.75, all seasons pooled) (Smultea et al., 2017). Mean group size of harbor porpoises in Puget Sound in the 2013–2015 surveys was 1.7 in Hood Canal.

4.3 Steller Sea Lion

4.3.1 Status and Management

In the North Pacific, NMFS has designated two Steller sea lion stocks: (1) the Western U.S. stock consisting of populations at and west of Cape Suckling, Alaska (144 degrees W longitude) and (2) the Eastern U.S. stock, consisting of populations east of Cape Suckling, Alaska. The Western U.S. stock is listed as depleted under the MMPA and endangered under the ESA. Although there is evidence of mixing between the two stocks (Jemison et al., 2013), animals from the Western U.S. stock are not present in Puget Sound. Individuals that occur in Puget Sound are of the Eastern Distinct Population Segment (Allen & Angliss, 2013). The Eastern Distinct Population Segment (stock) was removed from listing under the ESA in 2013 because it was stable or increasing throughout the northern portion of its range (Southeast Alaska and British Columbia) and stable or increasing slowly in the central portion of its range (Oregon through northern California) (78 FR 66140, NMFS, 2012). Critical habitat has been designated for the Steller sea lion (58 FR 45269); however, there is no designated critical habitat for the species in Washington State.

4.3.2 Distribution

The Eastern U.S. stock of Steller sea lions is found along the coasts of southeast Alaska to northern California where they occur at rookeries and numerous haulout locations along the coastline (Jeffries et al., 2000; Scordino, 2006; NMFS, 2013). Along the northern Washington coast, up to 25 pups are born annually (Jeffries, 2013). Male Steller sea lions often disperse widely outside of the breeding season from breeding rookeries in northern California (St. George Reef) and southern Oregon (Rogue Reef) (Scordino, 2006; Wright et al., 2010). Based on mark recapture sighting studies, males migrate back into these Oregon and California locations from winter feeding areas in Washington, British Columbia, and Alaska (Scordino, 2006).

In Washington, Steller sea lions use haulout sites primarily along the outer coast from the Columbia River to Cape Flattery, as well as along the Vancouver Island side of the Strait of Juan de Fuca (Jeffries et al., 2000). A major winter haulout is located in the Strait of Juan de Fuca at Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) (Edgell & Demarchi, 2012). Numbers vary seasonally in Washington with peak numbers present during the fall and winter months and a decline in the summer months that corresponds to the breeding season at coastal rookeries (approximately late May to early June) (Jeffries et al., 2000). In Puget Sound, Jeffries (2012) identified five winter haulout sites used by adult and subadult (immature or pre-breeding animals) Steller sea lions, ranging from immediately south of Port Townsend (near Admiralty Inlet) to Olympia in southern Puget Sound (see Figure 4-1). Numbers of animals observed at these sites ranged from a few to less than 100 (Jeffries, 2012). In addition, Steller sea lions opportunistically haul out on various navigational buoys in Admiralty Inlet south through southern Puget Sound near Olympia (Jeffries, 2012). Typically, one or two animals occur at a time on these buoys.

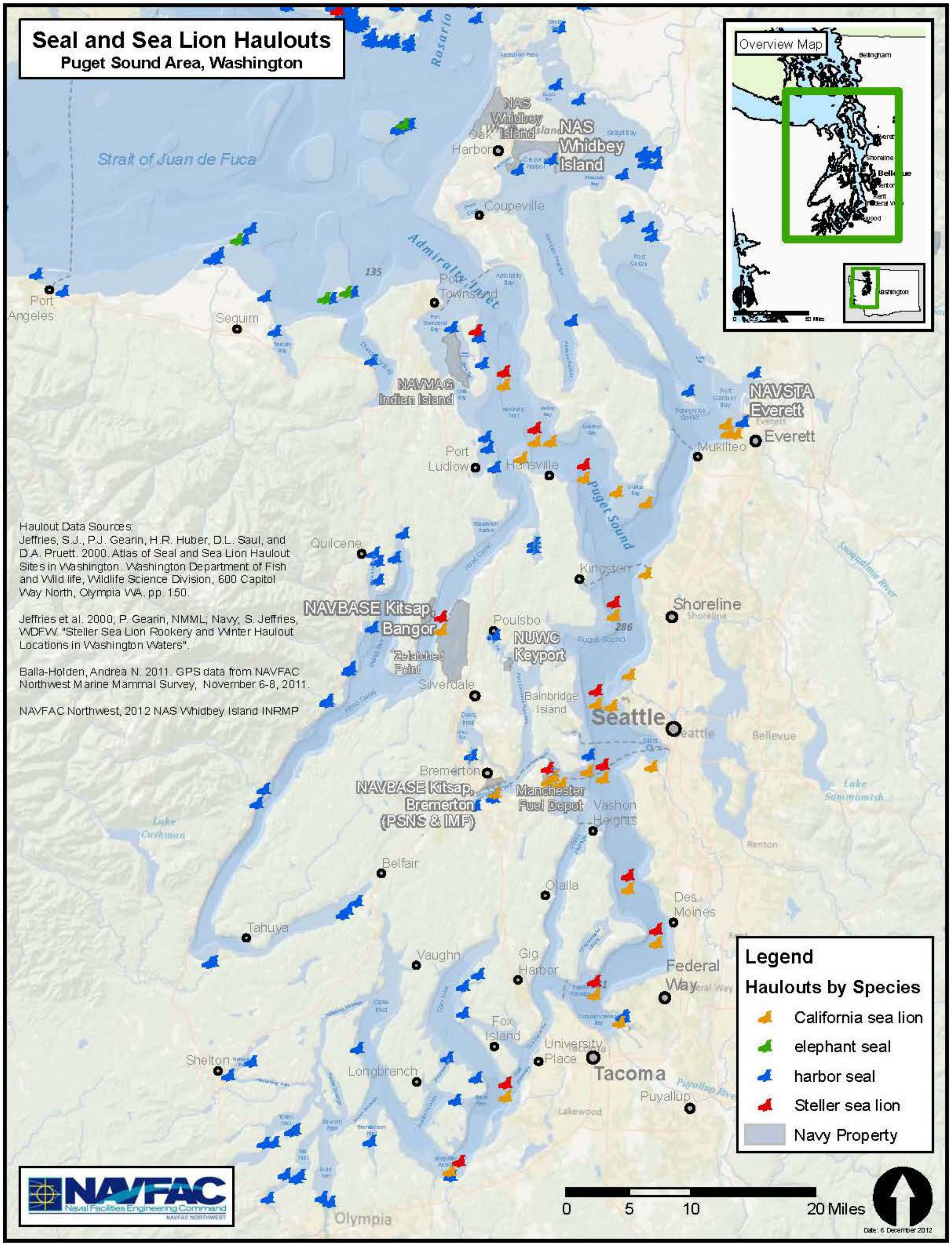

Figure 4-1. Pinniped Haulouts in Puget Sound

4.3.3 Site-Specific Occurrence

The Navy conducts surveys at haulouts at NAVBASE Kitsap Bangor (Figure 4-1). Survey methods and frequency are detailed Appendix A.

Steller sea lions have been seasonally documented in shore-based surveys at NAVBASE Kitsap Bangor in Hood Canal since 2008 with up to 15 individuals observed hauled out on submarines at Delta Pier (Figure 4-2) (Navy, 2016, 2019). Surveys at NAVBASE Kitsap Bangor indicate Steller sea lions begin arriving in September and depart by the end of May (Navy, 2016, 2019).

4.4 California Sea Lion

4.4.1 Status and Management

California sea lions are protected under the MMPA and are not listed under the ESA. NMFS has defined one stock for California sea lions (U.S. Stock), with five genetically distinct geographic populations: (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California. The Pacific Temperate population includes rookeries within U.S. waters and the Coronados Islands just south of the U.S./Mexico border. Animals from the Pacific Temperate population range north into Canadian waters, and movement of animals between U.S. waters and Baja California waters has been documented (Carretta et al., 2013).

4.4.2 Distribution

During the summer, California sea lions breed on islands from the Gulf of California to the Channel Islands and seldom travel more than about 31 miles from the islands. The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente. Their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability. In the nonbreeding season, adult and subadult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island, and return south in the spring. They are occasionally sighted hundreds of miles offshore. Primarily male California sea lions migrate into northwest waters with most adult females with pups remaining in waters near their breeding rookeries off the coasts of California and Mexico. Females and juveniles tend to stay closer to the rookeries. California sea lions also enter bays, harbors, and river mouths and often haul out on man-made structures such as piers, jetties, offshore buoys, and oil platforms.

4.4.3 Site-Specific Occurrence

Jeffries et al. (2000) and Jeffries (2012) identified dedicated, regular haulouts used by adult and subadult California sea lions in Washington inland waters (Figure 4-1). Main haulouts occur at NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, and Naval Station (NAVSTA) Everett, as well as in Rich Passage near Manchester, Seattle (Shilshole Bay), south Puget Sound (Commencement Bay, Budd Inlet), and numerous navigation buoys south of Whidbey Island to Olympia in south Puget Sound (Jeffries et al., 2000; Jeffries, 2012) (Figure 4-1). Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) has been identified as a major winter haulout for California sea lions (Edgell & Demarchi, 2012).

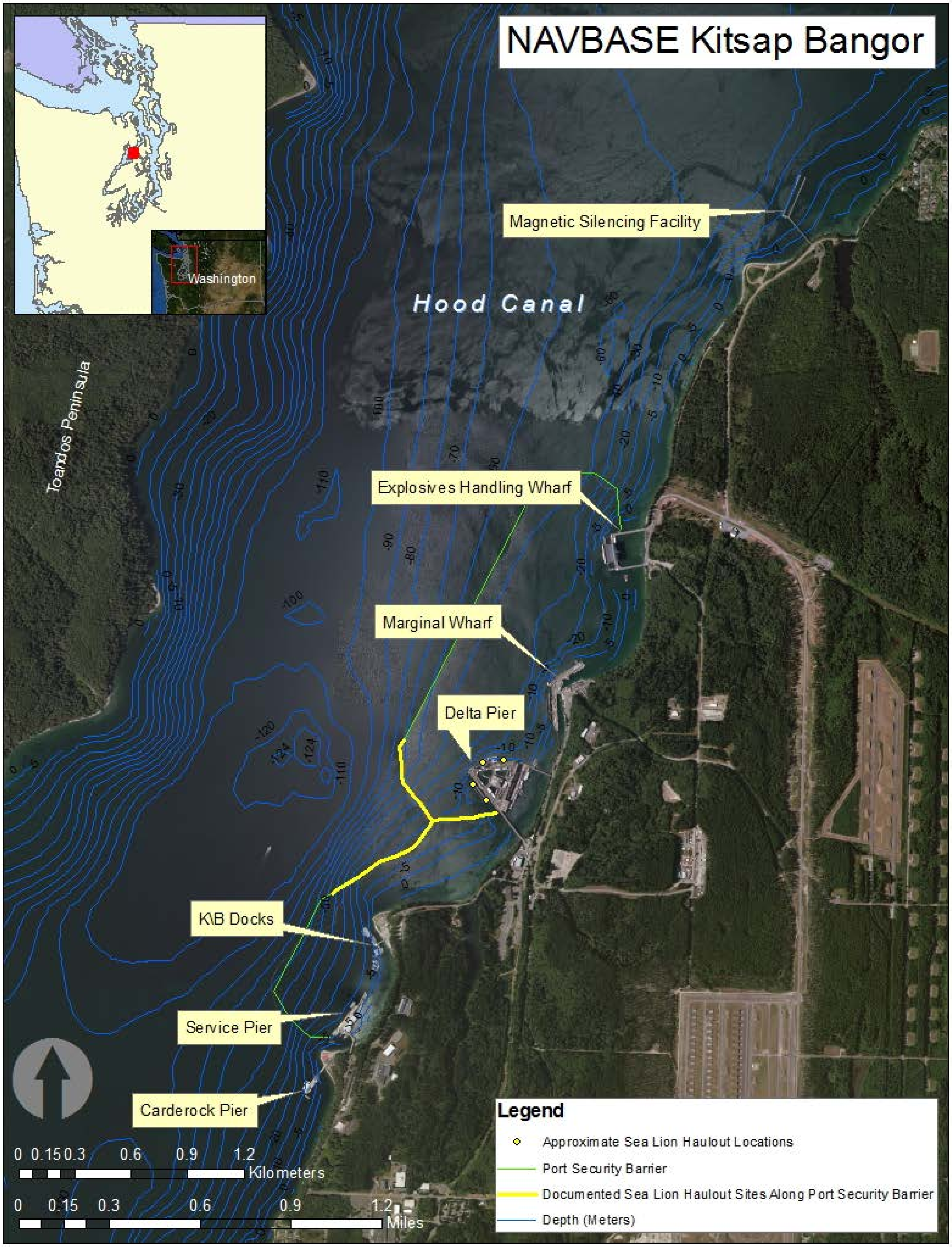

Figure 4-2. Pinniped Haulouts at NAVBASE Kitsap Bangor

California sea lions are typically present most of the year except for mid-June through July in Washington inland waters, with peak abundance numbers between October and May (NMFS, 1997; Jeffries et al., 2000). California sea lions would be expected to forage within the area, following local prey availability. During summer months and associated breeding periods, the inland waters would not be considered a high-use area by California sea lions, as they would be returning to rookeries in California waters. However, California sea lions have been documented during shore-based surveys at NAVBASE Kitsap Bangor in Hood Canal since 2008 in all survey months, with as many as 320 individuals observed at one time (October 2018) hauled out on submarines at Delta Pier and on port security barrier (PSB) floats (Figure 4-2) (Navy, 2016, 2019; Appendix A). Relatively few individuals (<17 sighted per survey) were present during these surveys from June through August.

4.5 Harbor Seal

4.5.1 Status and Management

Harbor seals are not listed as depleted under the MMPA, nor are they listed under the ESA.

Three stocks occur in Washington's inland waters:

- Hood Canal
- Northern Inland Waters
- Southern Puget Sound stocks

Based on radiotelemetry results, interchange between inland and coastal stocks is unlikely (Jeffries et al., 2003).

4.5.2 Distribution

Harbor seals are a coastal species, rarely found more than 12 miles from shore, and frequently occupy bays, estuaries, and inlets (Baird, 2001). Individual seals have been observed several miles upstream in coastal rivers (Baird, 2001). Ideal harbor seal habitat includes haulout sites, areas providing shelter during breeding periods, and areas with sufficient food (Bjørge, 2002). Haulout areas can include intertidal and subtidal rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and man-made structures such as log booms, docks, and recreational floats (Wilson, 1978; Prescott, 1982; Schneider & Payne, 1983, Gilbert & Guldager, 1998; Jeffries et al., 2000; Lambourn et al., 2010). Harbor seals do not make extensive pelagic migrations, though some long distance movement of tagged animals in Alaska (108 miles) and along the U.S. west coast (up to 342 miles) have been recorded (Brown & Mate, 1983; Womble & Gende, 2013). Harbor seals have also displayed strong fidelity to haulout sites.

Harbor seals are the most common, widely distributed marine mammal found in Washington marine waters and are frequently observed in the nearshore marine environment. They occur year-round and breed in Washington. Numerous harbor seal haulouts occur in Washington inland waters (Figure 4-2). Haulouts include intertidal and subtidal rock outcrops, beaches, reefs, sandbars, log booms, and floats. Numbers of individuals at haulouts range from a few to between 100 and 500 individuals (Jeffries et al., 2000).

4.5.3 Site-Specific Occurrence

Harbor seals are expected to occur year-round at NAVBASE Kitsap Bangor. In Hood Canal, where NAVBASE Kitsap Bangor is located, known haulouts occur on the west side of Hood Canal at the mouth of the Dosewallips River and on the western and northern shorelines in Dabob Bay located approximately 8 miles away from the Navy's installation (Figure 4-1). Vessel-based surveys conducted from 2007 to 2010 at NAVBASE Kitsap Bangor, observed harbor seals in every month of surveys (Agness & Tannenbaum, 2009; Tannenbaum et al., 2009, 2011). Harbor seals were routinely seen during marine mammal monitoring for two construction projects, the Test Pile Project and EHW-2 construction projects (HDR, 2012; Hart Crowser, 2013, 2014, 2015). Small numbers of harbor seals have been documented hauling out on the PSB floats, wavescreens at Carderock Pier, buoys, barges, marine vessels, and logs (Agness & Tannenbaum, 2009; Tannenbaum et al., 2009, 2011; Navy, 2016) and on man-made floating structures near K/B Dock and Delta Pier. Incidental surveys by a NAVFAC biologist in August and September 2016 recorded as many as 28 harbor seals hauled out under Marginal Wharf or swimming in adjacent waters. On two occasions, four to six individuals were observed hauled out near Delta Pier.

Past IHA applications for NAVBASE Kitsap Bangor indicated a few observations of harbor seal births or neonates. In 2014, the Navy's knowledge of harbor seal births increased due to increased pinniped surveys on the waterfront and increased contact with waterfront personnel who have had lengthy careers at Bangor (Navy, 2016). Known harbor seal births include one on the Carderock wave screen in August 2011 and at least one on a small 10- by 10-foot floating dock at EHW-2 in fall 2013, as reported by EHW-2 construction crews, and afterbirth observed on a float at Magnetic Silencing Facility with an unknown date. In addition, Navy biologists learned that harbor seal pupping has occurred on a section of the Service Pier since approximately 2001, according to the Port Operations vessel crews. Harbor seal mother and pup sets were observed in 2014 hauled out on the Carderock wavescreen and swimming in nearby waters, and swimming near Delta Pier (Navy, 2016).

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 MMPA, the Navy requests an IHA 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, the Navy requests an IHA for takes of marine mammals listed in Table 5-1. The IHA inclusive dates for the project will be July 16, 2021 to July 15, 2022, with pile driving occurring from July 16, 2021 to January 15, 2022. The Navy anticipates that pile driving will not be completed by the end of the first year and a second in-water work window will be required to complete the project. Therefore, the Navy is requesting a second IHA inclusive of the dates July 16, 2022 to July 15, 2023. It is expected that ten 24” inch steel fender and ten 30” steel guide piles will need to be installed during the second year, however any work not completed during this period will be completed during the following in-water work window, July 16, 2022 to January 15, 2023. The marine mammal takes listed in Table 5-1 are requested for both in-water work periods, that is, from July 16, 2021 to January 15, 2022, and from July 16, 2022 to January 15, 2023, if needed. Table 5-2 and Table 5-3 list estimated takes by year.

Table 5-1. Total Underwater Exposure Estimates by Species

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	1,944
Steller sea lion	0	360
California sea lion	0	4,410
Harbor seal	90	3,150

Table 5-2. Underwater Exposure Estimates by Species July 16, 2021 to July 15, 2022

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	1,728
Steller sea lion	0	320
California sea lion	0	4,320
Harbor seal	90	2,800

Table 5-3. Total Underwater Exposure Estimates by Species July 16, 2022 to July 15, 2023

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	216
Steller sea lion	0	40
California sea lion	0	540
Harbor seal	0	350

Except with respect to certain activities not pertinent here, the MMPA 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] (50 CFR, Part 216, Subpart A, Section 216.3 Definitions).

5.2 Method of Incidental Taking

This authorization request considers noise from vibratory and impact pile installation as outlined in Section 1 that has the potential to disturb or displace marine mammals or produce a temporary shift in their hearing ability (temporary threshold shift [TTS]) resulting in Level B harassment as defined above. Impact pile driving of steel pile has the potential to produce a permanent shift in the ability of harbor seals to hear, resulting in Level A harassment. Level A harassment is only requested where the zones are too large to fully monitor for this small resident species. Level A harassment will be minimized to the extent practicable given the methods of installation and measures designed to minimize the possibility of injury to marine mammals. First, vibratory pile drivers will be the primary method of steel support pile installation. Vibratory pile drivers also have relatively low sound levels (<180 dB re 1 µPa at 10 meters) and are not expected to cause injury to marine mammals. Second, impact driving of steel piles will not occur without a noise attenuation measure (such as a bubble curtain or other attenuating device) in place, and all pile driving will either not start or be halted if marine mammals approach the Level A injury zone ("shutdown zone") or, for harbor seals, a shutdown zone that encompasses the Level A injury zone to the extent practicable.

The TPP Pier is not anticipated to affect the prey base or significantly affect other habitat features of marine mammals that would meet the definition of take. To minimize, to the extent practicable, Level B harassment of cetaceans, the Navy will implement a shut-down of pile driving if whales or porpoises are seen entering a monitoring zone. This measure is intended to avoid exposure to any harassment. See Section 11 for more details on the impact reduction and mitigation measures proposed.

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 will temporarily increase the local underwater and airborne noise environment near the TPP project area. Research suggests that increased noise may impact marine mammals in several ways depending on many factors, as detailed in Section 7. 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 project described in Section 1 of this application is not expected to result in Level A exposure of marine mammals as defined under the MMPA. However, the noise-related impacts discussed in this application may result in Level B harassment. Impact pile driving could result in Level A and Level B exposure of marine mammals as defined under the 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 and 6.3);
- Evaluating potential presence of each species at NAVBASE Kitsap Bangor based on historical occurrence, density, or by site-specific survey as outlined in Section 6.4; 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).

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 similar to those that would be used for this project 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)*	*Reference*
Dredging	1–500	161–186 dB RMS re: 1 µPa at 1 meter	Richardson et al., 1995; DEFRA, 2003; Reine et al., 2014
Small vessels	860–8,000	141–175 dB RMS 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^2sec SEL at 1 meter	McKenna, 2011
Tug docking gravel barge	200–1,000	149 dB at 100 meters	Blackwell and Greene, 2002

Key: dB re 1 µPa @ 1 m = decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 meter; Hz = hertz; RMS = root mean square; SEL = sound exposure level

In-water construction activities associated with the proposed project 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 (Richardson et al., 1995; Southall et al., 2007), 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 et al., 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 Vocalization and Hearing of Marine Mammals

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 (see Schusterman, 1981; Au, 1993; Wartzok & Ketten, 1999; Nachtigall et al., 2007; Reichmuth at al., 2013). 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.

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, 2018a). The guidance places marine mammals into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency 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 Project Areas

Functional Hearing Group	*Representative Species*[1]	*Functional Hearing Range*[2,]
Low-frequency cetaceans	Humpback whale, gray whale, minke whale	7 Hz to 35 kHz
Mid-frequency cetaceans	Killer whale	150 Hz to 160 kHz
High-frequency cetaceans	Harbor porpoise, Dall's porpoise	275 Hz to 160 kHz
Phocidae	Harbor seal	In-water: 50 Hz to 86 kHz In-air: 75 Hz to 30 kHz
Otariidae	California sea lion, Steller sea lion	In-water: 60 Hz to 39 kHz In-air: 50 Hz to 75 kHz

Key: Hz = hertz; kHz = kilohertz

Notes:

1. Gray whale, minke whale, and Dall's porpoise are added here only as reference; these species are not likely to be present in the activity area.
2. In-water hearing data is from NMFS, 2018a. In-air data is from Schusterman, 1981; Hemilä et al., 2006; Southall et al., 2007.

6.4 Sound Exposure Criteria and Thresholds

Under the MMPA, NMFS has defined levels of harassment for marine mammals. Level A harassment is defined as, "Any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as, "Any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering."

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 (including behavioral disturbance and TTS) harassment (NMFS, 2005) (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 (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	219 dB Peak[4] 183 dB SEL_{CUM}[7]	160 dB RMS
Mid-Frequency Cetaceans	Not applicable	198 dB SEL_{CUM}[7]	120 dB RMS	230 dB Peak[4] 185 dB SEL_{CUM}[7]	160 dB RMS
High-Frequency Cetaceans	Not applicable	173 dB SEL_{CUM}[7]	120 dB RMS	202 dB Peak[4] 155 dB SEL_{CUM}[7]	160 dB RMS
Otariidae (sea lions)	100 dB RMS (unweighted)	219 dB SEL_{CUM}[7]	120 dB RMS	232 dB Peak[4] 203 dB SEL_{CUM}[7]	160 dB RMS
Phocidae (harbor seal)	90 dB RMS (unweighted)	201 dB SEL_{CUM}[7]	120 dB RMS	218 dB Peak[4] 185 dB SEL_{CUM}[7]	160 dB RMS

Key: dB = decibels; Peak = peak pressure; PTS = permanent threshold shift; re 20 µPa = referenced to (re) 20 micro (µ) Pascal (Pa); RMS = root mean square; SEL_{CUM} = cumulative sound exposure level

Notes:

1. Airborne disturbance thresholds not specific to pile driver type.
2. Underwater RMS (dB RMS) and Peak (dB Peak) sound pressure have a reference value of 1 µPa. Cumulative sound exposure level (dB SEL_{CUM}) has a reference value of 1 μPa^2•secsecond.
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 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 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 (2018a) equates the onset of permanent threshold shift (PTS), which is a form of auditory injury, with Level A harassment under the MMPA and "harm" under the ESA, 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 (dB SEL_{CUM}) metrics and peak pressure (dB Peak) rather than the previously used dB RMS metric. Level B harassment is considered to occur when marine mammals are exposed to impulsive underwater sounds > 160 dB RMS re 1 µPa from impact pile driving and to non-impulsive underwater sounds >120 dB RMS re 1 µPa (NMFS, 2005) (Table 6-3). The onset of TTS is a form of Level B harassment under the MMPA and "harassment" under the ESA. 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 FR 1871). Construction-period airborne noise would have little impact to cetaceans because noise from airborne sources would not transmit as well underwater (Richardson et al., 1995); thus, noise would primarily be a problem for hauled-out pinnipeds near the project locations. The 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 re 20 µPa (unweighted) and for all other pinnipeds is 100 dB RMS re 20 µPa (unweighted).

6.5 Limitations of Existing Noise Criteria

The application of the 120 dB RMS 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 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 continuous industrial sounds such as drilling operations.[6]

To date, there is no research or data supporting a response by pinnipeds or odontocetes 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 re 1 µPa generally do not appear to induce strong behavioral responses.

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

[6] The 120 dB referenced at 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 (Richardson et al., 1995; Miller et al., 1999).

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 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). Miksis-Olds & Tyack (2009) showed that during increased noise manatees modified vocalizations differently depending on whether or not a calf was present.

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 Hz 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.

Based on the frequency overlap between noise produced by both vibratory and impact pile driving (10 Hz to 1.5 kHz), animals that remain in a project area during steel pile driving may be vulnerable to masking for the duration of pile driving (typically 2 hours or less intermittently over the course of a day depending on site and project). Energy levels of vibratory pile driving are less than half that of impact pile driving; therefore, the potential for masking noise would be limited to a small radius around a pile. The likelihood that vibratory pile driving would mask relevant acoustic signals for marine mammals is negligible. In addition, most marine mammal species that may be subject to masking are transitory within the project areas. The animals most likely to be at risk for vocalization masking are resident pinnipeds (harbor seals and sea lions around local haulout areas). 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). Given the relatively high source levels for most marine mammal vocalizations, the Navy has estimated that masking events would occur concurrently within the zones of behavioral harassment estimated for vibratory and impact pile driving (see Section 6.7.2, Underwater Noise from Pile Driving) and are therefore taken into account in the exposure analysis.

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 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. A standard sound propagation model was used to estimate the range from pile driving activity to various expected SPLs at potential project structures. This model follows a geometric propagation loss based on the distance from the driven pile, resulting in a 4.5 dB reduction in level for each doubling of distance from the source. In this model, the SPL at some distance away from the source (e.g., driven pile) is governed by a measured source level, minus the TL of the energy as it dissipates with distance. The TL equation is:

$$TL = 15\log_{10}\left(\frac{R_1}{R_2}\right)$$

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 degree to which underwater noise propagates away from a noise source is dependent on a variety of factors, most notably by the water bathymetry and presence or absence of reflective or absorptive conditions including the sea surface and sediment type. The TL model described above was used to calculate the expected noise propagation from both impact and vibratory pile driving, using representative source levels to estimate the zone of influence (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 NAVBASE Kitsap Bangor waterfront and other locations 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.

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

Pile Type	*Installation Method*	*Pile Diameter (inches)*	*RMS (dB re 1 μPa)*	*Peak (dB re 1 μPa)*	*SEL (dB re 1 μPa²•secsecond)*
Steel	Impact	36	194	211	181
	Vibratory	24	161	N/A	N/A
		30	166	N/A	N/A
		36	166	N/A	N/A

Source: Navy, 2015
Key: dB re 1 µPa = decibels referenced at 1 micropascal; N/A = not applicable; Peak = peak pressure; RMS = root mean square; SEL = sound exposure level

For the analyses that follow, the TL model described above was used to calculate the expected noise propagation from pile driving, using a representative source level (Table 6-4) to estimate the area exceeding the noise criteria. Distances to the PTS thresholds for 24-inch, 30-inch, and 36-inch steel piles with vibratory pile driving were calculated using the NMFS Companion User Spreadsheet (NMFS, 2018b), which incorporates the auditory weighting functions for each hearing group using a single frequency.

The NMFS spreadsheet was also used to calculate distances to the PTS thresholds for 36-inch steel piles with impact pile driving.

Impact pile driving will use bubble curtains to reduce source sound levels by approximately 8 dB, as described in Appendix B. Vibratory pile driving sound levels can be 20 to 30 or more decibels lower than impact driving sound levels and do not produce high peak amplitudes with fast rise times typical of steel pile driving. Therefore, bubble curtains are not used for vibratory pile driving.

Calculated distances to the underwater marine mammal injury (PTS onset) SEL thresholds for the various hearing groups are provided in Table 6-5, and distances to the peak PTS onset thresholds are provided in Table 6-6. Calculated distances to the underwater marine mammal behavioral noise thresholds are provided in Table 6-5 for impact pile driving and Table 6-7 for vibratory pile driving. Adjusted maximum distances are provided where the extent of noise reaches land prior to reaching the calculated radial distance to the threshold. Areas encompassed within the threshold (ZOI) were calculated using the location of a representative pile. Pile locations were chosen to model the greatest possible affected areas; typically, these locations would be at the seaward end of the pier. Figure 6-1 illustrates the extent and area of each ZOI for a pile representing the worst-case extent of noise propagation for steel piles (pile location farthest from the shore) for Level B behavioral disturbance, and Figure 6-2 illustrates the extent and area for ZOIs for Level A injury impacts.

6.8 Airborne Sound Propagation

Pile driving can generate airborne noise that could potentially result in disturbance to marine mammals (pinnipeds) that are hauled out or at the water's surface. As a result, the Navy analyzed the potential for pinnipeds hauled out or swimming at the surface to be exposed to airborne SPLs that could result in Level B behavioral harassment. The airborne noise threshold for behavioral harassment for all pinnipeds, except harbor seals, is 100 dB RMS re 20 µPa (unweighted) and for harbor seals is 90 dB RMS re 20 µPa (unweighted) (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). A spherical spreading loss model, assuming average atmospheric conditions, was used to estimate the distance to the 100 dB and 90 dB RMS re 20 µPa (unweighted) airborne thresholds. 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.

Table 6-5. Calculated Radial Distance(s) to Underwater Marine Mammal Impact Pile Driving Noise Thresholds and Areas Encompassed Within Threshold Distance—SEL_{CUM} and RMS Thresholds[1]

Pile Size and Type	*Injury (PTS Onset) Level A Pinnipeds*[2]		*Injury (PTS Onset) Level A Cetaceans*[2]			*Behavioral Disturbance Level B (160 dB RMS)*[3]	
	PW	**OW**	**LF**	**MF**	**HF**	*Radial Distance to Threshold*	*Area Encompassed by Threshold*[4]
36-in steel[5]	157.5 m	11.5 m	294 m	10.5 m	351 m	541 m	0.75 sq km

Key: dB = decibel; in = inch; m = meter; PTS = permanent threshold shift; RMS = root mean square; SEL_{CUM} = cumulative sound exposure level; sq km = square kilometer

Functional Hearing Groups: HF = high-frequency cetacean; LF = low-frequency cetacean; MF = mid-frequency cetacean; OW= otariid (sea lion); PW = phocid (harbor seal)

Notes:

1. Calculations based on threshold criteria shown in Table 6-3 and source levels shown in Table 6-4. Threshold distances and ensonified areas calculated for representative piles located at seaward ends of wharfs, intended to model a conservative scenario for pile driving.
2. Distances to injury (PTS) onset thresholds calculated using the NMFS Companion User spreadsheet (NMFS, 2018b) with default Weighting Factor Adjustment of 2.0.
3. Distances to behavioral disturbance thresholds calculated using practical spreading loss model.
4. Areas were adjusted wherever land masses are encountered prior to reaching the full extent of the radius around the driven pile.
5. Assumes 1,600 strikes/day. Bubble curtain will be used for 36-inch steel piles assuming 8 dB attenuation.

Table 6-6. Calculated Radial Distance(s) to Underwater Marine Mammal Impact Pile Driving—Peak PTS Thresholds[1]

Pile Size and Type	*Injury (PTS Onset) Level A, Pinnipeds*[1]*(m)*		*Injury (PTS Onset) Level A, Cetaceans*[1]*(m)*		
	PW	*OW*	*LF*	*MF*	*HF*
36-in steel[2]	1	0	1	0	12

Key: in = inch; m = meter; PTS = permanent threshold shift

Functional Hearing Groups: HF = high-frequency cetacean; LF = low-frequency cetacean; MF = mid-frequency cetacean; OW= otariid (sea lion); PW = phocid (harbor seal)

Notes:

1. Calculations based on peak threshold criteria shown in Table 6-3 and source levels in Table 6-4. Distances to peak PTS thresholds calculated using practical spreading loss model.
2. Bubble curtain will be used for steel piles assuming 8 dB attenuation for 36-inch piles.

Table 6-7. Calculated Radial Distance(s) to Underwater Marine Mammal Vibratory Pile Driving Noise Thresholds and Areas Encompassed Within Threshold Distance—SEL_{CUM} and RMS Thresholds[1]

Pile Size and Type	*Injury (PTS Onset) Level A Pinnipeds*[2]		*Injury (PTS Onset) Level A Cetaceans*[2]			*Behavioral Disturbance Level B (120 dB RMS)*[3]	
	PW	**OW**	**LF**	**MF**	**HF**	*Radial Distance to Threshold*	*Area Encompassed by Threshold*[4]
24-in steel[5]	12 m	1 m	20 m	2 m	30 m	5.4 km	26.1 sq km
30-in steel[5]	26 m	2 m	43 m	4 m	64 m	11.7 km	49.1 sq km
36-in steel[5]	26 m	2 m	43 m	4 m	64 m	11.7 km	49.1 sq km

Key: in = inch; km = kilometer; m = meter; PTS = permanent threshold shift; RMS = root mean square; SEL_{CUM} = cumulative sound exposure level; sq km = square kilometer

Functional Hearing Groups: HF = high-frequency cetacean; LF = low-frequency cetacean; MF = mid-frequency cetacean; OW= otariid (sea lion); PW = phocid (harbor seal)

Notes:

1. Calculations based on threshold criteria shown in Table 6-3. Threshold distances and ensonified areas calculated for representative piles located at seaward ends of pier, intended to model a conservative scenario for pile driving.
2. Distances to the injury (PTS onset) thresholds calculated using NMFS Companion User spreadsheet (NMFS, 2018b) with default Weighting Factor Adjustment of 2.5. http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm).
3. Distances to the behavioral disturbance thresholds calculated using practical spreading loss model.
4. Areas were adjusted wherever land masses are encountered prior to reaching the full extent of the radius around the driven pile.
5. Daily pile driving duration for 24-inch, 30-inch, and 36-inch steel piles estimated at 5 hours.

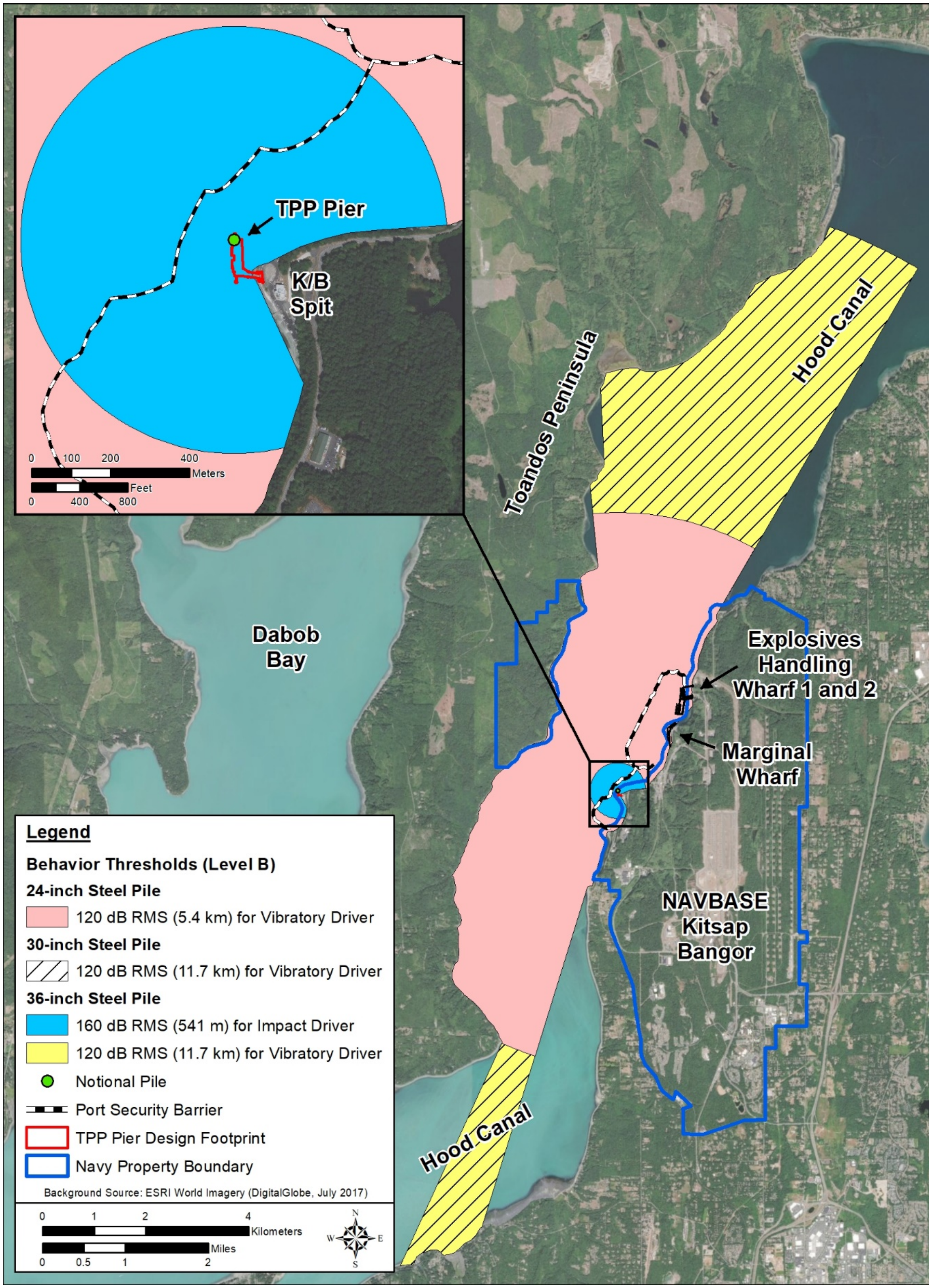

Figure 6-1. Representative Zones of Influence for Behavioral Disturbance of Marine Mammals due to Pile Driving Noise at NAVBASE Kitsap Bangor

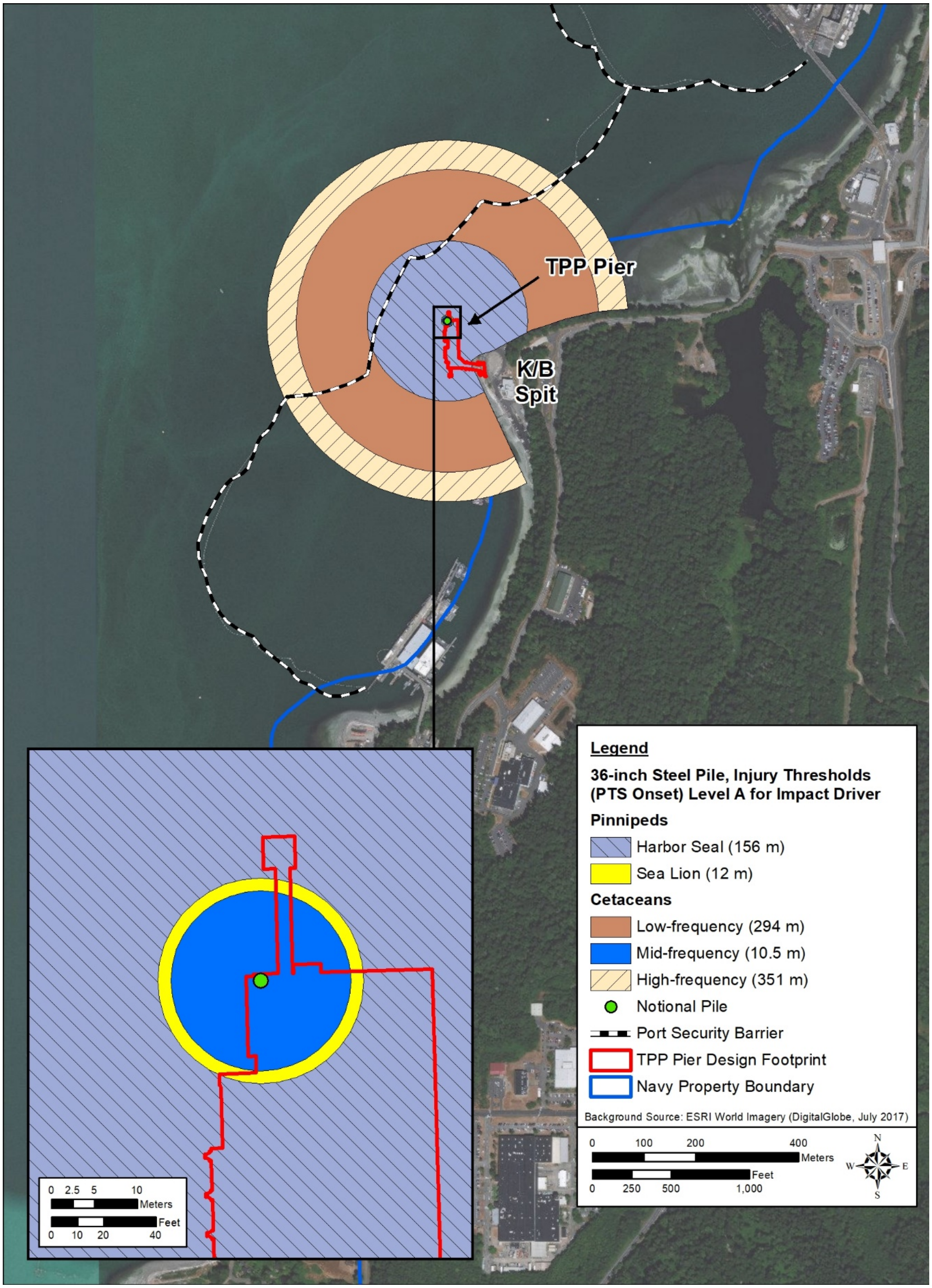

Figure 6-2. Representative Zones of Influence for Injury to Marine Mammals due to Pile Driving Noise at NAVBASE Kitsap Bangor

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 chosen based on a review of available pile driving in-situ recordings (see analysis in Appendix B). Available data were limited to steel pile installation (Table 6-8). The level of airborne noise from impact or vibratory pile driving of other pile types is anticipated to be quieter than the levels presented in Table 6-8.

Table 6-8. Airborne Sound Levels from Impact and Vibratory Pile Driving (dB)

Pile Type	Size (diameter in inches)	Installation Method: Impact RMS L_{max} Impact	Installation Method: Vibratory RMS L_{eq} Vibratory
Steel	24	110[1]	92[1]
	30	112[2]	95
	36	112	95

Source: Navy, 2015

Key: dB = decibels; L_{eq} = equivalent continuous sound level; L_{max} = maximum sound level; RMS = root mean square

Notes:

1. Limited data set
2. Data not available; assumes source level for 36-inch pile

The distances to the airborne harassment thresholds were calculated for steel pile impact and vibratory driving with the airborne TL formula. The distances to the pinniped airborne noise thresholds produced by the loudest pile installation method (impact installation of 36-in steel pipe), are shown in Table 6-9. Because these areas are smaller than the underwater behavioral threshold zones, a separate analysis of Level B take was not conducted for the airborne zones. Animals in the airborne zones would already have been exposed within a Level B underwater zone; therefore, no additional takes due to exposure to airborne noise are requested.

Table 6-9. Calculated and Measured Distances to Pinniped Behavioral Airborne Noise Thresholds

Pile Type	Installation Method	Pile Diameter (inches)	Harbor Seal Threshold = 90 dB RMS	Steller Sea Lion and California Sea Lion Thresholds = 100 dB RMS
Steel	Impact	36	189 m	60 m
	Vibratory	24	14 m	3 m
		30	Measured mean[1,3] = 33 m (51 m max) Calculated[2,3] = 27 m	Measured mean[1,3] = 10 m (16 m max) Calculated[2,3] = 8 m
		36	Measured mean[1] = 33 m (51 m max) Calculated[2] = 27 m	Measured mean[1] = 10 m (16 m max) Calculated[2] = 8 m

Key: dB = decibels; m = meter; RMS = root mean square

Notes:

1. Measured during EHW-2 construction, Illingworth & Rodkin, 2012
2. Calculated using spherical spreading model
3. No data available for 30-inch pile; assumes values for 36-inch pile

6.9 Estimated Duration of Pile Driving

The Navy is requesting two consecutive IHAs in order to complete the project. The IHA inclusive dates for the first year of the project will be July 16, 2021 to July 15, 2022, with pile driving occurring during the in-water work window July 16, 2021 to January 15, 2022. The dates for the second year will be July 16, 2022 to July 15, 2023, with pile driving occurring from July 16, 2022 to January 15, 2023. It is anticipated that the only in-water construction work that will remain at the end of the first in-water work window, January 15, 2022, would be installation of ten 24" fender and ten 30" guide piles using methods described in this IHA. However, any work not completed during the first year will be completed during the second year.

Pile driving is expected to take place during no more than 90 days between July 2021 and January 2023. For the purposes of this analysis, the most conservative pile driving production estimate of 90 days total is used, with an estimated 80 days of pile driving occurring during the first year and 10 days during the second year.

Vibratory pile drivers will be used to install a total of ten 24-inch steel fender piles, ten 30-inch steel guide piles, and forty 36-inch steel falsework piles in water. Additionally, one hundred 36-inch steel support piles for the trestle and pier will be installed with a vibratory driver, some of which will be proofed with an impact pile driver. Proofing at the end of vibratory installation will be conducted with an impact hammer for one of every three trestle piles and one of every four pier piles. Under expected conditions, impact pile strikes will not exceed 1,600 per construction day, or 45 minutes of impact driving, and vibratory installation of piles will not exceed 5 hours per construction day (Table 6-5).

Information from the EHW-2 construction project was reviewed to provide a general estimate of pile driving daily durations. Based on this review, the estimated median duration of impact and vibratory pile installation is summarized in Table 6-10. Navy geotechnical and engineering staff used data from a large wharf construction project in Hood Canal to estimate pile driving time and strikes needed to install steel piles using diesel hammers. Vibratory installation was estimated to take a median time of 10 minutes per pile with 45 minutes estimated as a maximum.[7] For steel piles that are "proofed" a median of 14 minutes per pile (approximately 600 strikes) was estimated.[8]

[7] Based on data from 501 piles installed at EHW-2, NAVBASE Kitsap Bangor, the median was 14 minutes/pile and the 95th percentile was 26 minutes/pile. Strike number estimates assumed an average estimated strike rate of 44 strikes per minute (or almost a strike every second and a half) rounded up from 3,960.

[8] Based on data from 399 piles installed with a vibratory hammer at EHW-2, NAVBASE Kitsap Bangor, the 95th percentile installation time was 57 minutes/pile.

Table 6-10. Pile Driving Duration Summary

Installation Method and Pile Type and Size	*Installation Rate*	*Estimated Duration*		
		Maximum/ Pile	*Maximum Daily Time*	*Estimated Maximum Strikes/Day*
Impact steel 24–30 inches[1]	1 to 4 piles/day	30 minutes	45 minutes	1,600
Vibratory steel 24–30 inches[2]	1 to 4 piles/day	60 minutes	5 hours	N/A

Key: N/A = not applicable

Notes:

1. Maximum based on data from 501 piles installed at EHW-2, NAVBASE Kitsap Bangor.
2. Maximum duration based on data from 809 piles installed at EHW-2, NAVBASE Kitsap Bangor.

6.10 Evaluation of Potential Species Presence

In prior Navy applications, either density data from the Navy Marine Species Density Database (Navy, 2015) or site-specific survey information has been used to quantify take. However, as described in Section 3.1, using a density-based analysis for species that occur intermittently does not adequately account for their unique temporal and spatial distributions.[9] For intermittently occurring species, historical occurrence and numbers as well as group size were reviewed to develop a realistic estimate of potential exposure. Therefore, potential exposure estimates in this application for species without a predictable occurrence are based on a historical likelihood of encounter. The transient killer whale is in this category for Hood Canal.

Harbor porpoise density data for Hood Canal were taken from aerial surveys reported in the literature (Smultea et al., 2017). Site-specific monitoring data are available for California sea lion, Steller sea lion, and harbor seal at NAVBASE Kitsap Bangor (Navy, 2016, 2019), allowing the calculation of installation-specific abundances (Appendix A).

6.11 Estimating Potential Exposures to Pile Driving Noise

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.

[9] Previously, a density-based exposure analysis was required for these species. The analyses often resulted in zero exposure estimates. Therefore, to obtain IHA 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 IHA applications for Puget Sound do not use a density estimate for marine mammal species with a low likelihood of occurrence.

Pinnipeds (seals and sea lions) spend significant amounts of time out of the water during breeding, molting, and hauling out periods. In the water, pinnipeds spend varying amounts of time underwater. California sea lions are known to rest at the surface in large groups for long amounts of time. 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 sea lions spend a portion of their time hauled out and, therefore, are expected to be exposed to less sound than is estimated by this approach.

To quantitatively assess exposure of marine mammals to noise levels from pile driving over the NMFS threshold guidance, one of three methods were used depending on the species spatial and temporal occurrence. For species with rare or infrequent occurrence during the in-water work window (transient killer whale), the likelihood of occurrence was reviewed based on the information in Section 3 and the potential maximum duration of work days and total work days. Based on this review, this species is not anticipated to linger for multiple days. Therefore, the duration of occurrence was set to 2 days, equivalent to a transit by a project site going one direction and then back. The calculation for transient killer whale was:

(1) Exposure estimate = Probable abundance during construction × 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 window. Assumed to be 4 days for transient killer whales.

For species that regularly occur in Hood Canal, but do not have site-specific abundances (i.e., harbor porpoise), density estimates were used to determine the number of animals potentially exposed in a ZOI on any one day of pile driving or extraction. The density estimate used for this analysis for harbor porpoise (0.44 per sq km) was reported by Smultea et al. (2017).

The equation for species likely to occur with only density estimates and no site-specific abundance was:

(2) Exposure estimate = (N × ZOI[10]) × maximum days of pile driving

where:

N = density estimate used for each species; and

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

For species with site-specific surveys available (Steller sea lion, California sea lion, and harbor seal), exposures were estimated by:

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

(3) Exposure estimate = Abundance × maximum days of pile driving

where:

Abundance = average monthly maximum over the time period when pile driving will occur.

Average monthly maximum counts of Steller sea lions and California sea lions (see Appendix A for abundance data of these species) were averaged over the in-water work window. The maximum number of animals observed during the month(s) with the highest number of animals present on a survey day was used in the analysis.

The following assumptions were used to calculate potential exposures to impact and vibratory pile driving noise for each threshold:

- For formulas (2) and (3), each species will be present in the project area each day during construction. 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 36-inch steel piles creates the largest ZOI, the exposure analysis calculates marine mammal exposures based on 36-inch steel piles.
- All piles will have an **underwater** noise disturbance distance 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 steel piles would be installed.
- All piles will have an **airborne** noise disturbance distance equal to the pile that causes the greatest noise disturbance (i.e., the pile furthest from shore) installed with the method that has the largest ZOI. The largest ZOI will be produced by impact driving. The ZOI for a vibratory hammer will be encompassed by the larger ZOI from the impact driver. Impact pile driving was assumed to occur on all days of pile driving. Exposures to airborne noise were considered included in the larger underwater ZOIs from vibratory or impact driving and were not calculated for pinnipeds.
- Days of pile driving (Table 6-10) were conservatively based on a relatively slow daily production rate, but actual daily production rates may be higher, resulting in fewer actual pile driving days. The pile driving days listed in Table 6-10 are used solely to assess the number of days during which pile driving could occur if production was delayed due to equipment failure, safety, etc. In a real construction situation, pile driving production rates would be maximized when possible.

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 all marine mammals except harbor seals, because the injury zones are small enough to be fully monitored. Harbor seal Level A exposure will be limited to the smallest extent practicable. Therefore, Level A exposures were only calculated for harbor seals where the full extent of the injury zone could not be practicably monitored. The exposure assessment estimates the numbers of individuals potentially exposed to the effects of pile driving noise exceeding NMFS established thresholds. Results from acoustic impact exposure assessments should be regarded as conservative overestimates that are strongly influenced by limited marine mammal data, the assumption that marine mammals will be present during pile driving, and the assumption that the maximum number of piles will be installed.

6.12 Exposure Estimates

Exposure estimates for each species are discussed in the following sections and presented in Table 6-11, Table 6-12 and Table 6-13 Annual reporting requirements will provide details of how many actual and extrapolated animals of each species are exposed to noise levels considered potential Level A or Level B harassment.

Table 6-11. Total Underwater Exposure Estimates by Species

Species	*Level A*	*Level B*
Transient killer whale	0	24
Harbor porpoise	0	1,944
Steller sea lion	0	360
California sea lion	0	4,860
Harbor seal	90	3,150

Table 6-12. Underwater Exposure Estimates by Species July 16, 2021 to July 15, 2022

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	1,728
Steller sea lion	0	320
California sea lion	0	4,320
Harbor seal	90	2,800

Table 6-13. Total Underwater Exposure Estimates by Species July 16, 2022 to July 15, 2023

Species	*Level A*	*Level B*
Transient killer whale	0	12
Harbor porpoise	0	216
Steller sea lion	0	40
California sea lion	0	540
Harbor seal	0	350

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 Puget Sound. When possible and with the available data, this is discussed by species in the sections that follow.

The assumptions described above tend to produce highly conservative exposure estimates. For example, construction of Pier 6 at NAVBASE Kitsap Bremerton provides a contrast between estimated exposures and actual reported exposure of several marine mammal species. The Navy requested takes of three species (harbor seal, California sea lion, and Steller sea lion), but determined through monitoring that only a fraction of the requested number of harbor seals and California sea lions were actually potentially exposed to elevated noise levels. All exposures in that project were due to use of vibratory pile drivers.

6.12.1 Killer Whale, West Coast Transient Stock

Transient killer whales occasionally occur throughout Puget Sound but are rare in Hood Canal. In Puget Sound, they are typically observed in small groups with an average group size of six individuals (Houghton, 2012). Based on a low probability of occurrence in the project area during the in-water work window, the Navy used formula (1) described in Section 6.11 to calculate exposure to Level B noise levels for a group of six individuals over a total of 4 days, 2 each year The Navy requests incidental takes of up to 24 individuals from Level B harassment from underwater sound during pile driving for the TPP Pier. 24 individuals will account for two groups of average size in Puget Sound passing the project site twice each year or a single larger than average group passing once. Killer whales of any age, sex, or reproductive status would be exposed.

To protect transient killer whales from noise impacts, the Navy will implement a shutdown if killer whales are seen by marine mammal monitors in an injury or behavioral harassment zone (see mitigation measures in Section 11). A monitor will be stationed at locations from which the injury zone for impact pile driving is visible and will implement shutdown if a whale enters either zone; however, monitors would likely detect the killer whale within the behavioral harassment zone first. With the implementation of monitoring, even if a whale enters an injury zone, shutdown would occur before cumulative exposure to noise levels that would result in PTS could occur. Because pile driving will be shut down if whales are in the injury zone, no Level A take is requested. Any exposure of killer whales to pile driving noise will be minimized to short-term behavioral harassment in areas beyond the visually monitorable portion of the disturbance zone during vibratory pile driving and extraction.

6.12.2 Harbor Porpoise

Harbor porpoises may be present in all major regions of Puget Sound throughout the year. Group sizes ranging from 1 to 46 individuals were reported in aerial surveys conducted from summer 2013 to spring 2015 but mean group size was 2 animals (Smultea et al., 2017). The estimated harbor porpoise density in Hood Canal is 0.44 animals/per sq km (Smultea et al., 2017). Level B exposure estimates utilized formula (2). Given 90 days of pile driving, the largest ZOI calculated for pile driving, the Navy estimates takes for level B exposure of up to 1,944 harbor porpoises during construction of the TPP project. The Navy estimates that 1,728 harbor porpoises could be exposed during year one and 216 during year two. Animals of any age, sex, or reproductive status could be exposed to elevated underwater noise.

To protect harbor porpoises from noise impacts, the Navy will implement a shutdown if harbor porpoises are seen by marine mammal monitors in an injury or behavioral harassment zone (see mitigation measures in Section 11). A monitor will be stationed at locations from which the injury zone for impact pile driving are visible and will implement shutdown if a porpoise enters either zone; however, monitors would likely detect the harbor porpoise within the behavioral harassment zone first. With the implementation of monitoring, even if a porpoise enters an injury zone, shutdown would occur before cumulative exposure to noise levels that would result in PTS could occur. Because pile driving will be shut down if porpoises are in the injury zone, no Level A take is requested. Any exposure of harbor porpoises to pile driving noise will be minimized to short-term behavioral harassment in areas beyond the visually monitorable portion of the disturbance zone during vibratory pile driving.

6.12.3 Steller Sea Lion

Steller sea lions are routinely seen hauled out from mid-September through May on submarines at NAVBASE Kitsap Bangor, with a maximum haulout count of 15 individuals in November 2018. Because the daily average number of Steller sea lions hauled out at Bangor has increased since 2013 compared to prior years, the Navy relied on monitoring data from July 2012 through February 2019 to determine the average of the maximum count of hauled out Steller sea lions for each month in the in-water work window (Navy, 2016, 2019). Pinnipeds may haul out longer than the period required for pile driving and, thus, would not be exposed to underwater sound. However, the Navy conservatively assumes that any Steller sea lion that hauls out at Bangor may swim into the behavioral harassment zone each day during pile driving. The largest ZOI for behavioral disturbance (Level B) would be 11.7 km for vibratory driving and extraction of 36-inch steel piles. Therefore, the Navy estimates takes for the average of the monthly maximum counts during the in-water work window, which would be four exposures per day for an estimated 90 days of pile driving. These values provide a worst-case assumption that on all of the days of pile driving all animals would be in the water each day during pile driving. Applying formula (3) to this abundance and the pile driving days, the Navy estimates takes for exposure of up to 360 Steller sea lions during pile driving for the TPP Pier, with 320 occurring during year one and 40 occurring during year two If project work occurs during months when Steller sea lions are less likely to be present, or if daily pile driving duration is short, actual exposures would be less.

Mostly adult male Steller sea lions would exposed to elevated underwater noise. Animals could be exposed when traveling, resting, and foraging. Because the Level A injury zone can be effectively monitored, a shut-down zone will be implemented, and no exposure to Level A noise levels is anticipated.

6.12.4 California Sea Lion

California sea lions are routinely seen hauled out from August through June on the PSB floats and submarines at NAVBASE Kitsap Bangor. Because the daily average number of California sea lions hauled out at Bangor has increased since 2013 compared to prior years, the Navy relied on monitoring data from July 2012 through February 2019 to determine the average of the maximum count of hauled out California sea lions for each month during the in-water work window (Navy, 2016, 2019), for an average maximum count of 54 individuals. Pinnipeds may haul out longer than the period required for pile driving and, thus, would not be exposed to underwater sound. However, the Navy conservatively assumes that any California sea lion that hauls out at Bangor may swim into the behavioral harassment zone each day during pile driving. The largest ZOI for behavioral disturbance (Level B) would be 11.7 km for vibratory driving and extraction of 36-inch steel piles. Therefore, the Navy projects takes for the average of the monthly maximum counts during the in-water work window, which would be 54 exposures per day for an estimated 90 days of pile driving. These values provide a worst-case assumption that on all days of pile driving all animals would be in the water each day. Applying formula (3) to this abundance and the pile driving days, the Navy estimates takes for Level B exposure of up to 4,860 California sea lions with 4,320 occurring during year one and 540 occurring during year two.

If project work occurs during months when California sea lions are less likely to be present, or if daily pile driving duration is short, actual exposures would be less. Adult and subadult male California sea lions would be exposed to elevated underwater noise at NAVBASE Kitsap Bangor, as females and immatures do not migrate to Washington waters. Animals could be exposed when traveling, resting, and foraging. Because the Level A injury zone can be effectively monitored, a shut-down zone will be implemented, and no exposure to Level A noise levels is anticipated.

6.12.5 Harbor Seal

Harbor seals occur year-round in Hood Canal. The closest major haulouts to NAVBASE Kitsap Bangor that are regularly used by harbor seals are the mouth of the Dosewallips River located approximately 8.2 miles away. No harbor seal haulout have been seen on the shoreline opposite Bangor (the east-side of the Toandos Peninsula) during 2015 and 2016 beach seine surveys. A small haulout occurs at NAVBASE Kitsap Bangor under Marginal Wharf and small numbers of harbor seals are known to routinely haul out around the Carderock pier (Figure 1-2). Boat-based surveys and monitoring indicate that harbor seals regularly swim in the waters at NAVBASE Kitsap Bangor (Appendix A). Hauled-out adults, mother/pup pairs, and neonates have been documented occasionally but quantitative data are limited. Incidental surveys in August and September 2016 recorded as many as 28 harbor seals hauled out under Marginal Wharf or swimming in adjacent waters. Assuming a few other individuals may be present elsewhere on the Bangor waterfront, the Navy estimates that 35 harbor seals may be present during summer and early fall months. Based on haulout survey data from NAVSTA Everett (Navy, 2016), the number of harbor seals present at Bangor is likely to be lower in late fall and winter months.

Exposure of harbor seals to pile driving noise will be primarily in the form of short-term behavioral harassment (Level B). Formula (3) was used with site-specific abundance data to calculate potential exposures of harbor seals due to pile driving for the TPP Pier. Animals of any age, sex, or reproductive status could be exposed while traveling, resting, or foraging within the Level B ZOIs.

Pinnipeds may haul out longer than the period required for pile driving and, thus, would not be exposed to underwater sound. However, the Navy assumes that any harbor seal that hauls out at Bangor could swim into the behavioral harassment zone each day during pile driving. The largest ZOI for behavioral disturbance (Level B) would be 11.7 km for vibratory driving and extraction of 36-inch steel piles. Applying formula (3) to the abundance of this species (35 individuals) and the 90 pile driving days (Table 6-10), the Navy requests takes for Level B exposure of up to 3,150 harbor seals during pile driving for the TPP Pier (Table 6-11), with 2,800 occurring during year one and 350 occurring during year two (Table 6-12 and 6-13)

The largest ZOI for Level A injury will be 217 meters for impact driving of 36-inch steel piles (with bubble curtain) assuming 1,600 pile strikes per day. The presence of existing structures on the Bangor waterfront at K/B Spit and the TPP Pier, as construction progresses, may interfere with monitors' ability to observe the entire injury zone. Some individuals could enter, and remain in, the injury zone undetected by monitors, resulting in potential PTS. Marine mammal monitoring will be conducted and pile driving will be shut down in the event that harbor seals are detected within the injury zone. Nonetheless, because visibility may be obstructed during pile driving, some individual harbor seals may inadvertently be exposed to injurious noise levels during impact driving of steel piles. We estimate that one of the 35 individuals present on the Bangor waterfront would enter, and remain in, the injury zone without being detected by marine mammal monitors each day. Therefore, with 90 pile driving days and one individual per day being exposed to Level A noise levels, 90 Level A takes of harbor seals are requested. It should be noted that Level A takes of harbor seals would likely be multiple exposures of the same individuals, rather than single exposures of unique individuals. This request overestimates the likely Level A exposures because seals are unlikely to remain in the Level A zone underwater long enough to accumulate sufficient exposure to noise resulting in PTS, and the estimate assumes that new seals are in the Level A ZOI every day during pile driving. No Level A takes are requested for vibratory pile driving because the maximum harbor seal injury zone is 26 meters and is within a practicable shutdown distance. Therefore, all potential Level A takes would be expected to occur during the first year of the project since impact pile driving is not anticipated during the second year.

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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

The effects of pile driving noise on marine mammals are dependent on several factors, including the species, size of the animal, and proximity to the source; the depth, intensity, and duration of the pile driving sound; the depth of the water column; the substrate of the habitat; the distance between the pile and the animal; and the sound propagation properties of the environment. Impacts to marine mammals from pile driving activities are expected to result primarily from acoustic pathways. As such, the degree of effect is intrinsically related to the received level and duration of the sound exposure, which are in turn influenced by the distance between the animal and the source. In general, sound exposure should be less intense farther away from the source. The substrate and depth of the habitat affect the sound propagation properties of the environment. Shallow environments are typically more structurally complex, which leads to rapid sound attenuation. In addition, substrates that are soft (i.e., sand) will absorb or attenuate the sound more readily than hard substrates (rock) which may reflect the acoustic wave. Soft porous substrates will also likely require less time to drive the pile, and possibly less forceful equipment, which would ultimately decrease the intensity of the acoustic source.

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'Keefe & Young, 1984; Ketten, 1995; Navy, 2001).

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 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 TTSs 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). 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 and the conservative modeling assumptions discussed in Section 6, Level A harassment is not expected to any individuals, except potentially harbor seals during impact pile driving for the project. However, based on the continued presence of harbor seals near EHW-1 at NAVBASE Kitsap Bangor through multiple years of construction, no effect to the harbor seal population at NAVBASE Kitsap Bangor is expected. Therefore, auditory effects could be experienced by individual harbor seals, but will not cause population-level impacts or affect the continued survival of the species.

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, its auditory sensitivity, its biological and social status (including age and sex), and its 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 (Richardson et al., 1995; National Research Council, 2003; Wartzok et al., 2004; Southall et al., 2007). 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 and Symonds 2002; also see reviews in Gordon et al., 2004; Wartzok et al., 2004; and 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 dB RMS 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 two pinniped species 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 400–500 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. Several sea lions, however, were observed at distances of 500–1,000 meters swimming rapidly and porpoising away from pile driving activities. The reasons for these differences are not known, although Kastak and Schusterman (1998) reported that sea lions are more sensitive than harbor seals to underwater noise at low frequencies.

Observations of marine mammals on NAVBASE Kitsap Bangor during the 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, 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. Relatively few observations of cetacean behaviors were obtained during pile driving, and all were outside the Waterfront Restricted Area (WRA). Most harbor porpoises were observed swimming or traveling through the project area and no obvious behavioral changes were associated with pile driving.

A total of 3 years of marine mammal monitoring were completed to support vibratory and impact pile driving for the construction of EHW-2 (Hart Crowser, 2013, 2014, 2015). Over the 3 years of monitoring, harbor seals, California sea lions, and Steller sea lion were detected within the shut down and behavioral disturbance zones (Primary Surveys) and outside the WRA (Outside Boat Surveys). Results from monitoring have varied slightly year to year, but in general it has been found that marine mammals were equally observed moving away (or swimming parallel) from the pile or having no motion during vibratory pile driving. During impact driving, animals were most frequently observed moving away (or moving parallel to) or having no relative motion to the pile (Hart Crowser 2013, 2014, 2015). Harbor porpoises were only observed outside the WRA, where the predominant behavior during construction (vibratory pile driving) was swimming or traveling through the project area. During pre-construction monitoring, marine mammal observers also reported harbor porpoise foraging. Marine mammal observers did not detect adverse reactions to Test Pile Project or EHW-2 construction activities 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 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) (Integrated Concepts and Research Corporation, 2009). 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.

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.

7.1.2 Potential Effects Resulting from Airborne Noise

Marine mammals 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 MMPA. 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. 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 and 96 dB RMS, 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 PSB 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 impact zones may exhibit temporary behavioral reactions to airborne pile driving noise. These exposures may have a temporary effect on individual or groups of animals, but this level of exposure is very unlikely to result in population-level impacts.

7.2 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to increased SPLs during pile driving operations, which may result in Level B behavioral harassment and, for harbor seals, some Level A 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. For harbor seals, exposure to Level A harassment during impact driving of steel piles could result in a change in hearing thresholds permanently. To avoid permanent impacts to harbor seal hearing, a shut-down zone will be implemented that will encompass as much of the Level A zone as practicable. The sound generated from vibratory pile driving will not result in injury to marine mammals because the areas where injury could potentially occur are small, will be fully monitored, and pile driving will shut-down if marine mammals are seen approaching these zones. Mitigation is expected to avoid most potential adverse underwater impacts to marine mammals from impact pile driving. Nevertheless, some exposure is unavoidable. The expected level of unavoidable exposure (defined as acoustic harassment) is presented in Section 6. This level of effect is not anticipated to have any adverse impact to population recruitment, survival, or recovery.

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.

8.1 Subsistence Harvests by Northwest Treaty Indian Tribes

There are no known active ceremonial and/or subsistence hunts for marine mammals in Puget Sound, Hood Canal, or the San Juan Islands. Carretta et al. (2007) estimated annual subsistence takes of zero to two California sea lions. No data are available for the number of annual harbor seal subsistence takes (Carretta et al., 2015).

Potential impacts resulting from the Proposed Action will be limited to individuals of marine mammal species located in the marine waters near each NAVBASE Kitsap Bangor and will be primarily limited to Level B harassment. For all species, no population impacts will result from the Proposed Action. Therefore, no impacts to the availability of species or stocks for subsistence use are expected.

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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. Impacts will not result in permanent impacts to habitats used directly by marine mammals.

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 proposed project and surrounding areas encounter vessel traffic associated with both Navy and non-Navy activities. At Navy installations, vessels are used in day-to-day activities including security along the waterfront. Several studies have linked vessels with behavioral changes in killer whales in Pacific Northwest inland waters (Kruse, 1991; Kriete, 2002; Bain et al., 2006; Williams et al., 2006, 2009), although it is not well understood whether the presence and activity of the vessels, the vessel noise produced, or a combination of these factors produces the changes. The probability and significance of vessel and marine mammal interactions is dependent on several factors including numbers, types, and speeds of vessels; the regularity, duration, and spatial extent of activities; and the presence/absence and density of marine mammals.

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; Ng & Leung, 2003; Foote et al., 2004; Mocklin, 2005; Bejder et al., 2006; Nowacek et al., 2007). Some dolphin species approach vessels and are observed bow riding or jumping in the wake of vessels (Norris and 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 TPP 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 MMPA.

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 is expected to be negligible.

9.2 Impacts on 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. Effects to turbidity and sedimentation are expected to be short-term, minor, and localized. Turbidity will return to normal levels within minutes to hours after pile installation or removal. Turbidity and sedimentation levels are not anticipated to result in increases that are significant for marine mammals or their forage base. During pile installation and removal activities, suspension of anoxic sediment compounds could result in temporary, minor, localized reduced dissolved oxygen in the water column. However, if decreases occur, they would be minimal and localized and are not anticipated to result in levels that are significant for marine mammals or their forage base.

9.3 Impacts on Prey Base (Fish)

Pile installation and removal will impact marine habitats used by fish. Marine habitats used by fish species that occur in the TPP 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 injuries due to pile driving noise. Secondary impacts include benthic habitat displacement and re-suspension of sediments. The prey base for pinniped species in the project area includes a wide variety of pelagic and bottom fish, such as Pacific hake, Pacific herring, and salmonids. Harbor porpoise likely feed on schooling forage fish, such as Pacific herring, smelts, and squid. Transient killer whales in the Puget Sound prey on pinnipeds.

9.3.1 Underwater Noise Impacts on Fish

The greatest impact to marine fish during construction will occur during impact pile driving because pile driving will exceed the established underwater noise injury thresholds for fish. However, most piles will be installed with a vibratory driver; this method results in lower amplitude sound levels and is not typically associated with fish kills.

During pile driving, the associated underwater noise levels will have the potential to cause injury and could result in project area avoidance. To reduce potential effects to salmonids, including juvenile ESA-listed salmonids, the project will adhere to the in-water work window for pile extraction and installation. A bubble curtain, or another noise-attenuating device, will be deployed to reduce the underwater noise levels and associated impacts to underwater organisms during impact pile driving of steel piles. To further minimize the underwater noise impacts during steel pile driving, vibratory pile drivers will be used to the maximum extent practicable to drive piles. An impact hammer will be primarily used to verify load-bearing capacity or where piles cannot be advanced further with a vibratory driver due to hard substrate conditions.

Thus, prey availability for marine mammal predators within an undetermined portion of the affected areas could be reduced temporarily in localized areas during pile driving. However, with the minimization measures that will be implemented, the effect to the overall marine mammal fish forage base will be minimized. Therefore, adverse effects to the marine mammal prey base will be insignificant and will not rise to the level of MMPA take.

9.3.2 Impacts on Fish Habitats/Abundance

Pile installation and removal activities will adversely affect some habitat conditions for marine fish, including forage fish, in the project area. Positioning and anchoring the construction barges and driving and removing piles will locally increase turbidity, disturb benthic habitats, and potentially injure forage fish in the immediate project vicinities. Construction could bury benthic organisms with limited mobility under sediment. Increased turbidity could make it difficult for predators to locate prey. All of these actions will be temporary with sediments settling back soon after the cessation of activities, and will be localized to the immediate project area around piles. During construction, foraging and refuge habitat quality for prey species will be temporarily degraded over localized areas. In the long term, habitat in the footprint of the new pier will be degraded through effects on marine vegetation, the benthic community, and forage fish spawning habitat; migration by juvenile salmon and forage fish may be affected. However, the effect is expected to be insignificant to the overall forage base for marine mammals because the affected area will be small.

Impacts to salmonid and forage fish populations, including ESA-listed species, will be minimized by adhering to the designated in-water work period (July 16 to January 15). These work periods are designated when out-migrating juvenile salmonids are least likely to occur. Some fish habitat degradation is expected during construction and operation of the pier. However, the numbers of marine mammals affected by impacts to prey populations will be small; therefore, the impact will be insignificant in the context of marine mammal populations.

9.4 Likelihood of Habitat Restoration

The impacts of the Proposed Action on marine habitats will be compensated for through habitat enhancement actions designed and implemented under the Hood Canal Coordinating Council's In-Lieu Fee Program.

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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 activities are 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 TPP Pier 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 injury to fish species during pile driving. Information provided in Section 9 indicates there may be temporary impacts, but those impacts will be minimized through avoidance and mitigation measures and limited to the immediate area surrounding the TPP Pier. Impacts will cease upon the completion of construction of the TPP Pier.

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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

The Navy will employ the BMPs and minimization measures listed in this section to avoid and minimize impacts to marine mammals, their habitats, and forage species. BMPs, mitigation, and minimization measures are included in construction contract plans and specifications for individual projects and must be agreed upon by the contractor prior to any construction activities.

11.1 General Construction Best Management Practices

- To reduce the likelihood of any petroleum products, chemicals, or other toxic or deleterious materials from entering the water, fuel hoses, oil or fuel transfer valves, and fittings will be checked regularly for drips or leaks and will be maintained and stored properly to prevent spills from construction and pile driving equipment into state waters.
- To limit soil erosion and potential pollutants contained in stormwater runoff, a Storm Water Pollution Prevention Plan will be prepared and implemented for construction in conformance with the *Stormwater Management Manual for Western Washington* (WDOE, 2019) (also applies to Operations).
- Oil booms will be deployed around in-water construction sites, as required by the Clean Water Act Section 401 Water Quality Certification for the projects, to minimize water quality impacts during construction.
- Construction debris will be prevented from entering the water during all demolition or new construction work. During in-water construction activities, floating booms will be deployed and maintained to collect and contain floatable materials released accidentally. Any accidental release of equipment or materials will be immediately retrieved and removed from the water. Following completion of in-water construction activities, an underwater survey will be conducted to remove any remaining construction materials that may have been missed previously. Retrieved debris will be disposed of at an upland disposal site.
- To minimize impacts on marine habitats, limitations will be placed on construction vessel operations, anchoring, and mooring line deployment. A mooring and anchoring plan will be developed by the contractor and approved by the Navy to minimize vessel movement. Barge and other large construction vessel operations will be restricted to an area 100 feet to the west from the proposed pier. No large construction vessels will be allowed to operate to the east or north of the proposed pier to reduce potential temporary impacts to the marine aquatic environment. To provide access for construction workers, small skiffs will operate in a narrow band east, north, and south of the proposed pier. Anchoring in existing eelgrass habitat will be avoided whenever possible and vessel operators will be provided with maps of the construction area with eelgrass beds clearly marked to enable avoidance.
- To minimize impacts on marine habitats including eelgrass and macroalgae beds, a Sediment Management Plan will be developed and implemented to control the spread of silt from pile driving. At a minimum, this Plan will include the use of a floating silt curtain along the eastern portion of the

temporary work zone to prevent sediment re-suspended during construction activities from migrating onto adjacent eelgrass and macroalgae beds.

11.2 Timing Restrictions

To minimize the number of fish exposed to underwater noise and other construction disturbance, in-water work will occur during the in-water work windows when ESA-listed salmonids are least likely to be present (USACE, 2017). For NAVBASE Kitsap Bangor (waterfront) the period is July 16 to January 15.[11]

All in-water construction activities will occur during daylight hours (sunrise to sunset) except from July 16 to September 15 when impact pile driving will only occur starting 2 hours after sunrise and ending 2 hours before sunset, to protect foraging marbled murrelets during the nesting season (April 15–September 23). Sunrise and sunset are to be determined based on National Oceanic and Atmospheric Administration data found at http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html.

Non in-water construction activities could occur between 7:00 AM and 10:00 PM any time of the year.

11.3 Minimization Measures for Marine Mammals

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 shall 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 Acoustic Minimization Measures

- Vibratory installation will be used to the extent possible to drive steel support piles to minimize high SPLs associated with impact pile driving.
- A bubble curtain or other noise attenuation device that achieves an average of at least 8 dB of noise attenuation will be employed during impact installation or proofing of steel support piles where water depths are greater than 0.67 meters (2 feet). A noise attenuation device is not required during vibratory pile driving.
- If a bubble curtain or similar measure is used, it will distribute air bubbles around 100 percent of the pile perimeter for the full depth of the water column. Any other attenuation measure must provide 100 percent coverage in the water column for the full depth of the pile. The lowest bubble ring shall be in contact with the mudline for the full circumference of the ring. The weights attached to the

[11] The window required by the U.S. Army Corps of Engineers ends March 1 for salmon (USACE, 2017), and the bull trout window ends February 15, but the Navy observes an end date of January 15 to be protective of Endangered Species List-listed Hood Canal summer-run chum juvenile outmigrants.

bottom ring shall ensure 100 percent mudline contact. No parts of the ring or other objects shall prevent full mudline contact.

- A performance test of the noise attenuation device will be conducted prior to initial use for impact pile driving. If a bubble curtain or similar measure is utilized, the performance test shall confirm the calculated pressures and flow rates at each manifold ring. The contractor shall also train personnel in the proper balancing of air flow to the bubblers. The contractor shall submit an inspection/performance report to the Navy for approval within 72 hours following the performance test. Corrections to the noise attenuation device to meet the performance stands shall occur prior to use for impact driving.
- If USFWS concurs that turning off the noise attenuation will not negatively impact marbled murrelets, baseline sound measurements of steel pile driving will occur prior to the implementation of noise attenuation to evaluate the performance of a noise attenuation device. Impact pile driving without noise attenuation will be limited to the number of piles necessary to obtain an adequate sample size for each project.

11.3.3 Soft Start

The objective of a soft-start is to provide a warning and/or give animals in close proximity to pile driving a chance to leave the area prior to an impact driver operating at full capacity thereby, exposing fewer animals to loud underwater and airborne sounds.

- A 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 1 hour.
- The following soft-start procedures will be conducted:
  - The contractor will start the bubble curtain prior to the initiation of impact pile driving to flush fish from the zone near the pile where SPLs are highest.
  - The contractor will provide an initial set of strikes from the impact hammer at reduced energy, followed by a 30-second waiting period, then two subsequent sets. (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 Visual Monitoring and Shutdown Procedures

A marine mammal monitoring plan will be approved by NMFS prior to commencement of project activities. At a minimum, the plans will include the following:

- For all impact and vibratory pile driving, a shutdown and disturbance zone will be monitored.
- All disturbance and shutdown zones will initially be based on the distances from the source predicted for each threshold level.
- The shutdown zone will include all areas where the underwater SPLs are anticipated to equal or exceed the Level A (injury) criteria for marine mammals. The shutdown zone will always be a minimum of 10 meters (33 feet) to prevent injury from physical interaction of marine mammals with construction equipment. 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 SPLs are anticipated to equal or exceed the Level B (disturbance) criteria for marine mammals during impact pile driving. However, due to the large area of this zone and limited visibility due to structures such as the PSB, this zone may be reduced to a visually monitorable area in the final approved monitoring plan.
- If a cetacean is seen approaching or entering the injury zone or visually monitorable portion of the disturbance zone during impact or vibratory pile driving, pile driving will cease. Pile driving will cease if pinnipeds are detected in the injury zone. If a pinniped 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 visually monitorable portion of the disturbance zone, for pinnipeds and cetaceans, respectively, or 15 minutes have elapsed without re-detection of the animal.
- Monitoring will take place from 15 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 15 minutes to ensure that the zones are clear of marine mammals. Pile driving will only commence once observers have declared the shutdown zone clear of pinnipeds and the shutdown/visually monitorable behavior zones are clear of cetaceans.
- Visual monitoring will be conducted by qualified, trained marine mammal observers (hereafter "observer"). An observer 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.
- A trained observer 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 to the pile driver operator.
- 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 Data Collection

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

- 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

- 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 a different individuals are being taken.

11.3.6 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 the shutdown zone makes the likelihood of detecting a marine mammal in this zone extremely high.

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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 activities will not occur in the Arctic, and therefore will produce no adverse effects on the availability of species or stocks for Arctic subsistence hunting.

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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 each in-water work period covered by the IHA, the Navy will update NMFS on the progress of construction of the TPP facilities (bimonthly [September 15, November 15, and January 15]).

13.2 Monitoring Plan

To reduce impacts to marine mammals to the lowest extent practicable, a marine mammal monitoring plan will be approved by NMFS prior to the start of construction. A draft monitoring plan is provided in Appendix C. Final monitoring plans will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft plan from NMFS. Components of the monitoring plan are described in Section 11.3.4.

13.3 Reporting

A draft report will be submitted to NMFS within 90 work days of the completion of required monitoring for each in-water work window. 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 the NMFS within 30 days following receipt of comments on the draft report from the NMFS. The draft Marine Mammal Monitoring Plan (Appendix C) contains detailed reporting measures.

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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 U.S. 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 2013, the Navy has funded over $240M 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[12] 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

[12] https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/lmr.html

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 Puget Sound marine mammal monitoring activities and contracted studies are being conducted by the Navy outside of and in addition to the Navy's commitments to the NMFS under existing permits. To better understand marine mammal presence and habitat use in the Puget Sound Region, the Navy has funded and coordinated four major efforts, which are described in detail in Appendix A:

- **Puget Sound Pinniped Haulout Surveys at Specific Naval Installations:** Biologists conduct counts of seals and sea lions at NAVBASE Kitsap Bremerton, Bangor, Manchester, and NAVSTA Everett. Counts are conducted several times per month, depending on the installation. All animals are identified to species where possible. This information aids in determination of seasonal use of each site and trends in the number of animals.
- **Marine Mammal Vessel Surveys in Hood Canal and Dabob Bay:** The Navy conducted a marine mammal density survey in Hood Canal and Dabob Bay during September and October 2011 and again in October 2012 (HDR, 2012).
- **Aerial Pinniped Haulout Surveys:** The Navy funded and contracted the Washington Department of Fish and Wildlife to conduct aerial surveys of pinniped haulouts in all of Puget Sound and the Strait of Juan de Fuca out to Cape Flattery. NMFS Northwest Region funded the San Juan Islands Region. Collectively this information will be used to revise and update the 2000 Atlas of Seal and Seal Lion Haulouts in Washington State. The surveys began in 2013 and continued until spring 2014. Surveys included flyovers at NAVBASE Kitsap Bremerton and Manchester. The survey area did not cover the outer coast of Washington, only the inland waters.
- **Aerial Cetacean Surveys in Puget Sound (Admiralty Inlet and south):** The Navy has contracted aerial surveys of cetaceans in Puget Sound to better understand seasonality and distribution with the goal of improved density values. These surveys began in late 2013 and reports have been published (Jefferson et al., 2016; Smultea et al., 2017).

Overall, 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 NMFS from research and development efforts, and current research as previously described.

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Appendix A

Marine Mammal Surveys and Density and Abundance Determinations at Naval Installations in Puget Sound

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1 Introduction

The United States Department of the Navy (Navy) performs quantitative analyses to estimate the number of marine mammals that could be affected by at-sea training and testing activities. A key element of this quantitative impact analysis is knowledge of the abundance and concentration (density) of the species in specific areas where those activities will occur. The Navy's Marine Species Density Database (NMSDD) (Navy, 2015) reviews historical temporal and spatial distribution records and group size of marine mammals in Navy's Pacific 3rd and 7th Fleet's Area of Responsibility, which includes Puget Sound. This report includes a description of the currently available density data used in the quantitative impact analysis for marine species that may be impacted by the Navy's projects. The unit of metric for this type of analysis is density or the number of animals present per unit area.

However, some marine mammal species occur infrequently in the vicinity of shoreline construction projects, and using a density-based analysis for species that occur intermittently does not adequately account for their unique temporal and spatial distributions. For the transient killer whale, the historical likelihood of encounter at Naval Base (NAVBASE) Kitsap Bangor was used to develop a realistic estimate of potential exposure. The likelihood of exposure of individuals of this species to project impacts is discussed in Section 6.11 of this application.

Application of the density values in the NMSDD is appropriate for other species that occur regularly in the vicinity of NAVBASE Kitsap Bangor, in cases where there are no more comprehensive site-specific survey data, such as harbor porpoise.

In locations where marine mammals congregate, density-based analyses tend to under-estimate impacts because density values assume even distribution of individuals over the region. To remedy this, the Navy has conducted site-specific haulout surveys to help estimate abundances, as opposed to density, of pinnipeds that haul out at or near several Navy installations. Available surveys include the Steller sea lion, California sea lion, and harbor seal.

The analysis of project impacts on these species does not use density data because site-specific survey data are considered a better predictor of marine mammal exposures than density data. The following sections provide summaries of the Navy's survey and monitoring efforts at NAVBASE Kitsap Bangor, and discuss the reasoning behind determination of species abundances used in the analysis of project impacts.

2 Survey and Monitoring Efforts

2.1 Survey and Monitoring Efforts in the Vicinity of NAVBASE Kitsap Bangor

Available data on marine mammal populations in Hood Canal are from surveys of harbor seal haulouts (Jeffries et al., 2000) and recent surveys and monitoring efforts on NAVBASE Kitsap Bangor (Agness & Tannenbaum, 2009; Tannenbaum et al., 2009, 2011; HDR, 2012; Hart Crowser, 2013; Navy, 2016, 2019), some of which covered a very limited area.

2.1.1 Baseline Surveys of Hauled Out Pinnipeds

Since April 2008, Navy personnel have recorded sightings of marine mammals (California sea lion, Steller sea lion, and harbor seal) at known haulouts along the Bangor waterfront, including submarines and the nearshore pontoons of the floating security fence. Sightings of marine mammals within the waters adjoining these locations were also recorded. Sightings were attempted during a typical work week (i.e., Monday through Friday), but inclement weather, holidays, or security constraints often precluded surveys. Through 2012, these sightings took place frequently (average 14 per month) and only included haulouts. Surveys were minimal in 2013 and from July 2017 through June 2018. Surveys since 2013 have been conducted weekly (approximately 4 per month). During the surveys, staff visited each of the above mentioned locations and recorded observations of marine mammals on data collection forms, noting date, time, location, number, and species of marine mammals (by location), plus other relevant notes. Surveys were conducted using binoculars and the naked eye from shoreline locations or from the piers/wharves. Data were compiled for the period from April 2008 through February 2019 for analysis in this Incidental Harassment Authorization (Navy, 2016, 2019). Additional incidental observations of harbor seals were reported by Naval Facilities Engineering Command biologists in September and October 2016.

2.1.2 Vessel Surveys of Bangor Shoreline

Boat-based opportunistic sightings along portions of the Bangor waterfront during the course of beach seine fish surveys during the spring/summer of 2007 detected two marine mammal species (harbor seal and California sea lion) (Agness & Tannenbaum, 2009). In these surveys, seals and sea lions were noted in a field notebook, as well as date, time, location, number of individuals, species, and other relevant notes.

Boat-based protocol marine wildlife surveys conducted during July through September 2008 (12 surveys) and November through May 2009/2010 (12 surveys) (Tannenbaum et al., 2009, 2011) detected four marine mammal species (harbor seal, California sea lion, harbor porpoise, and Dall's porpoise). These protocol surveys operated along pre-determined transects parallel to the shoreline from the nearshore out to approximately 1,800 feet from shoreline, at a spacing of 100 yards, and covered the entire Bangor waterfront (approximately 1.5 square miles) at a speed of 5 knots or less. Two observers recorded sightings of marine mammals both in the water and hauled out, including date, time, species, number of individuals, age (juvenile, adult), behavior (swimming, diving, hauled out, avoidance dive), and haulout location. Positions of marine mammals were obtained by recording distance and bearing to the animal with a rangefinder and compass, noting the concurrent location of the boat with Global Positioning System (GPS), and, subsequently, analyzing these data with the coordinate geometry application available in ArcInfo to produce coordinates of the locations of all animals detected.

2.1.3 Surveys in Hood Canal and Dabob Bay

The Navy conducted vessel-based line transect surveys in 2011 in Hood Canal and Dabob Bay to collect density data for species present in Hood Canal. The primary impetus for the Hood Canal/Dabob Bay surveys was that observational data during pile driving monitoring (HDR, 2012) indicated an unexpected abundance of harbor porpoise within Hood Canal. The surveys in Hood Canal were conducted in September and October and detected three marine mammal species (harbor seal, California sea lion, and harbor porpoise). Transects generally covered the area from Hazel Point on the south end of the Toandos Peninsula to Thorndyke Bay. The surveys operated along pre-determined transects that followed a double saw-tooth pattern to achieve uniform coverage of the entire Bangor waterfront. The vessel traveled at a speed of approximately 5 knots when transiting along the transect lines. Two observers recorded sightings of marine mammals both in the water and hauled out, including the date, time, species, number of individuals, and behavior (swimming, diving, etc.). Positions of marine mammals were obtained by recording the distance and bearing to the animal(s), noting the concurrent location of the boat with GPS, and subsequently analyzing these data with the coordinate geometry application available in ArcInfo to produce coordinates of the locations of all animals detected. Distance sampling methodologies were used to estimate densities of animals.

Surveys in adjacent Dabob Bay represented a different pattern and generally followed the shoreline while completing a circular route through the bay. A large exclusion zone surrounding a Navy ship moored temporarily in Dabob Bay made it difficult to perform zigzag transects across the bay; therefore, early attempts at surveys in Dabob Bay did not follow a zigzag pattern, and switching to this survey pattern later in the project would have made density information collected during early "loop pattern" surveys incompatible with later data. Therefore, the loop pattern was followed during all subsequent baseline surveys in Dabob Bay.

2.1.4 Monitoring During Test Pile Program and Explosive Handling Wharf-#2 Construction

Marine mammal monitoring was conducted in the Explosive Handling Wharf #2 (EHW-2) project area in late 2011 during a test pile program as mitigation for pile driving noise (HDR, 2012).

Marine mammal monitoring was conducted during in-water construction periods on the EHW-2 from late September 2012 to mid-January 2015 (Hart Crowser, 2013, 2014, 2015). Monitoring was conducted in several areas: (1) Primary Surveys within the behavioral monitoring and shutdown zones in the waterfront restricted area (WRA) (464-meter radius of the driven pile); (2) in the first construction year, Outside Boat Surveys within the larger Level B behavioral harassment zone due to vibratory pile driving but outside of the WRA; and (3) Delta Pier Surveys of marine mammals hauled out on submarines at Delta Pier and, in the second construction year, at Marginal Wharf. Monitoring of the first two areas was conducted in accordance with an approved Marine Mammal Monitoring Plan for the EHW-2 project. The monitoring consisted of placing marine mammal observers on construction barges, the construction pier, and vessels located in near-field (within the behavioral monitoring zone in the WRA) locations. In the first year construction, monitoring also occurred in far-field (outside the WRA but within the Level B harassment zone) locations. Marine mammal observers reported occurrences of marine mammals during actual construction (i.e., pile driving activity) and non-construction periods. The survey effort continued for the third and final construction year (mid-July 2014 through mid-January 2015) within the behavioral monitoring and shutdown zones in the WRA with similar monitoring protocols.

3 Abundance Determinations by Species

3.1 Steller Sea Lion and California Sea Lion

Abundance of Steller sea lions and California sea lions was determined by evaluating ground-based on-site counts of animals at haulouts using data compiled by the Navy (2016) for NAVBASE Kitsap Bangor. Abundance was based on the highest average monthly maximum counts. Surveys at NAVBASE Kitsap Bangor were initiated in 2008 and a noticeable upward trend in the numbers of Steller sea lions and California sea lions has become apparent since mid-2012. Therefore, abundance at Bangor was calculated based on average monthly maximum counts during the in-water work window starting in mid-2012. As described in Section 6.11 of this application, the monthly average maximum counts that occurred during the in-water work window were evaluated to estimate marine mammal exposures to pile driving noise (Tables A-1 and A-2). This average is considered the abundance of that species during pile driving activity.

3.2 Harbor Seal

Expert review of Navy-funded line-transect aerial survey data and other datasets and analytic approaches provided estimates of harbor seal abundance and density near NAVBASE Kitsap Bangor (Jefferson et al., 2017). Density in the sub-region adjacent to NAVBASE Kitsap Bangor was 1.34 seals/sq km with an abundance of 58 animals. Highest density and abundance were in the spring and lowest were in winter.

Incidental observations (N = 6 surveys) in September and October 2016 by Naval Facilities Engineering Command biologists recorded as many as 28 harbor seals hauled out or in the water near Marginal Wharf at NAVBASE Kitsap Bangor.

Table A-1. Maximum Number of Steller Sea Lions Observed in a Single Survey at NAVBASE Kitsap Bangor[1]

Maximum Number of Steller Sea Lions Observed in Single Survey at NAVBASE Kitsap Bangor											
Month	***2008–2009***	***2009–2010***	***2010–2011***	***2011–2012***	***2012–2013***	***2013–2014***	***2014–2015***	***2015–2016***	***2016–2017***	***2018–2019***	***MAX Average 2012–2019***
July	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0
September	0	0	5	0	0	0	0	1	6	0	1
October	0	0	4	3	6	9	3	6	6	2	5
November	4	6	4	5	4	11	13	9	14	15	11
December	0	3	2	4	4	N/A	7	5	5	11	6
January	0	2	1	3	N/A	1	6	0	0	4	2
February	1	0	2	2	2	0	0	2	0	4	1
March	0	2	2	3	N/A	1	1	1	1	N/A	1
April	0	4	6	4	0	2	1	0	1	N/A	1
May	0	0	6	3	0	2	0	0	0	N/A	0
June	0	0	0	0	N/A	0	0	0	0	N/A	0

Key: N/A = not available.
Note: 1. Only two observations were recorded in 2017–2018; not included in this analysis.

Table A-2. Maximum Number of California Sea Lions Observed in a Single Survey at NAVBASE Kitsap Bangor[1]

Maximum Number of California Sea Lions Observed in a Single Survey at NAVBASE Kitsap Bangor											
Month	***2008–2009***	***2009–2010***	***2010–2011***	***2011–2012***	***2012–2013***	***2013–2014***	***2014–2015***	***2015–2016***	**2016–2017**	**2018–2019**	**MAX Average 2012–2019**
July	0	0	0	0	3	0	1	1	2	0	1
August	0	1	3	4	5	0	15	3	4	5	5
September	12	32	33	14	11	35	44	30	28	29	30
October	47	44	42	56	70	88	84	113	99	320	129
November	50	58	42	81	70	122	93	102	131	309	138
December	27	38	50	64	69	N/A	63	118	72	60	76
January	4	44	33	43	N/A	48	43	16	42	52	40
February	28	34	42	48	44	42	32	56	46	124	57
March	37	40	54	82	N/A	65	55	104	43	N/A	67
April	46	51	66	52	32	49	48	106	34	N/A	54
May	33	17	54	18	N/A	20	12	54	41	N/A	32
June	3	12	17	4	N/A	8	8	17	8	N/A	10

Key: N/A = not available
Note: 1. Only two observations were recorded in 2017–2018; not included in this analysis.

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Appendix B

Proxy Source Sound Levels and Potential Bubble Curtain Attenuation for Acoustic Modeling of Nearshore Marine Pile Driving at Navy Installations in Puget Sound

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Proxy Source Sound Levels and Potential Bubble Curtain Attenuation for Acoustic Modeling of Nearshore Marine Pile Driving at Navy Installations in Puget Sound

Revised
January 2015

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1.0 BACKGROUND

The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) issue incidental take for Endangered Species Act (ESA)-listed species potentially adversely affected by the Navy's activities. This includes sound pressure levels (SPLs) produced from pile driving. Incidental take statements (ITS) are an outcome of Section 7 consultations and addressed in the Biological Opinions. The NMFS also issues authorizations for noninjurious take (Level B) for marine mammals for noise produced by pile driving. Such take provisions are authorized by the Marine Mammal Protection Act.[1]

ITS often authorize incidental take by the area encompassed within zones above noise thresholds for ESA-listed fish. ITS for other animals such as marbled murrelets and marine mammals are based upon the number of animals anticipated to occur in the zones above the noise thresholds. For example, the peak SPL for the onset of injury threshold for fish is 206 dB referenced to 1 micropascal (µPa)[2]. If actual project noise exceeds the extent of the modeled authorized area, the project would exceed authorized incidental take allotted in the ITS. Consequently, the project would be required to reinitiate consultation under Section 7 of the ESA and a shut-down of impact pile driving would occur until a new ITS is issued. For marbled murrelets and marine mammals, injurious incidental take is avoided by monitoring areas exceeding the injury thresholds. If an animal enters this area, pile driving is shut down until it leaves. In addition, there can be provisions in an ITS or MMPA authorization allocating incidental take for potential behavioral disturbance. In this case, monitoring is required within the behavioral disturbance zones. Therefore, accurate establishment of the extent of the area exceeding established thresholds is essential to complying with the terms of an ITS or MMPA authorization.

When possible data obtained for a given site are used to predict expected source levels. However, for most project sites, prior measurements of the extent of pile driving noise have not been made. For these sites the extents of the areas where noise exceeds threshold values are modeled with an equation for sound propagation using proxy values for the source pile driving levels. Proxy source values are therefore either from prior measurements obtained on-site by installing the same type and size of piles or, when site specific information is lacking, obtained from the same or most similar type and size pile at locations with a similar sound environment. Other important factors include the type of equipment used to install the pile, substrate type, and water depth, all of which result in variations in pile driving noise levels. Detailed analyses of these factors are beyond the scope of this source document. The following section considers the

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[1] New NMFS criteria using frequency weighted (filtered) responses are in development, with new standards anticipated. The current revision of this document does not include frequency weighted results; such results will be promulgated in a revised edition.

[2] All peak and root-mean-square (RMS) sound pressure levels in this document are referenced to 1 µPa. All sound exposure levels (SEL) in this document are referenced to 1 μPa^2-second. All peak SPLs in this document refer to absolute peak overpressures or under pressures.

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rationale we used when reviewing proxy impact and vibratory pile driving source values for noise threshold metrics. We first discuss the available data included in the review. Second, we discuss the values for each threshold metric (peak SPL, root-mean-square [RMS], and sound exposure level [SEL]) that will result in a high likelihood of encompassing the extent of actual project noise levels. Last, we review relevant data available for various types and sizes of piles typically used for pile driving and recommend proxy source values for Navy installations in Puget Sound.

Section 2 of this document is a review of attenuation levels reported for various impact pile driving projects.

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2.0 PROXY SOURCE SOUND LEVELS FOR ACOUSTIC MODELING OF NEARSHORE MARINE PILE DRIVING AT NAVY INSTALLATIONS IN PUGET SOUND

2.1 UNDERWATER PILE DRIVING SOURCE LEVELS

2.1.1 Data Sources

Differences in underwater source levels for a given pile size and type will vary because of differences in geologic conditions, water depths where piles are installed, and pile driver type. In other words, the same size pile and type may generate different noise characteristics when installed in dissimilar environments. To obtain source values and model distances to the USFWS and NMFS thresholds for nearshore marine environments at Navy installations in Puget Sound, we reviewed available values from multiple nearshore marine projects obtained from the California Department of Transportation (CALTRANS), Washington State Department of Transportation (WSDOT), and Navy pile driving acoustic reports. Projects were located in California, Oregon, and Washington. Non-marine projects were excluded because of differences in substrate and/or acoustic conditions, and are not relevant herein due to the dissimilar nature from typical work performed at Navy marine facilities in Puget Sound. For example, a project located in Lake Washington and a freshwater bay (SR 520 Test Pile Project) was excluded due to very different substrate conditions present at those sites. Projects located in rivers were excluded because substrate characteristics, such as presence of bedrock, were not typical of Puget Sound. River projects also had different bathymetric profiles as well as increased current velocities. Of the projects reviewed, only measurements from unattenuated piles (e.g. a noise attenuation device was not operating[3]) were evaluated. Attachments 1 through 5 in Appendix A list the projects considered in this review.

All projects considered in the review had similar nearshore project depths from less than 5 m to approximately 15 m with the exception of Test Pile Program at Naval Base (NAVBASE) Kitsap Bangor where depths ranged from approximately 13 to 27 m. Impact pile driver type is listed in the attachments. Impact pile drivers can be drop, pneumatic, hydraulic, or diesel powered. With some exceptions at the Friday Harbor Ferry Terminal, all impact driven piles were installed with diesel powered drivers. Vibratory drivers vary only by size (energy) and type (variable moment/non-variable moment), but because of the limited data set, no attempt was made to distinguish between driver energies when reviewing noise levels produced from different impact or vibratory drivers.

Proxy values in similar marine sound environments can be challenging to obtain for pile driving because of variations in geologic conditions between projects and variability within

[3] Pile caps are routinely placed on top of piles prior to driving to cushion equipment. While they are recognized as providing some sound attenuation, they are not considered in this analysis because they are part of baseline sound measurement presented in many reports.

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project sites. Substrate types were not reported for most projects included in the review. Substrate types typical of Puget Sounds are sand/silt to sand/silt/cobbles overlying glacial till or hard clay layers. Therefore, projects located in the marine waters of Puget Sound, including the San Juan Islands, were considered more heavily because they would be more likely to share the same substrate characteristics than projects located in the San Francisco Bay area, the mouth of the Columbia River, or coastal bays. However, it should be noted that within Puget Sound a considerable variability in substrate conditions can exist between projects and within projects due to harder glacial layers and unforeseen encounters with glacial erratics (e.g. erratic rocks). Depending on the substrate type, piles may easily be advanced or, because of glacial till or submarine boulders, piles may require much more energy to drive. Piles driven to different tip elevations could also experience different driving conditions. For example, fender piles generally are not driven to the same depth as structural piles and may not encounter the same resistance during driving. Therefore, considerable variation in values is expected when looking from project to project or pile to pile within a project. To ensure proxy values are protective of species, conservative values were chosen to encompass regional and pile to pile variation. The following section considers the rationale we used when reviewing values for various sound metrics.

2.1.2 Other Considerations in Evaluation of Pile Driving Source Values

Proxy values need to be conservative. This ensures the area modeled above the injury thresholds is correctly assessed and remains within an ITS for fish. This approach will also preclude incidental take considered injurious based on the established injury criteria of marbled murrelets and marine mammals. In addition, proxy values are used to model the areas above the marbled murrelet and marine mammal behavioral thresholds or guidance values. Sound levels from pile driving are reported on either a per pile basis within a project, or per project summary basis. Summary data reported in acoustic reports varies, but can include one or more of the following:

- Per pile averages
- Ranges
- Minimum and maximum values
- Per project average
- Typical values
- Average range
- Minimum, maximum, average minimum
- Average maximum value
- Standard deviation.

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Thus, interpretation of the reported levels may depend on the analytical methodology selected, which in turn can affect the proxy source level selected for modeling analysis. For example, one approach to choosing a source value is to pick the mean value from a number of projects reviewed. The results from the model utilizing this mean value will adequately characterize the estimated average extent of noise from pile driving. However, depending on the pile to pile variability it would only characterize the area for individual piles if the pile to pile variability in the source data were low. If the data were highly variable, the extent of the area above the threshold would be smaller or larger than described by the model on a per pile basis. Therefore, on-site monitoring of pile driving noise could exceed the modeled values on a significant portion of the piles. Another, but more conservative approach is to select the proxy source value from the highest value of all values reported. This method would ensure that most, if not all, measured values on a pile by pile basis would be below the selected value, but could significantly overestimate the area or extent of biological impact.

In the section below we outline the rationale we used for selecting proxy values from the available data for each threshold metric. Values were chosen to ensure that a reasonable worst case scenario is modeled to estimate the extent of noise from pile driving.

2.1.2.1 ROOT MEAN SQUARE

The root-mean-square (RMS) value is the metric used to define the behavioral zones for fish, marbled murrelets, and marine mammals. For piles that are impact driven, RMS values are generally reported for individual piles over the duration of the driving of a given pile; often the number of strikes is also reported on a per-pile basis. Thus, in order to best characterize a broad-base proxy SPL, average RMS pressures were computed from the reported SPL (dB) values, and then weighted by the number of pile strikes for a given pile. This weighting methodology estimates proxy values across multiple projects with differing numbers of piles or strike counts, and the effect of using weighting values ensures that a single project or pile does not overtly bias the result high or low. This proxy value represents the most likely value expected for individual pile strikes for a typical project.

For piles that are vibratory driven, RMS values are typically computed over 10-second or 30-second averaging periods, and represent the most probable typical value over a long event. Thus, recommended proxy RMS values for vibratory and impact pile driving are computed using different techniques. For vibratory piles, reported values were selected on a pile-by-pile basis for a given pile type and size. An average value was computed by converting selected SPL values (dB) into pressure values, summing them together in linear space, dividing by the total number, n, of selected piles, and converting the result back to SPL (dB). In following this approach, the proxy value represents the arithmetic average value for each pile type and size from applicable projects. Thus, for vibratory driven piles averaged RMS values were used from all applicable projects as a representative average level of long-term pile driving events.

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Weighted SPL averages are computed by first converting all SPL values to linear space, weighting pressure values by the number of events (for example, by number of strikes, *n*), normalizing by dividing by the number of events, and then converting back to SPL. Using k as an index counter for all piles, 1 = pile #1, 2 = pile #2, etc.:

$$Weighted\ SPL = 10\log_{10}[\frac{1}{n_{total}}\sum_{k=1}^{n_{total}}(n_k P_k)]$$

where

$$n_{total} = n_1 + n_2 + n_3 \ldots$$

Charts depicting the behavior of the measured data used to prepare proxy values within this document are presented in Appendix B. Two types of charts are provided. First, for all data types, a sorted chart showing amplitude for all piles included, recommended proxy value, and when available, minimum and maximum levels observed. Next, the cumulative probability distribution function charts are provided for all pile sizes, with the recommended proxy value annotated on each chart.

2.1.2.2 PEAK SOUND PRESSURE LEVEL

The peak sound pressure level (SPL) metric is used to evaluate the potential for injurious effects to fish. The barotrauma injury to fish due to peak over or under pressurization could result in instantaneous injury with a single strike. Average peak impact SPL values were selected from applicable projects, from which a weighted probability distribution function (PDF) was computed based on the number of pile strikes for each pile. To ensure a conservative proxy value, a value representing the ninetieth percentile of the PDF was selected, meaning that for a typical impact pile driving project, 90% of all pile strikes would typically occur below this proxy value. Use of this value ensures potentially injurious effects to fish would have a high likelihood of being within the area exempted for incidental take.

2.1.2.3 SOUND EXPOSURE LEVEL

The sound exposure level (SEL) metric for impact driving is used to calculate the area of cumulative exposure potentially resulting in injury to fish or marbled murrelets over a daylong pile driving event (the accumulation of energy received from all pile strikes). To compute the cumulative SEL all single strike SEL energy in a workday is summed to calculate the overall SEL. However, modeling for the SEL “dosage” generally involves estimation of a typical single pile value logarithmically added to sum the expected energy over the day. While some strikes may be lower and some higher than the mean SEL value, use of the mean value would result in the best overall estimate of expected cumulative energy over the work day. In practice, the SEL value will vary on any given workday due to variability in the levels measured for each individual strike. The acoustic reports reviewed typically provided the mean single strike SEL per pile. Therefore, the most representative estimate of the single strike SEL for a proxy value is to use a mean SEL value from data from all piles in applicable projects. Furthermore, to avoid biasing the data high or low from a single pile or project, a weighted average was computed using the number of pile strikes, *n*, in the same manner as was followed for computation of impact RMS values. This approach ensures that a single project or pile does not bias the result high or low. This proxy value represents the most likely value expected for individual pile strikes for a typical project.

2.1.3 Impact Driving Source Values

Table 2-1 summarizes projects from Attachment 1 in Appendix A that were considered in the final analysis and highlights proxy values. Theses highlighted proxy source values are reasonably conservative for modeling future Navy pile driving projects in Puget Sound. Detailed discussions of the projects considered and the values obtained for each pile type and size are provided below.

Table 2-1. Summary of Unattenuated Impact Pile Driving Levels Considered. Recommended Proxy Source SPLs at 10 m Bolded.

Pile Size	Number of Projects Considered[1]	Range of Average RMS (n-weighted pile average) dB re 1µPa	Range of Average Peak (90% PDF value) dB re 1µPa	Range of Average SEL (n-weighted pile average) dB re 1µPa
Steel				
24-inch	2	181-198 (**193**)	196-213 (**210**)	176-185 (**181**)
30-inch	3	192-196 (**195**)	203-217 (**216**)	182-187 (**186**)
36-inch (all projects)	3	185-196 (**192**)	202-211 (**211**)	173-186 (**184**)
36-inch (Bangor only)	1	185-196 (**194**)	Not reported[3]	173-183 (**181**)
All 24/30/36-inch	7	181-198 (**193**)	196-217 (**211**)	173-193 (**184**)
Concrete				
≤18-inch	3	158-173 (**170**)[2]	172-188 (**184**)[2]	147-163 (**159**)[2]
24-inch	7	167-179 (**174**)[2]	180-191 (**188**)[2]	158-167 (**164**)[2]

[1]See Appendix A, Attachment 1 and 2 for projects reviewed.
[2]Number of pile strikes, *n*, was not available for any concrete projects; all piles were equally weighted.
[3]Although absolute peak values were collected for TPP testing, average peak values were not reported; unattenuated data from EHW-2 was not collected.

2.1.3.1 24-INCH STEEL PILE IMPACT DRIVING SOURCE VALUES

Attachment 1 in Appendix A lists six marine nearshore projects reviewed for possible inclusion in the analysis. Data for one 24-inch pile installed with an impact hammer in the Test Pile Project at NBK Bangor are listed in Attachment 1. However, only 7 pile strikes were reported and measurements from this pile are lower than all of the other five projects reviewed. Therefore, these data were not considered in the selection of the most conservative value. Of the remaining five projects reviewed, the Bainbridge Island Ferry Terminal Preservation Project and the Friday Harbor Restoration Ferry Terminal project were considered as the most representative

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of typical glacial till and erratics encountered in Puget Sound and were carried forward in the analysis. We based this on the assumption that substrate conditions are more similar than those found in San Francisco Bay or the mouth of the Columbia River.

For the two ferry terminal sites, five piles were driven at Bainbridge Island in substrate that consisted of a mix of sand and fist-sized rocks with occasional rocks one-foot in diameter. At Friday Harbor six piles were driven into a silty sand substrate approximately 9 meters thick and underlain by a hard clay lens. Three of the piles at this site encountered a large rock ledge approximately 10.7 meters below the mudline. One of the six piles in the project had the high end of the data clipped[4] and therefore invalid, so this pile was excluded from the analysis. This project used different hammer types, but because the report noted little variation in the data, all five remaining piles were included in our review. Data from the two ferry projects only included values without a bubble curtain attenuator operating, i.e. no attenuation.

Source levels for each metric reviewed are discussed below. Table 2-1 summarizes unattenuated impact pile driving source data from Attachment 1 for the two ferry terminal projects.

RMS SPL

Weighted average proxy RMS source values for the two Puget Sound ferry terminal projects were 189 dB (range 181 dB to 193 dB) and 195 dB (range 193 dB to 198 dB) (Attachment 1), representing 1007 pile strikes. Therefore, actual RMS values would be expected to fall between 181 dB and 198 dB. The weighted average RMS value of 193 dB was chosen as a conservative value that likely encompasses the average extent of the area exceeding the injury thresholds for marine mammals and the behavioral thresholds for marine mammals, fish and marbled murrelets.

Peak SPL

Average peak SPLs reported for individual piles at the Bainbridge Island and Friday Harbor projects were 202 dB to 209 dB and 196 dB to 213 dB, with an average weighted value of 207 dB. Of the applicable projects, the 90% probability from the weighted cumulative distribution density function value of 210 dB was chosen as a conservative proxy value that likely encompasses the modeled extent of the area over the onset of injury threshold for fish. Table 2-1 summarizes the values from the two projects considered likely to be most representative.

[4] Clipping occurs when a signal exceeds the linear limits of an electronics system in essence the extreme levels of the signal are truncated or "clipped" off. For pile driving measurements, clipped data can produce results that are lower than the actual signal of interest, thus producing invalid results.

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SEL

Mean weighted SEL values for the two Puget Sound projects reviewed are each 181 dB for all piles. The mean SEL per any one pile for both projects ranged from 176 and 185 dB. These values are higher than the values reported for the other three projects reviewed (project SEL means that ranged from 168 to 177 dB). Therefore, the Washington projects were considered the most conservative and a mean weighted SEL of 181 dB was chosen as a reasonable proxy value of the overall SEL for 24-inch piles.

2.1.3.2 30-INCH STEEL PILE IMPACT DRIVING SOURCE VALUES

Data for 30-inch steel pipe piles were available from three marine pile driving projects in Puget Sound, Washington and one project from San Francisco Bay, California. No projects from Bangor were available for analysis, and data from the California project provided only typical data, and did not provide per-pile SPL or number of strikes for each pile (see Attachment 1 in Appendix A). All available data in Attachment 1 were reviewed. However, as with the 24-inch pile source values, values from the Puget Sound projects were considered the most representative of source values because of similar substrate characteristics and are the only values considered in the Table 2-1 summary. Note that data from the Vashon Island project were acquired from 7m to 16m from the pile, and were normalized using a $15 \cdot \log_{10}(\text{range}/10\text{m})$ relationship.

RMS SPL

Average RMS source values for three Puget Sound projects ranged from 192 dB to 196 dB. The minimum average value reported for any one pile is 192 dB (Eagle Harbor Ferry Terminal) and a maximum average reported of 196 dB (Vashon Island Ferry Terminal, two piles). The RMS values from three Puget Sound projects were moderately higher than values measured from the California project considered, which reported a typical RMS value 190 dB. A conservative proxy RMS value is the weighted average value of 195 dB from the three projects in Puget Sound representing 263 pile strikes. This value would be a reasonable worst case ensuring that noise levels modeled would have a high likelihood of not exceeding this value.

Peak SPL

Average peak SPLs reported from the Puget Sound projects with available data ranged from 203 dB to 217 dB (n=3 projects) on a per-pile basis, with a computed weighted average of 214 dB. Levels from three piles at Eagle Harbor Ferry Terminal range from 7 to 11 dB quieter than those measured at two other Puget Sound sites, indicating a significant variability between sites. The typical peak SPL reported for the single California project was 205 dB, which was noted to be on the lower end of the range of data reported from Puget Sound, although the number of pile strikes was not reported, thus this data were not included in the weighted average for 30” peak values. The 90% weighted cumulative probability value of 216 dB was chosen as a reasonable and conservative proxy value.

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SEL

Average per-pile SEL values were reported for the two Puget Sound Projects representing 214 pile strikes; the Eagle Harbor project did not report single strike SEL levels, and a California project did not report any SEL levels. SEL values from the two applicable projects ranged from 182 dB to 187 dB with an overall weighted average of 186 dB. Thus, a reasonable conservative SEL source value for future projects in Puget Sound is 186 dB derived from the weighted value of reported Puget Sound levels.

2.1.3.3 36-INCH STEEL PILE IMPACT DRIVING SOURCE VALUES

Data for 36-inch steel pipe piles were available from three marine pile driving projects in Puget Sound, Washington and one project from Humboldt Bay along the California coast (Attachment 1 in Appendix A). All projects installed piles with a diesel hammer. The Humboldt Bay project did not report number of pile-strikes, and furthermore, this pile was only measured by re-striking a pile that had already been driven. Therefore, this project was excluded from the 36-inch average value computations. Data from two piles measured during the NBK Bangor Test Pile Program were at 11m and 20m from the pile, and were normalized using a $15 \cdot \log_{10}(\text{range}/10\text{m})$ relationship.

RMS SPL

Average RMS source values for the three Puget Sound projects ranged from 185 dB to 196 dB, representing 662 pile strikes, the full range of which were observed during the Test Pile Program at NBK Bangor project. The weighted average value for these projects was 192 dB, and represents a reasonable proxy RMS value for impact driven 36-inch piles. The average RMS value of 193 dB reported for the 36-inch pile from the Humboldt Bay Bridge project in California fell within the range of values for the three Washington 36-inch pile projects reviewed, although as previously discussed, this value was not included in the averaging calculations. Considering just the Test Pile Program at Bangor, 121 pile strikes produced a set of measurements ranging from 185 to 196 dB, with a weighted average value of 194 dB.

Peak SPL

Average peak SPLs reported from two Puget Sound projects ranged from 202 dB to 211 dB on a per-pile basis, representing 541 pile strikes. Average peak values were not reported for the NBK Bangor project. A proxy peak value of 211 dB was chosen representing the 90% cumulative probability SPL.

SEL

Average SEL values were reported for three Puget Sound projects, with 662 pile strikes measured. SEL values ranged from 173 dB to 186 dB with an overall weighted average of 184 dB, the recommended proxy value for piles driven in Puget Sound. Only one value was

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reported for the Humboldt Bay project, 183 dB, which was within the range of values reported in Puget Sound. A reasonable conservative SEL source value for future projects in Puget Sound is 184 dB derived from the weighted average of three Puget Sound projects. Analyzing data from just the NBK Bangor project resulted in a weighted average value of 181 dB, with a data range of 173 to 183 dB.

2.1.3.4 COMBINED STEEL PIPE IMPACT DRIVING SOURCE VALUES

Review of RMS, average peak, and SEL values for steel pipe piles of 24, 30, and 36-inches shows that often only slight differences are noted across the three sizes (see Table 2-1). In some cases, weighted average values for smaller piles are higher than for larger piles, even if by only one or two decibels. For this reason a combined analysis was done for each of the metrics to investigate the potential value of preparing overall average values over multiple sizes of steel pipe piles. Each of the metrics is discussed in the following paragraphs.

RMS SPL

Average RMS values over 24, 30, and 36-inch piles ranged from 181 dB to 198 dB, although weighted averages were very close, 193, 195, and 192 dB, respectively, with an overall weighted average value of 193 dB. 30-inch piles (three projects located in Puget Sound, not including any NBK Bangor projects) produced average RMS levels of 195 dB, higher than both 24-inch and 36-inch average values. Even though few piles and a lower number of pile strikes were measured with 30-inch piles, the scatter in the points measured only ranged from 192 to 196 dB, without a large deviation. 24-inch and 36-inch piles have larger data sets, but nonetheless, the recommended proxy value for each of these sizes is only a few decibels different. Figure B-4 in Appendix B graphically shows how the scatter for each pile size compares with other pile sizes. While it is reasonable to assert that RMS impact values for steel pipe piles can be represented by a single, composite value of 193 dB, additional data is recommended to be collected to increase the size of the analysis sample set.

Peak SPL

Peak SPL values varied over a broader range than RMS values, although 24- and 36-inch 90% cumulative probability results were within 1 dB, representing 1,669 pile strikes. 30-inch results were measurably higher than either 24- or 36-inch data, represented by fewer piles, and fewer strikes (263 strikes). Furthermore, 30-inch pile data is somewhat bi-modal in behavior, with three values near 203 to 204 dB, and four in the 211 to 217 dB range, and nothing in between. Figure B-11 in Appendix B graphically shows the distribution of levels by pile size. Three piles represented in the 211 to 217 dB range were measured from distances other than the standard 10 meter de facto measurement range, which were corrected using the traditional practical spreading model. Although not necessarily incorrect, this serves to increase the uncertainty of those measurements. Since none of the 30-inch (nor 24-inch measurements) represent data acquired directly from NBK projects, it makes sense to prepare a broader analysis to consider different pile sizes for the purpose of increasing confidence in the estimated peak

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values. The 90% cumulative distribution value for all 24-, 30-, and 36-inch applicable projects is 211 dB, represented by 1,932 pile strikes, and is the recommended proxy value for NBK Bangor projects, especially those using 24-inch and 30-inch steel pipe piles, until such time that Bangor-specific data can be acquired using these pile sizes.

SEL

Weighted average SEL values for 24-, 30-, and 36-inch piles also resulted in somewhat anomalous data with 30-inch steel pipe piles, with both 24-inch and 36-inch data producing lower values. As described above, the 30-inch data set includes range corrected values, and furthermore, only represented 4 piles, since single strike SEL values were not reported for one of the Puget Sound projects (Eagle Harbor Ferry Terminal). Figure B-16 in Appendix B shows the data grouping by pile size. This gives rise to increased uncertainty in the 30-inch average vales.

There is some evidence that SEL values for 36-inch piles at NBK Bangor (182 dB, weighted average) is lower than a proxy value including Puget Sound projects (184 dB). This conclusion is drawn from a modest sample size (4 piles, 121 strikes) of NBK Bangor measurements. Similar analyses could not be done with 24- and 30-inch piles, since these data did not exist for NBK Bangor projects.

Taken in summary, there is motivation to compute a single proxy value for all 24-, 30-, and 36-inch steel pipe piles, but this approach is not recommended at this time due to the uncertainty in the data scatter, and different results among RMS, SEL, and peak metrics. Additional data should be collected before using combined analyses.

2.1.3.5 18-INCH CONCRETE PILE IMPACT DRIVING SOURCE VALUES

Attachment 2 in Appendix A lists three marine nearshore projects that monitored sound levels during installation of 18-inch or similar (16-inch) concrete piles, none of which were conducted in Puget Sound. Two projects were conducted at the Berkeley Marina in San Francisco Bay, California, one in 2007 and one in 2009 using 18-inch concrete piles. Acoustic measurements were only collected for four piles total for both projects. Water depth was fairly shallow ranging from 3 to 4 meters. Source levels for each metric reviewed are discussed below. Another project located near Concord, CA at the Naval Weapons Station (NWS) drove five 16-inch concrete piles, with water depth of 10 meters. Source values for this project were similar to those for the Berkeley Marina projects, and thus data from the Concord NWS were included in the analysis. Table 2-1 summarizes unattenuated impact pile driving source data from Attachment 2 and highlights recommended proxy source values. Since the number of pile strikes for all concrete projects were not reported, pile averages were computed.

RMS SPLs

Average RMS values for three projects using 16 or 18-inch concrete piles ranged from of 158-173 dB (Table 2-1), with an average RMS value of 170 dB over 9 piles, selected as a

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conservative value likely to encompass the maximum extent of the area exceeding the behavioral thresholds and guidance for marine mammals, fish and marbled murrelets. No concrete pile levels exceed the RMS injury thresholds established for marine mammals (180 dB RMS for cetaceans and 190 dB RMS for pinnipeds).

Peak SPLs

Average peak SPLs reported for all piles at the Berkeley Marina projects ranged from 172 dB to 188 dB. Because only three projects with relatively small samples sizes were available for review, a per-pile average value of 184 dB was chosen as the recommended SPL proxy value for all piles. This value is below the threshold for the onset of injury in fish (206 dB). Table 2-1 summarizes the values from these projects.

SEL

Two average SEL values of 155 and 159 dB were reported for the two Berkeley marina projects, both with very small sample sets ranging from 147 dB to 163 dB. SEL data were not acquired for the Concord NWS project. The per-pile average value of 159 dB SEL was selected as the most conservative proxy value available for 18-inch concrete piles until additional data are obtained.

2.1.3.6 24-INCH CONCRETE PILE IMPACT DRIVING SOURCE VALUES

Only one value from a single 24-inch concrete pile was available for the Mukilteo Ferry Terminal in Puget Sound. Therefore, we reviewed seven additional marine projects: six in San Francisco Bay, California, and one in Humboldt Bay, California (Attachment 2 in Appendix A). Note that some of the San Francisco Bay projects included data from the same site in two different time periods. Two projects (Humboldt State Floating Dock and Pier 40 Marina) included piles that were driven using a jetting technique, often in combination with a reduced level of fuel to minimize driving energy. Piles driven under these circumstances were not included in the calculation of piles averages. Table 2-1 summarizes unattenuated impact pile driving source data from Attachment 2 and highlights recommended proxy source values.

RMS SPLs

The one pile in Puget Sound reported a maximum RMS value of 170 dB, with average values reported for the California projects ranging from 167 dB RMS to 179 dB RMS. The recommended proxy source value was chosen from the highest average pile value over all projects, 174 dB RMS (Table 2-1). No concrete pile noise levels exceed the RMS injury threshold established for pinnipeds (190 dB RMS), nor the RMS injury threshold for cetaceans (180 dB RMS).

Peak SPLs

Average Peak SPLs reported for projects ranged from approximately 180 dB to 191 dB. The per-pile 90% cumulative probability value of 188 dB was chosen as the recommended proxy

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peak SPL value. This value is below the peak threshold for the onset of injury in fish (206 dB). Table 2-1 summarizes the values from the two projects.

SEL

Sound exposure levels were only reported for six of the eight projects reviewed, with per-pile values ranging from 158 dB to 167 dB (Table 2-1). The pile SEL average over all projects of 164 dB was considered representative of a conservative average SEL source value for 24-inch piles.

2.1.4 Vibratory Pile Driving Source Values

NMFS has established non-impulsive injury thresholds (180 dB RMS for cetaceans, 190 dB RMS for pinnipeds) and a disturbance threshold (120 dB RMS) for marine mammals. Vibratory driving is considered a non-impulsive sound source. Attachment 3 in Appendix A contains a list of vibratory projects and derived proxy source values we reviewed in order to calculate how far sound from vibratory driving exceeds the thresholds discussed in Section 1.2.1. Table 2-2 presents the summary of vibratory pile driving data from the projects reviewed. Due to the similarity in levels across multiple projects, 16-inch and 24-inch piles were considered together, and 30-inch and 36-inch piles were considered together.

Table 2-2. Vibratory Pile Driving SPLs.*
Recommended Proxy Source SPLs at 10 m Bolded.

Pile Size and Type	Number of Projects Considered[1]	Range of Average RMS dB re 1µPa @ 10 meters	Reasonable Source Level dB re 1µPa dB @ 10 meters
Timber			
12-inch	1	152-155[2]	**153[2]**
Steel Pipe			
16-inch and 24-inch	4	Bangor 153-162 All projects 159-162	**161**
30-inch and 36-inch	7	Bangor 166 All projects 159-172	**NBK Bangor 166** **Other Puget Sound Locations 167**
Steel Sheet			
24-inch	3	160-163**	**163**

[1]See Attachment 3 for projects reviewed.
[2]Data reported at 16m, converted to equivalent range of 10m using 15Log$_{10}$[16/10] range correction factor.
* Recommended values for 10 meters unless otherwise indicated.
**Highest value for pile; value includes some averages from only top or bottom depth measurements and one from top and bottom averaged.

2.1.4.1 TIMBER PILE VIBRATORY DRIVING SOURCE VALUES

Only one timber pile study is available and only for noise measurements taken during extraction of one 12-inch diameter pile (see Attachment 3 in Appendix A). The highest RMS

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value was 152 dB measured at 16 meters (Table 2-2), with an average value of 150 dB reported at 16 meters.

2.1.4.2 24-INCH DIAMETER STEEL PIPE PILE VIBRATORY DRIVING SOURCE VALUES

Two projects in Washington and one in California were reviewed for 24-inch diameter steel pipe piles. The Washington marine projects at the Friday Harbor Terminal and NBK, Bangor waterfront, only measured one pile each, but reported similar sound levels of 162 dB RMS and 159 dB RMS (range 157 dB to 160 dB), respectively (see Attachment 3 in Appendix A). Because only two piles were measured in Washington, the California project was also included in the analysis. The California project was located in a coastal bay and reported a "typical" value of 160 dB RMS with a range 158 to 178 dB RMS for two piles where vibratory levels were measured. Caltrans summarized the project's RMS level as 170 dB RMS (Table I.2-3 in Caltrans 2012), although most levels observed were nominally 160 dB. A fourth project at NBK, Bangor drove 16-inch hollow steel piles, and measured levels similar to those for the 24-inch piles; therefore these data were included in the 24-inch analyses. Although the data set is limited to these four projects, close agreement of the levels (average project values from 159 to 162 dB at 10 meters) indicate similar vibratory conditions at NBK, Bangor. The highest project average of 162 dB was selected as the most reasonable proxy for 24-inch steel pipe piles. This number is higher than the data from the Bangor Test Pile Program and is therefore conservative.

2.1.4.3 30-INCH AND 36-INCH DIAMETER STEEL PIPE PILE VIBRATORY DRIVING SOURCE VALUES

Five projects were reviewed for 30-inch diameter piles and four projects were reviewed for 36-inch diameter piles, with a total sample set of seven projects since some projects used both 30-inch and 36-inch piles. All projects were located in Puget Sound. Because the 30-inch diameter pile average RMS measurements overlap (164 dB, 168 dB, 170 dB, and 171 dB) the measurements reported for 36-inch diameter piles at the Bangor waterfront, the Edmonds and Anacortes ferry terminals range (159 dB, 162.5 dB, 169 dB, respectively), the 30-inch and 36-inch pile data were combined for the review.

We reviewed data from Bangor waterfront projects for 30 and 36-inch piles, which were based on a large sample size relative to other projects (n~68 piles, Attachment 3). RMS vibratory average levels were consistently lower at Bangor than other Puget Sound locations. We recommend using the site-specific data average RMS level for modeling vibratory pile driving at NBK, Bangor, that is, the recommended RMS vibratory installation proxy source value 30-inch to 36-inch diameter piles is 166 dB. Because site specific data is unavailable for all other Navy installations in Puget Sound, we recommend the more conservative proxy value of 167 dB for other Puget Sound Navy sites, which represents the average level for all Puget Sound locations excluding NBK, Bangor for both 30-inch and 36-inch piles.

Table 2-2 summarizes the ranges for the combined size category. Table 2-2 presents reasonable proxy values expected from reviewing values taken from the highest average project SPL for all projects reviewed.

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2.1.4.4 24-INCH STEEL SHEET PILE VIBRATORY DRIVING SOURCE VALUES

Sound levels for vibratory sheet pile driving were reported for three Caltrans projects at the Port of Oakland in San Francisco Bay (see Attachment 3in Appendix A). No data were found for sheet pile driving in Puget Sound. RMS values were only available for one pile at one project and this had an average RMS value of 163 dB. The second project reported 1 sec SEL levels at 10 m for 5 vibratory driven sheet piles. The average per pile SEL ranged from 157 to 160 dB based on the average top and bottom depth measurements. Caltrans also reported 162 dB RMS as the highest average for a single depth for the same project. The third project reported 163 dB RMS (Table I.2-3 in Caltrans 2012). Caltrans reported 160 dB RMS as the typical sheet pile value for all three projects (Table I.2-2 in Caltrans 2012). Based on the levels from the three projects, 163 dB RMS value was used as a conservative proxy value.

2.2 AIRBORNE PILE DRIVING SOURCE VALUES

NMFS has established an in-air noise disturbance threshold of 90 dB RMS re 20µPa (unweighted) for harbor seals, and 100 dB RMS re 20µPa (unweighted) for all other pinnipeds. Attachment 4 and Attachment 5 in Appendix A list the impact and vibratory pile driving projects, respectively, that were reviewed. Most projects report A-weighted levels. For this review, however, only unweighted data were considered. Two airborne noise values are presented for most projects: L_{max} and L_{eq}, The L_{max} is the instantaneous highest sound level measured during a specified period, or maximum noise level. It typically represents a short duration average, usually 35 milliseconds. Because impact pile driving is an impulsive sound with short durations, the signal is most appropriately characterized by the L_{max} value. Proxy values for impact driving are found in Attachment 4.

The L_{eq} is the equivalent steady-state noise level in a stated period of time. It contains the same acoustic energy as the time-varying noise level during the same period. L_{eq} is primarily used for a steadier, non-impulsive noise. The L_{eq}, which averages the source over a period of time, is a better descriptor for non-impulsive sound like vibratory pile driving. These values are listed in Attachment 5 for vibratory pile driving and Table 2-3 summarizes L_{max} and L_{eq} data.

Review of the available literature provided two unweighted L_{max} levels, both from the NBK Bangor Test Pile Program. A maximum level of 112 dB re 20 µPa was measured for 36-inch piles (n=9 piles), at the de facto measurement distance of 50 feet, and was therefore chosen as a conservative proxy value for piles 30 and 36-inches. A maximum level of 110 dB was measured for a single 24-inch pile, and was selected as the most representative value for modeling analysis.

Unweighted RMS L_{eq} values of 88 dB were obtained from vibratory pile driving 18-inch steel pipe piles. A single 30-second measurement was made for 24-inch piles during the Test Pile Program at NBK, Bangor. These data fit the overall trend of smaller and larger pile sizes. The limited data set for 24-inch steel pipe, supports a reasonable representative proxy value of 92 dB.

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Limited data were available for 30 and 36-inch piles. One 30-inch pile measured at the Keystone ferry terminal fell within the range of 36-inch piles measured at Bangor., although the average value for this was 2 dB above the average value measured at Bangor. Levels measured at Vashon Island ferry terminal were made using A-weighted filters, and adjusted for range and filter type. Even after corrections were made observed levels were significantly lower than other sites, thus these data were not considered for further analysis. We therefore selected 95 dB (unweighted) as the representative L_{eq} average proxy value for 30-inch and 36-inch piles. Based on the limited data available, the RMS L_{eq} value for 18-inch steel pipe piles was chosen as the proxy source value for vibratory installation or removal of piles less than 24-inch regardless of pile type. The RMS L_{eq} value for 24-inch steel pipe piles was chosen as the best estimate for 24-inch sheet piles.

Table 2-3. Summary of Airborne Source Levels.
Recommended Proxy Source Values Bolded.[1]

Pile Type	Size (diameter in inches)	Installation Method	
		Impact RMS L_{max} (Unweighted) Impact	Vibratory RMS L_{eq} (Unweighted) Vibratory
Timber	12-inch	---	---
Steel Pipe	18-inch	---	**88**
	24-inch	**110**[2]	**92**[2]
	30-inch	---	**95**
	36-inch	**112**	**95**
Steel Sheet	24-inch	---	---

Notes: All values relative to 20μPa and at 15 m (50 ft) from pile.
[1]See Attachments 4 and 5 in Appendix A for projects reviewed.
[2] Limited data set.

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3.0 EVALUATION OF POTENTIAL BUBBLE CURTAIN SOUND ATTENUATION

To reduce noise produced from impact pile driving, bubble curtains are used around the pile as it is driven and can be confined or unconfined. Confined bubble curtains place a fabric shroud or rigid sleeve around the pile to hold air bubbles near the pile, ensuring they are not washed away by currents or tidal action. They are recommended when water velocities are 0.6 meters (1.6 feet per second) or greater (NMFS 2008).

None of the project locations at Naval Base Kitsap, Naval Magazine Indian Island, Naval Station Everett, Naval Air Station Whidbey Island Seaplane Base, Manchester Fuel Depot are in high current areas; therefore, this discussion focuses on unconfined bubble curtains. Unconfined bubble curtains involve use of pressurized air injected from an air compressor on the pile driving barge through small holes in aluminum or PVC pipe around the driven pile. Noise reduction results from unconfined bubble curtains were reported from several projects. There was a wide range of effectiveness from very little measurable attenuation in some cases to high attenuation in others (Illingworth and Rodkin 2001; WSDOT 2013). Caltrans (2009) summarized the application of unconfined bubble curtain systems in various California projects and reported from 1 to 5 dB of attenuation in high current situations and 5 to 15 dB of attenuation in low current situations. Application of a multiple-ring system in a deep water, strong current setting (Benicia-Martinez Bridge) achieved 15 to more than 30 dB attenuation when driving 8-foot diameter piles. Because some sound pressure waves also propagate from the pile through the substrate and reenter the water column, not all sound pressure waves will be attenuated by a bubble curtain (Reinhall and Dahl 2011). Variability in bubble curtain performance when measured at various distances out from the pile is likely explained by the sound propagation properties of various substrates, the localized bathymetry, as well as variances in embedment depths of piles.

3.1 NOISE ATTENUATION ASSUMPTIONS FOR ACOUSTIC MODELING

The Navy conducted a Test Pile Program at Naval Base Kitsap, Bangor where attenuation of an unconfined bubble curtain was measured when driving 24-inch, 36-inch, and 48-inch steel pipe piles.[5] It should be noted that attenuation measurements were not conducted at EHW-2, and are therefore excluded from calculations herein.[6] Calculations for attenuation were made by calculating the amplitude ratio reduction of the pressure metric with the bubble curtain on compared to the bubble curtain off measurements, and then converting the ratio into a decibel

[5] Illingworth and Rodkin, 2012
[6] Attenuated measurements from pile installation at EHW-2 in 2012 were similar to nonattenuated measurements from test piles installed in 2011 at the project site, indicating a nonfunctional bubble curtain. Most commonly observed problems reported for non-functional bubble curtains reflect inadequate air-flow or poor seating of the bottom of the curtain at the water-sediment boundary resulting in a non-attenuated sound path.

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value. Weighted values are computed for each metric based on the number of strikes measured. All measurements were taken from the nominal 10 meter de facto distance from the pile.

The sole 24-inch pile in this project was struck a total of 3 times with the bubble curtain turned on. Therefore, the results are unlikely to be indicative of values that would be obtained on this site with more extensive measurements and are not considered further in this review. Piles for which fewer than 10 strikes were measured were also excluded. It is recommended to acquire a larger 24-inch data set to obtain a better synopsis for these results.

For 36-inch piles the weighted average peak, RMS, and SEL reduction with use of the bubble curtain was 10 dB, where the averages of all bubble-on and bubble-off data were compared (see Table 3-1 below). This data set represents 2 piles, for a total of 165 strikes. For 48-inch piles, the weighted average pressure reduction for RMS, peak, and SEL with use of a bubble curtain was 8 dB, representing 138 strikes. Across all piles (36" and 48") and all metrics (RMS, peak, SEL), the weighted average attenuation was 9 dB.

Table 3-1. Reduction (dB) in Weighted Average Noise Values for Impact Pile Driving of Steel Piles with a Bubble Curtain. Measured at 10 Meters Averaging Mid-Depth and Deep-Depth Data. Measurements Obtained during Bangor Naval Base Test Pile Program.

Pile Size	Attenuation Level (RMS)		Attenuation Level (Peak)		Attenuation Level (SEL)		Weighted Average (all metrics)
	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted	
36-inch	9	9	11	11	10	10	10
48-inch	7	7	9	9	7	7	8
					Overall weighted average		9
Source: Illingworth & Rodkin 2012							

We also reviewed unconfined bubble curtain attenuation rates from available reports from projects in Washington, California, and Oregon that impact drove steel pipe piles up to 48-inches in diameter. Table 3-2 contains a summary of the attenuation levels reported. Several studies were reviewed, but not included in the summary because they were not considered representative. Excluded studies were:

- Willamette River Bridge Project (Caltrans 2012). Bubble curtain was poorly designed and deployed in a river with a high current. No RMS SPLs reported.
- South Umpqua River (Caltrans 2012). Current conditions resulted in little coverage of piles by bubble curtain. No RMS SPLs reported.
- Ten Mile River Bridge Project (Caltrans 2012). 30-inch piles driven with bubble curtain, but inside of cofferdam.

Of the remaining studies reviewed, significant variability in attenuation occurred; however, an average of at least 8 dB of peak SPL attenuation was achieved on ten of the twelve projects

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(Table 3-2). Some of the lower attenuation levels reported were attributed to the bottom ring not seated on the substrate, poor airflow, or currents that resulted in an uneven distribution of bubbles (WSDOT 2005a, WSDOT 2005b, Caltrans 2012).

In summary, bubble curtain performance is highly variable. Effectiveness depends on the system design and on-site conditions such as water depth, water current velocity, substrate and underlying geology. Installation and how well the curtain is seated on the substrate at the bottom are also important factors. To avoid loss of attenuation from design and implementation errors, our project has specific bubble curtain design specifications, including testing requirements for air pressure and flow prior to initial impact hammer use, and a requirement for placement on the substrate.

While bubble curtain performance is variable, we believe that, based on information from the Bangor Naval Base Test Pile Program, an average peak SPL[7] reduction of 8 dB to 10 dB at 10 meters would be an achievable level of attenuation for steel pipe piles of 36- and 48-inches in diameter. However, to be more conservative for 48 inch piles, use of 7 dB for both RMS and SEL metrics is justified.

[7] For most of the studies reviewed, Peak SPLs were the only metric reported.

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Table 3-2. Summary of Attenuation Levels Reported with Unconfined Bubble Curtains During Impact Driving of Steel Pipe Piles up to 40-Inches Diameter.

Project/Location	Steel Pipe Pile Diameter	Range (dB)	Mean Peak dB re 1μPa @ 10 m	Standard Deviation (dB)
Friday Harbor Ferry Terminal Restoration/ San Juan Island marine waters, WA[1]	24-inch 30-inch	0-5	2	2.2
Bainbridge Island Ferry Terminal Preservation/ Puget Sound marine waters, WA[1]	24-inch	3-14	7	4.7
Cape Disappointment Boat Launch Facility, Wave Barrier Project/ Columbia River, Illwaco, WA[1]	12-inch (n=5*)	6-17	11	4.9
Mukilteo Ferry Terminal Test Pile/Puget Sound marine waters, WA[1]	36-inch (n=2)	7-22	15	10.6
Anacortes Ferry Terminal Dolphin Replacement/Puget Sound marine waters, WA[1]	36-inch (n=7)	3-11	8	3.1
SR 520 Test Pile Project/Lake Washington/Portage Bay (freshwater), WA[1, 2]	24-inch (n=4) 30-inch (n=2)	3-32	20	11.1
Columbia River Crossing Test Pile Program/Columbia River, WA/OR[3]	24-inch (n=1)	---	10	---
Tesoro's Amorco Wharf/San Francisco Bay, Martinez, CA[2]	24-inch (n=8 battered and n=8 vertical)	---	~10 dB (not well seated, stated capable of up to 15 dB and strong currents present at times and poor positioning on some piles)*	---
Deep Water-tongue Point Facility Pier Repairs/ Columbia River, Astoria, OR[2]	24-inch (n=10)	5-22	14	---
Portland-Milwaukie Light Rail Project/Willamette River, Portland, OR[2]	24-inch (n=5)	8-27	---	---
Bay Ship and Yacht Dock/San Francisco Bay, Almeda, CA[2]	40-inch (n=2)	---	~10-15 (Not installed at the substrate at start of drive. Performance from part of drive when bubble curtain properly situated).*	---
Richmond-San Rafael Bridge Project/San Francisco Bay, CA[2]	30-inch (n=2)	---	9	---

Sources: [1]WSDOT 2013, Also, see individual report references for WSDOT; [2]Caltrans 2012; [3]CRC 2011.
*As reported by Illingworth and Rodkin in Caltrans 2012.

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4.0 REFERENCES

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2) Caltrans. 2012. Compendium of Pile Driving Sound Data. Sacramento, California. Updated October 2012, posted March 20, 2013. Available at http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm.

3) CRC (Columbia River Crossing). 2011. Columbia River Crossing test pile project hydroacoustic monitoring final report. Technical report prepared by David Evans and Associates, Inc. July 2011. Available at http://www.columbiarivercrossing.org/filelibrary/technicalreports/CRC_Pile_R.

4) Illingworth and Rodkin, Inc. 2001. Noise and vibration measurements associated with the pile installation demonstration project for the San Francisco-Oakland Bay Bridge East Span, Final Data Report, Task Order 2, Contract No. 43A0063.

5) Longmuir, C. and T. Lively. 2001. Bubble curtain systems for use during marine pile driving. Produced by Fraser River Pile & Dredge, Ltd.

6) MacGillivray, Al, Ziegler, E. and J. Laughlin. 2007. Underwater acoustic measurements from Washington State Ferries 2006 Mukilteo ferry terminal test pile project. Technical report prepared by JASCO Research, Ltd for Washington State Ferries and Washington State Department of Transportation, 27 pp. Available at http://www.wsdot.wa.gov/environment/air/piledrivigreports.htm.

7) Navy (Department of the Navy). 2012. Naval Base Kitsap at Bangor test pile program acoustic monitoring report. Prepared by Illingworth and Rodkin, Inc. for the U.S. Navy, April 15, 2012.

8) Navy (Department of the Navy). 2013. Naval Base Kitsap, Bangor Explosives Handling Wharf-2 acoustic monitoring report. Prepared by Illingworth and Rodkin, Inc. for the U.S. Navy.

9) Reinhall, P.G. and P.H. Dahl. 2011. Underwater Mach wave radiation from impact pile driving; theory and observation. Journal of the Acoustical Society of America 130:120-1216.

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10) NMFS (National Marine Fisheries Service). 2008. Programmatic Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Revisions to Standard Local Operating Procedures for Endangered Species to Administer Maintenance or Improvement of Road, Culvert, Bridge and Utility Line Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES IV Roads, Culverts, Bridges and Utility Lines). National Marine Fisheries Service, Northwest Region, August 13, 2008.

11) WSDOT (Washington Department of Transportation). 2005a. Underwater sound levels associated with restoration of the Friday Harbor Ferry Terminal. May 2005. Available at http://www.wsdot.wa.gov/environment/air/piledrivingreaports.htm.

12) WSDOT. 2005b. Underwater sound levels associated with pile driving at the Bainbridge Island ferry terminal preservation project. November 2005. Available at http://www.wsdot.wa.gov/environment/air/piledrivingreports.htm.

13) WSDOT. 2006. Underwater sound levels associated with pile driving at the Cape Disappointment boat launch facility, wave barrier project. March 2006. Available at http://www.wsdot.wa.gov/environment/air/piledrivingreports.htm.

14) WSDOT. 2007. Underwater sound levels associated with pile driving during the Anacortes ferry terminal dolphin replacement project. April 2007. Available at http://www.wsdot.wa.gov/environment/air/piledrivingreports.htm.

15) WSDOT. 2010. Underwater sound levels associated with driving steel piles for the State Route 520 bridge replacement and HOV project pile installation test program. Prepared by Illingworth and Rodkin, Inc. Available at http://www.wsdot.wa.gov/environment/air/piledrivingreports.htm.

16) WSDOT. 2013. Biological Assessment Preparation Advanced Training Manual Version 2013 (Chapter 7 – updated February 2012). Available at http://www.wsdot.wa.gov/environment/biology/ba/baguidance.htm.

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APPENDIX A

STUDIES REVIEWED FOR EVALUATION OF UNDERWATER PILE DRIVING SOUND

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Appendix A: Studies Reviewed for Evaluation of Underwater Pile Driving Sound

Attachment 1. Impact Pile Driving SPLs from Studies Utilizing Steel Pipe/CISS Piles. Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Hammer Type	Water Depth (m)	Distance (m)	RMS (dB re 1 µPa)	Peak (dB re 1 µPa)	SEL (dB re 1 µPa^{2}s)
24-inch Steel Pipe								
Bainbridge Island Ferry Terminal[1]	**Bainbridge Island, WA**	**n=5**	**Diesel**	**2.1-3.4**	**10**	**Weighted Ave 195 Ave range 193-198**	**Weighted Ave 206 Ave range 202-209**	**Weighted Ave 181 Ave range 177-184**
Friday Harbor Ferry Terminal[2]	**Friday Harbor, WA**	**n=5**	**Diesel, pneumatic, hydraulic**	**10-14.3*, ****	**10**	**Weighted Ave 189 Ave range 181-193**	**Weighted Ave 207 Ave range 196-213**	**Weighted Ave 181 Ave range 176-185**
Bangor Test Pile Program[3]	Bangor Naval Base, WA	† n=1	Impact	4.6	10	Max 180	Max 193	Ave 167
Conoco/Phillips Dock [4]	Rodeo, San Francisco Bay, CA	n=2	Diesel	>5	10	Range 188-189	203 (unclear if this is average or ave max)	Typical 177 Range 177-178
Tesoro's Amorco Wharf- all values were attenuated- values reported are mostly unattenuated – strong currents present[4]	San Francisco Bay; Martinez, CA	(1st pile with poor attenuation)	Diesel	10-15	10	189	Max 209	174
Deep Water-Tongue Point Facility Pier Repairs[4]	Mouth of Columbia River; Astoria, OR	n=10	Diesel	unknown	10	Ave 182 Ave range 178-189	Ave max 198 Range 193-206 Max 207	Ave 168 Ave range 160-175
30-inch Steel Pipe								
Richmond-San Rafael Bridge, CALTRANS[4]	San Rafael, CA	n=4	Diesel	4-5	10	Typical 190 (max=192)	210 max (typical 205)	---
Eagle Harbor Maintenance Facility[5]	**Bainbridge Island, WA**	**n=3**	**Diesel**	**10**	**10 (n=2) 16 (n=1)**	**Weighted Ave 192 Ave range 192-193**	**Weighted Ave 204 Ave range 203-204**	**---*** **
Friday Harbor Ferry Terminal #8[2]	**Friday Harbor, WA**	**n=1**	**Diesel**	**10.4***	**10**	**196**	**211**	**187**
Vashon Ferry Terminal[6,#]	**Vashon Island, WA**	**n=3**	**Diesel**	**11-12**	**10**	**Weighted Ave 195 Ave range 192-196**	**Weighted Ave 215 Ave range 212-217**	**Weighted Ave 186 Ave range 182-187**

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Attachment 1. Impact Pile Driving SPLs from Studies Utilizing Steel Pipe/CISS Piles (continued). Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Hammer Type	Water Depth (m)	Distance (m)	RMS (dB re 1 µPa)	Peak (dB re 1 µPa)	SEL (dB re 1 µPa²s)
36-inch Steel Pipe****								
Humboldt Bay Bridge[4]	Humboldt Bay – Eureka, CA	CISS n=1, restrikes	Diesel	10	10-	193 (max)	210 (max)	183 (max)
Mukilteo Test Piles[7]	**Mukilteo, WA**	**n=2**	**Diesel**	**7.3**	**10**	**Weighted Ave 190 Ave range 187-191**	**Weighted Ave 205 Ave range 202-207**	**Weighted Ave 183 Ave range 180-184**
Anacortes Ferry[8]	**Anacortes, WA**	**n=7**	**Impact**	**12.8**	**10**	**Weighted Ave 192 Ave range 189-193**	**Weighted Ave 209 Ave range 205-211**	**Weighted Ave 185 Ave range 183-186**
Bangor Test Pile Program[3,#]	**Bangor Naval Base, WA**	**n=4**	**Diesel**	**13.7-26.8**	**10**	**Weighted Ave 194 Ave range 185-196**	**---^**	**Weighted Ave 181 Ave range 173-183**

Notes: Ave = Average.
***** Substrate was sandy silt/clay.
****** Substrate was sandy silt/rock.
*** Single strike SEL not reported.
****EHW-2 project at Bangor waterfront measured 24- and 36-inch piles; however, all piles were attenuated so they are not included in the table. 24-inch (n = 41) averages were: average peak = 199 (s.d. 9.58), average RMS = 179 (s.d. = 24.10), SEL = 170 dB (s.d. = 7.48). 36-inch pile (n = 26): average peak = 205 (s.d. = 4.33), average RMS = 188 (s.d. = 5.01), average SEL = 175 (s.d. = 5.11) (Navy 2013).
† 24-inch piles were not hit very hard, so these are not representative of the levels that may occur in the future or elsewhere.
\# distance to pile ranged above and below 10m. Data normalized to 10m using $15\log_{10}$ (range/10m) relationship.
^ Average peak values not reported.

Sources:

[1] WSDOT 2005a
[2] WSDOT 2005b
[3] Navy 2012
[4] Caltrans 2012
[5] JASCO Research. 2005, WSDOT 2008
[6] WSDOT 2010b
[7] WSDOT 2007a
[8] WSDOT 2007b

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Attachment 2. Impact Pile Driving SPLs from Studies Utilizing Concrete Piles. Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Hammer Type	Water Depth (m)	Distance (m)	RMS (dB re 1 μPa)	Peak (dB re 1 μPa)	SEL (dB re 1 μPa²s)
16-inch and 18-inch Piles								
Pier 2 Concord NWS[1] (16-inch square)	**Concord, CA**	**n=5**	**Drop Steam Powered**	**7**	**10**	**Ave 171 Ave range 167-173**	**Ave max 183 Ave max range 182-184 Max 184**	**N/A**
Berkeley Marina (2007) [1] (18-inch octagonal)	**Berkeley, CA**	**n=1**	**Diesel**	**2-3**	**10**	**Ave 159 Ave range 155-167**	**Ave max 172 Ave range 172-181 Max 181**	**Ave 155**
Berkeley Marina (2009) [1] (18-inch octagonal)	**Berkeley, CA**	**n=3**	**Diesel**	**2-3**	**10**	**Ave 169 Ave range 165-178**	**Ave max 189 Ave max range 184-192 Max 192**	**Ave 159**
24-inch Piles								
Mukilteo Ferry Terminal[2] (octagonal)	**Mukilteo, WA**	**n=1**	**Diesel**	**7-8**	**10**	**Ave 170 (single pile)**	**Ave max 184 Single pile**	**Ave 159 dB Range 159-170**
Amports Pier 95[1] (octagonal)	**Benicia, CA**	**Not provided**	**Diesel**	**3-7**	**10**	**Ave 170 Range 168-172**	**Ave max 184 Range 180-192 Max 192**	**N/A**
Pier 40 Marina[1] (square)	**San Francisco, CA**	**n=7**	**Diesel**	**3-4**	**10**	**Ave 171* Ave range 167-174***	**Ave max 184* Ave range 180-186* Max 186****	**N/A**
Berth 22 Port of Oakland (December 2004)[1] (octagonal)	**Oakland, CA**	**Several**	**Diesel**	**0-15 (dependent on row)**	**10 (mostly)**	**Ave 176*** Ave range*** 171-179 Max 181**	**Ave max 188*** Ave max range*** 183-191 Max 193**	**Ave 165*** Ave range** 162-167**
Berth 22 Port of Oakland (August 2004)[1] (octagonal)	**Oakland, CA**	**n=4**	**Diesel**	**10-13**	**10**	**Ave 175 Ave range during loudest part of drive 174-176 Max 178**	**Ave max 187 Ave max range during loudest part of drive 186-188 Max 190**	**Ave 165 Ave range during loudest part of drive 164-166 Max 168**

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Attachment 2. Impact Pile Driving SPLs from Studies Utilizing Concrete Piles (continued).
Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Hammer Type	Water Depth (m)	Distance (m)	RMS (dB re 1 μPa)	Peak (dB re 1 μPa)	SEL (dB re 1 μPa^{2}s)
Berth 32 Port of Oakland (2005)[1] (octagonal)	**Oakland, CA**	**n=2**	**Diesel**	**3-7**	**10**	**Ave 174** **Ave range 172-176**	**Ave max 186** **Ave max range 185-187** **Max 187**	**Ave 163** **Ave range 158-165**
Berth 32 Port of Oakland (2004)[1] (octagonal)	**Oakland, CA**	**n=5**	**Diesel**	**>10**	**10**	**Ave 173** **Ave range 173-174**	**Ave max 185** **Ave max range 184-185** **Max 185**	**Ave 162** **Ave range 161-163**
Humboldt State University Floating Dock****[1] **(octagonal)**	Humboldt Bay, Eureka, CA	n=3	Diesel	3-4	10	Ave 157 Ave range 156-158	Ave max 179 Ave max range 176-179 Max 179	Ave 148 Ave range 142-151

Notes: Ave = Average.
* For piles with fuel setting on high, no jetting.
**Pile with fuel setting on low, no jetting.
*** Average for row, not pile. Sound levels varied by depth. Only in-water sound levels reported in table (unattenuated values from Row A-D in Table 1.5-4 in Caltrans 2013).
****Piles jetted, so project data is not included in analysis.

Sources:
[1] Caltrans 2012
[2] WSDOT 2007a

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Attachment 3. Vibratory Pile Driving SPLs from Marine Projects. Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Water Depth (meters)	Distance (meters)	Mean RMS* dB re 1 µPa
12-inch Timber					
Port Townsend Dolphin Timber Pile Removal[1]	**Port Townsend, WA**	**n=1**	**---**	**16**	**Average 150 Range 149-152**
13-inch Steel Pipe					
Mad River Slough Pipeline Construction[2]	Mad River Slough, Arcata, CA	n=3	4.5-5.5	10	155
16-inch Steel Pipe					
EHW-1[3]	**Bangor, WA**	**n=8**	**9-12**	**10**	**162 Ave range 153-168**
24-inch Steel Pipe					
Friday Harbor[4]	**Friday Harbor, WA**	**n=1**	**2.6**	**10**	**162**
Trinidad Pier Reconstruction[2]	**Trinidad Bay, Humbolt County, CA**	**n=2**	**15.2**	**10**	**Typical 160 range 158-178**
Bangor Test Pile Program[5]	**Bangor Naval Base, WA**	**n=2 (1 pile vibed in and out)**	**4.6**	**10**	**160 Ave range 157-160****
30-inch Steel Pipe					
Edmonds[6]	**Edmonds, WA**	**n=2**	**6.4**	**10**	**165-166**
Keystone Ferry Terminal[7]	**Coupeville, WA**	**n=4**	**~9.4**	**10 11 6 11**	**Per pile values due to different distances (165 176 176 165) Ave 173 Ave range 165-176**
Vashon Ferry Terminal[8]	**Vashon Island, WA**	**n=4**	**<6**	**11-16**	**167 Ave range 160 - 169**
Port Townsend Test Pile Project[9, 10]	**Port Townsend, WA**	**n=1**	**8.8**	**10**	**170 Ave range 164-174**
EHW-1[3]	**Bangor, WA**	**n=35**	**9-12**	**10**	**168 Ave range 155-174**
36-inch Steel Pipe					
Edmonds Ferry Terminal[6]	**Edmonds, WA**	**n=2**	**5.8**	**11**	**Ave range 162-163**
Anacortes Ferry Terminal[11]	**Anacortes, WA**	**n=2**	**12.7**	**11**	**Ave range 168-170**
Port Townsend Test Pile Project[9, 10]	**Port Townsend, WA**	**n=1**	**9.5**	**10**	**172 159-177**
Bangor Test Pile Program[5]	**Bangor Naval Base, WA**	**n=~33**	**13.7-26.8**	**10**	**164 ** Ave range 154-169**

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Attachment 3. Vibratory Pile Driving SPLs from Marine Projects (continued). Bolded values were considered for proxy source levels.

Project	Location	Number of Piles Measured	Water Depth (meters)	Distance (meters)	Mean RMS* dB re 1 µPa
24-inch AZ25 Steel Sheet					
Berth 23, Port of Oakland[2]	**Oakland, CA**	**n=1**	**~12-14**	**10**	**163*** **
Berth 30, Port of Oakland[2]	**Oakland, CA**	**n=5**	**~12**	**10**	1-sec SEL****** = 159** **Ave range 157-160 (162 highest ave from bottom depth)**
Berth 35/37, Port of Oakland[2]	**Oakland, CA**	**---**	**15**	**10**	**163**

Notes: Ave = Average.
*WSDOT typically reports average of 30-second RMS values calculated over the duration of a drive.
** Average of all pile driving events.
***Involved only stabbing. Average reported by Caltrans Table I-1.2-3.
****RMS SPLs were not reported, but would be similar to SEL for 1 second. Average top and bottom depths.

Sources:
[1] WSDOT 2011a
[2] Caltrans 2012
[3] Miner 2012
[4] WSDOT 2010a
[5] Navy 2012
[6] WSDOT 2011b
[7] WSDOT 2010c
[8] WSDOT 2010d
[9] WSDOT 2010e
[10] Laughlin 2010
[11] WSDOT 2012

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Attachment 4. Impact Pile Driving Lmax Airborne SPL Studies. Bolded projects were considered for proxy source levels.

Project	Location	Number of Piles Measured	Distance (meters/feet)	L_{max} dB re 20 µPa
12-inch Steel Pipe				
Cape Disappointment Boat Launch Facility, Wave Barrier Project[1]	Columbia River, Astoria, OR	1 at 50 m	50 m/164 ft	89 A-weighted
24-inch Steel Pipe				
Bangor Test Pile Program	**Bangor Naval Base, WA**	**1**	**15.2 m/50 ft 121.9 m/400 ft**	**110 dB (109dBA) 95 dB (93 dBA)**
SR 520 Bridge Replacement Test Pile[2]	Portage Bay, Seattle, WA	2	11-15 m/36-49 ft	95-100 dBA
30-inch Steel Pipe				
Friday Harbor Ferry Terminal Restoration[3]	San Juan Island Area, Friday Harbor, WA	1	49 m/160 ft	---
SR 520 Bridge Replacement Test Pile[2]	Union Bay, Lake Washington, Seattle, WA	4	11-15 m/36-49 ft	103-106 dBA
36-inch Steel Pipe				
Bangor Test Pile Program[4]	**Bangor Naval Base, WA**	**---**	**15 m/50 ft**	**109 dB (s.d.=2.58) Range 106-112 dB**

Notes: All values unweighted unless indicated. Only unweighted values were considered for proxy values.

Sources:
[1] WSDOT 2006
[2] WSDOT 2010f
[3] WSDOT 2005b
[4] Navy 2012

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Attachment 5. Vibratory Pile Driving L_{eq} Airborne SPL Studies. Bolded projects were considered for proxy source levels.

Project	Location	Number of Piles Measured	Distance (meters/feet)	Average RMS L_{eq} dB re 20 μPa*	Average RMS L_{eq} dBA re 20 μPa*
18-inch Steel Pipe					
Wahkiakum Ferry Terminal [1]	**Columbia River, WA**	**1**	**15.2 m/50 ft***	**87.5**	
24-inch Steel Pipe					
Bangor Test Pile Program	Bangor Naval Base, WA	1	15.2 m/50 ft 121.9 m/400 ft	92 78 dB	85 72
SR 520 Bridge Replacement Test Pile[2]	Portage Bay, Seattle, WA	1	11 m/36 ft	88 dBA	---
30-inch Steel Pipe					
Keystone Ferry Terminal[1]	**Puget Sound, WA**	**1**	**15.2 m/50 ft***	**95 Range 93-96**	
Vashon Ferry Terminal Test Pile Project[1,3]	Puget Sound, Vashon Island, WA	2	15.2 m/50 ft*	~83-85**	~77-80 dBA*
36-inch Steel Pipe					
Bangor Test Pile Program[4]	**Bangor Naval Base, WA**	**---**	**15 m/50 ft**	**93 (s.d. =3.08) Range 89-102**	

Notes: All values unweighted unless indicated.
* Sound pressure levels standardized to 50 ft range. Measurements made at 11 meters.
**Converted to C-weighted from A-weighted measurements to approximate unweighted sound level, reported at a distance of 26 to 36 feet.

Sources:
[1] WSDOT 2010g
[2] WSDOT 2010f
[3] WSDOT 2010d
[4] Navy 2012

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APPENDIX B

DATA CHARTS FOR MEASURED DATA AND CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS

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Appendix B: Data Charts for Measured Data and Cumulative Probability Distribution Functions

Impact RMS

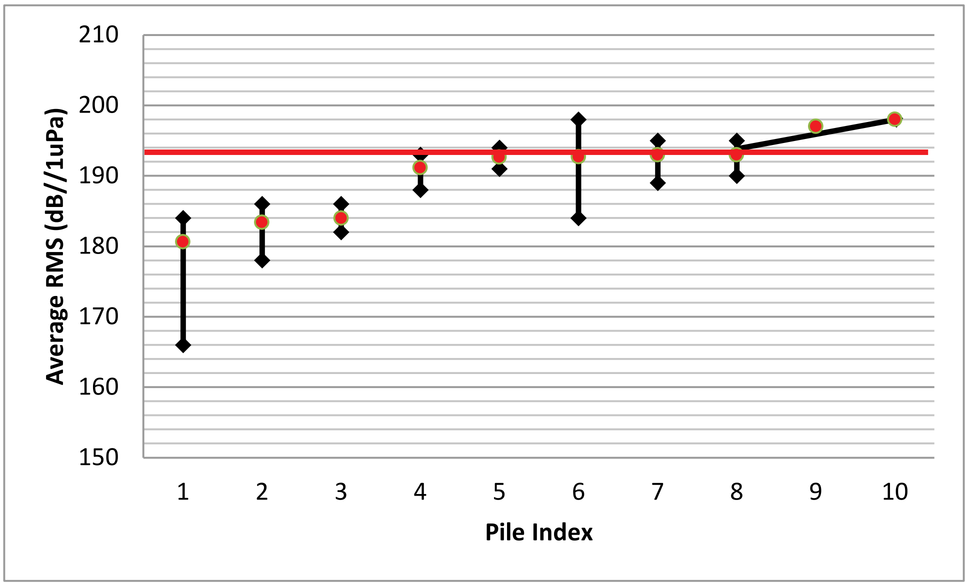

Figure B-1. 24-inch RMS Measurements

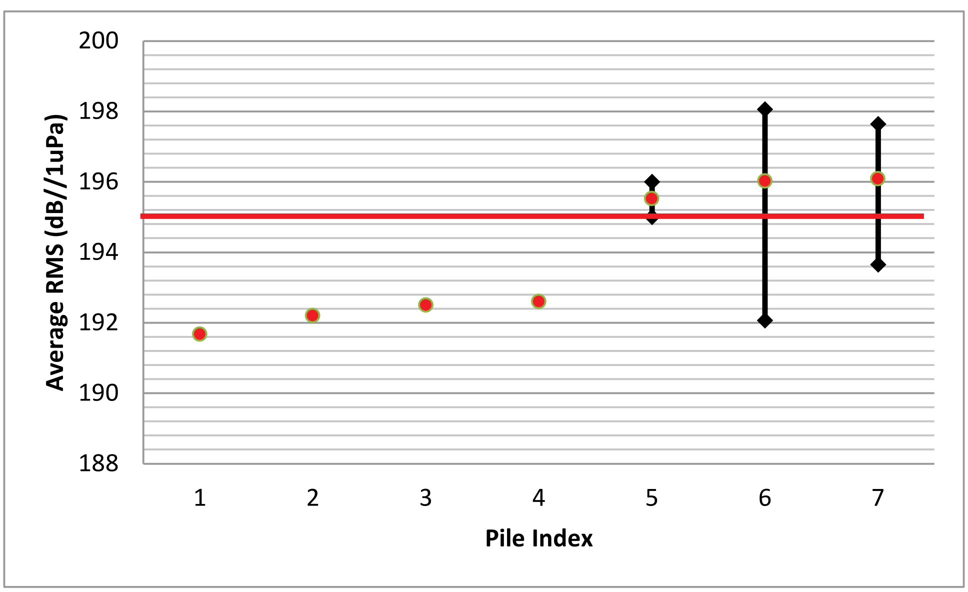

Figure B-2. 30-inch RMS Measurements

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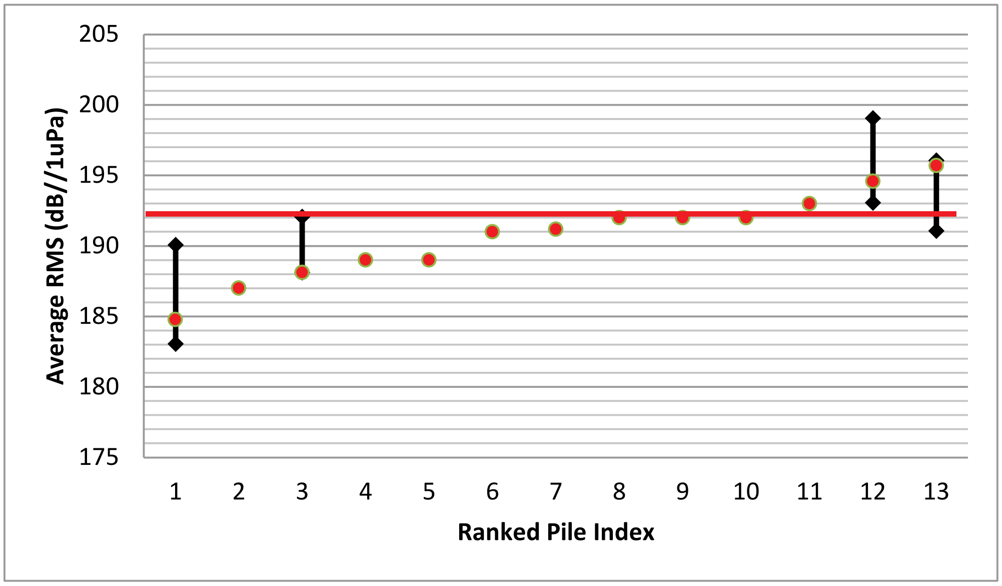

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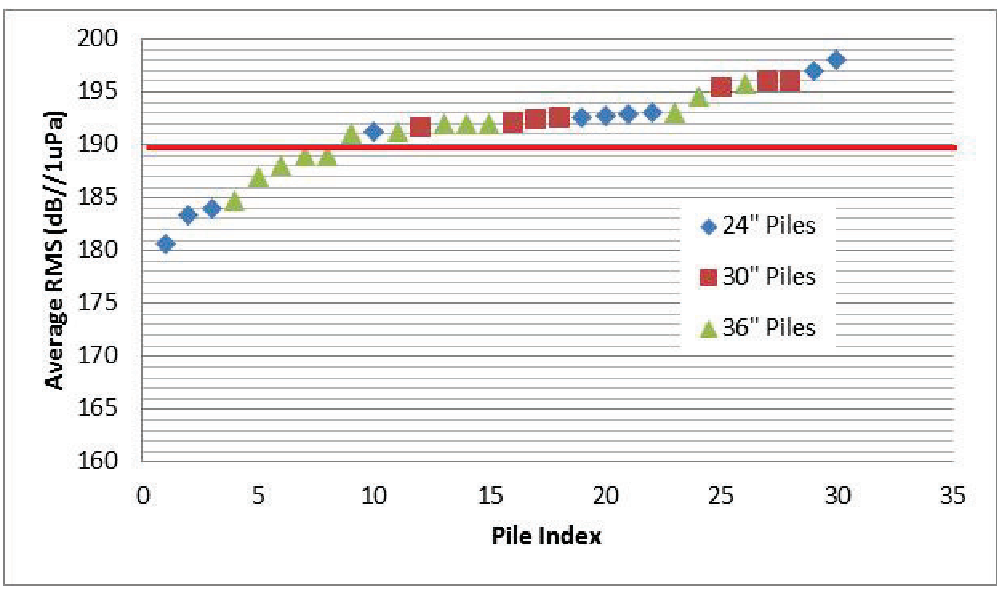

Figure B-4. Combined Analysis: 24, 30, 36-inch RMS Measurements

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Impact Average Peak

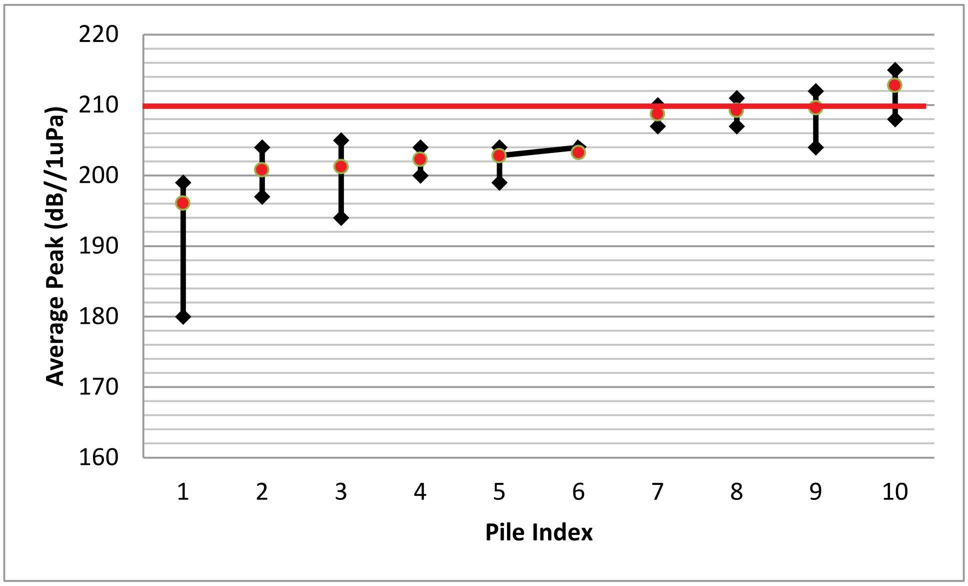

Figure B-5. 24-inch Average Peak Measurements

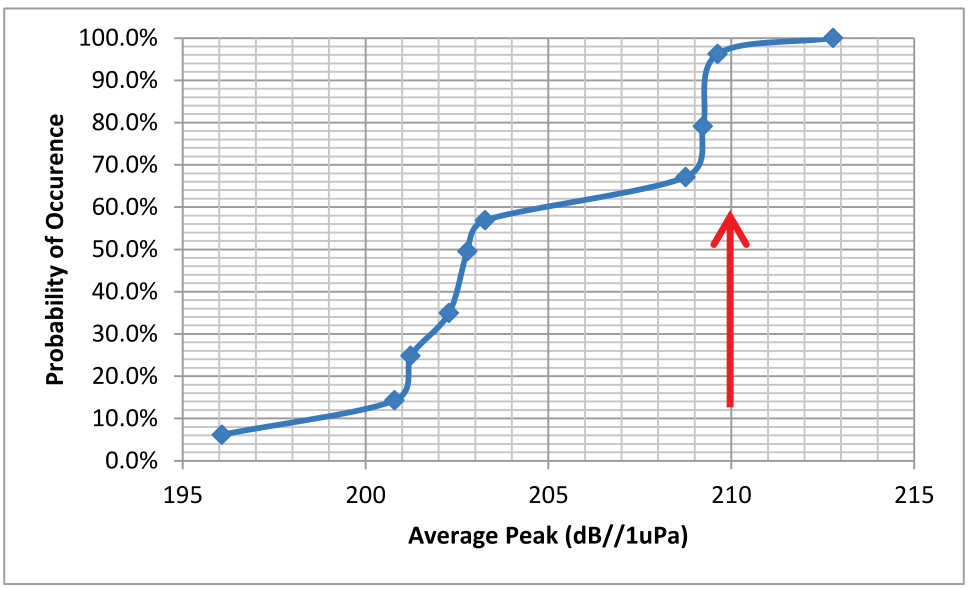

Figure B-6. 24-inch Average Peak Cumulative Distribution Function

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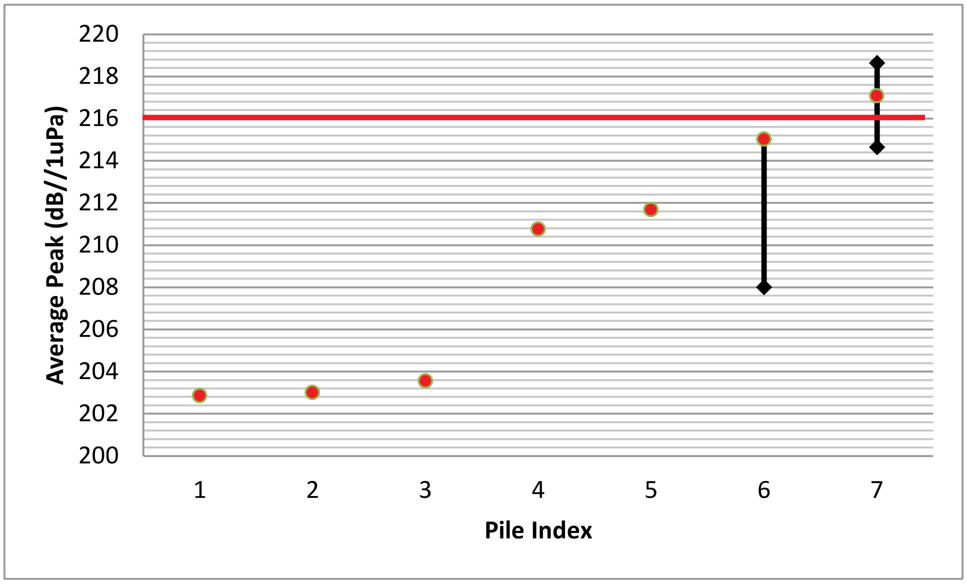

Figure B-7. 30-inch Average Peak Measurements

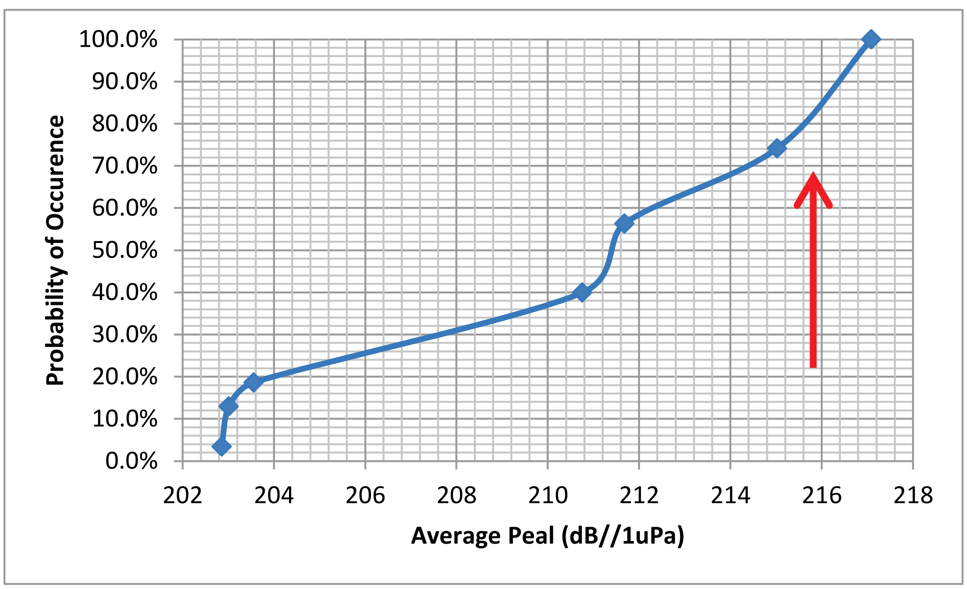

Figure B-8. 30-inch Average Peak Cumulative Distribution Function

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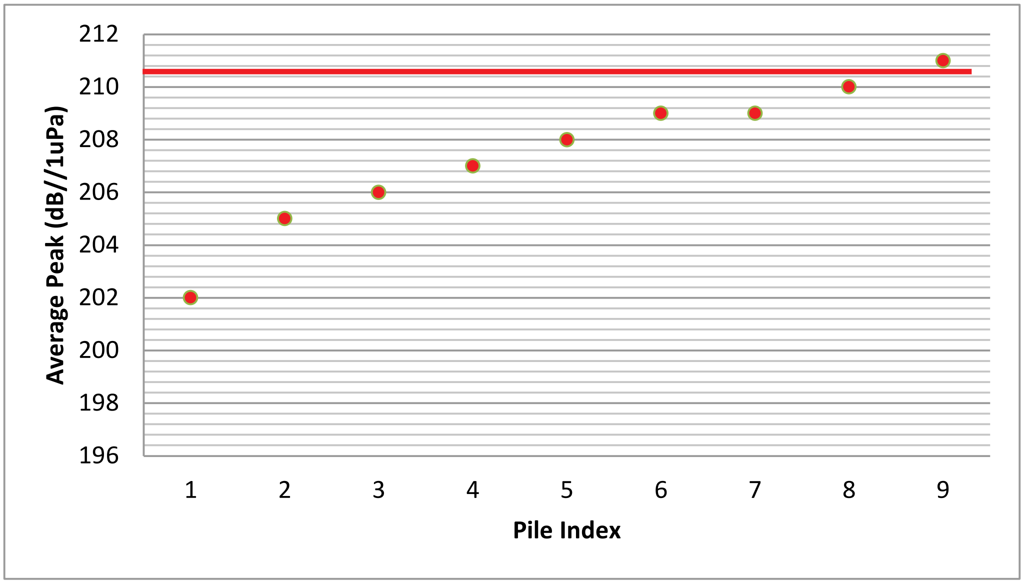

Figure B-9. 36-inch Average Peak Measurements

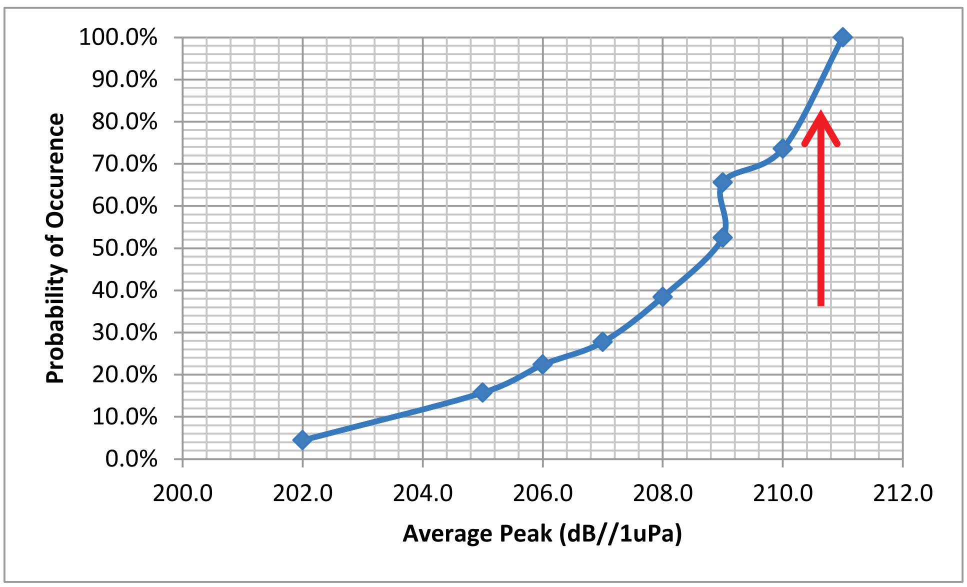

Figure B-10. 36-inch Average Peak Cumulative Distribution Function

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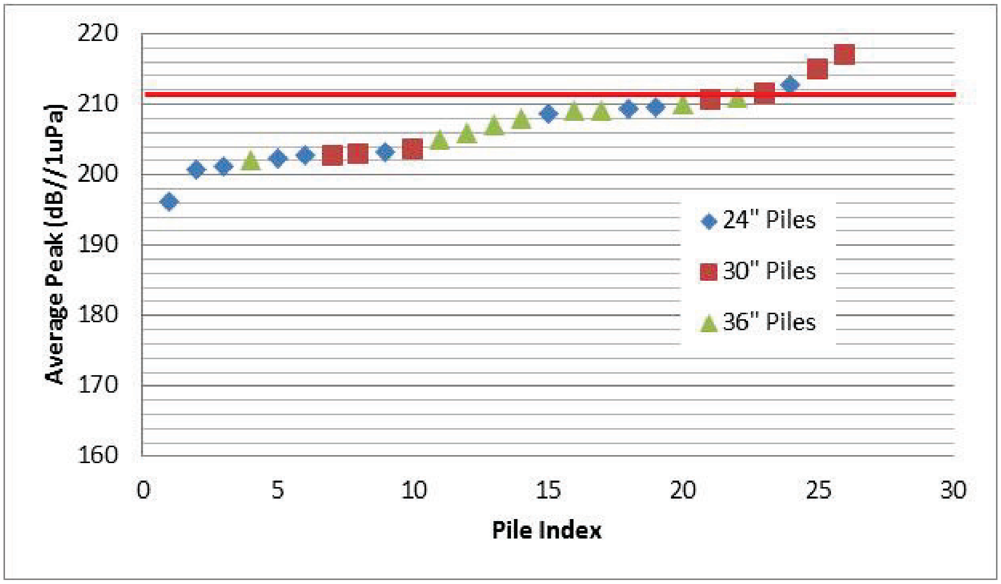

Figure B-11. Combined Analysis: 24, 30, 36-inch Average Peak Measurements

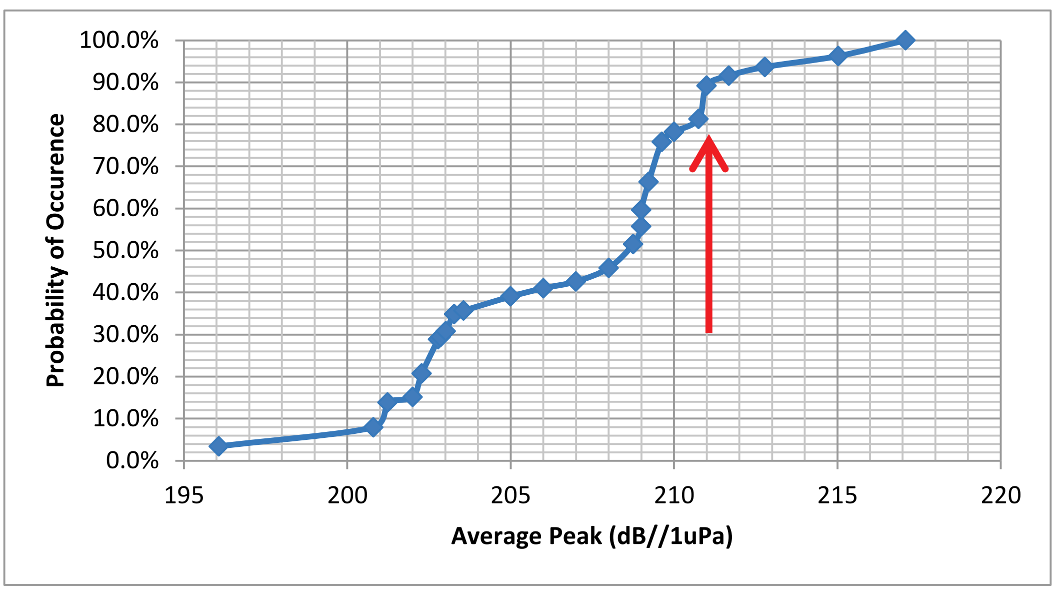

Figure B-12. Combined Analysis: 24, 30, 36-inch Average Peak Cumulative Distribution Function

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Impact SEL

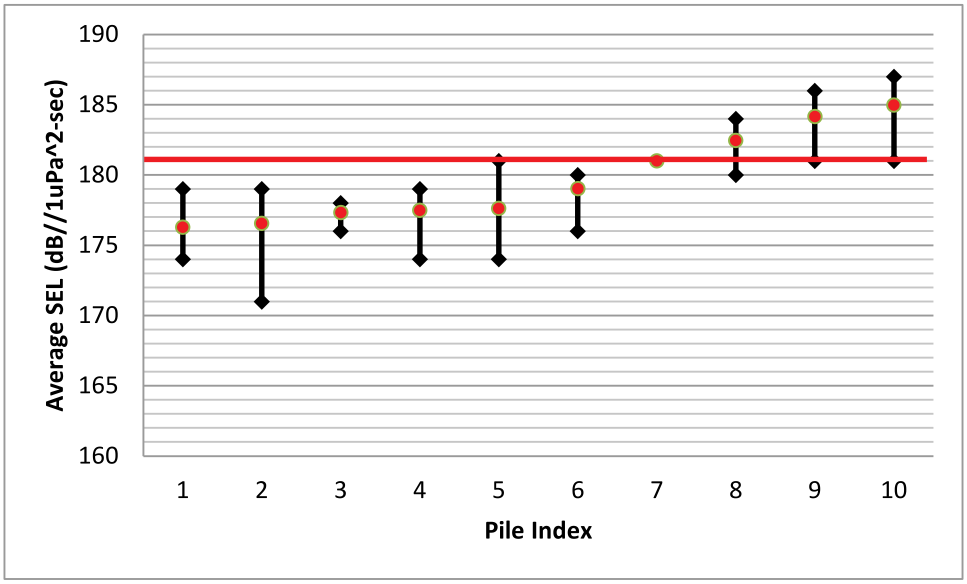

Figure B-13. 24-inch SEL Measurements

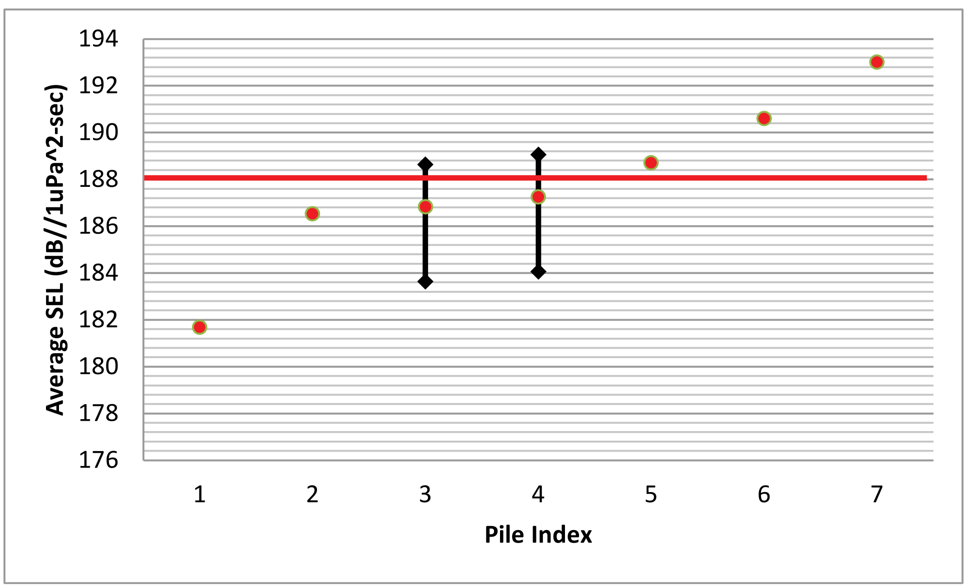

Figure B-14. 30-inch SEL Measurements

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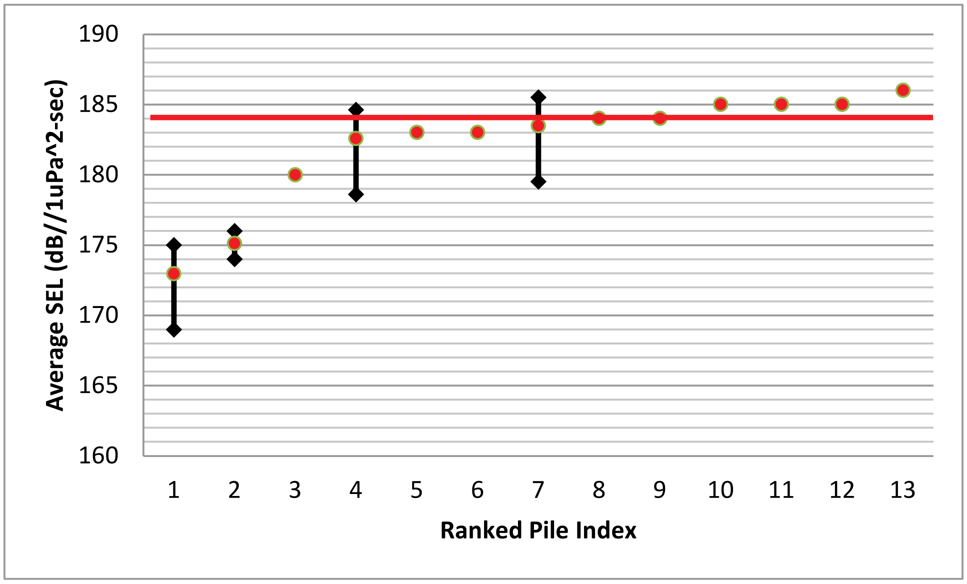

Figure B-15. 36-inch SEL Measurements

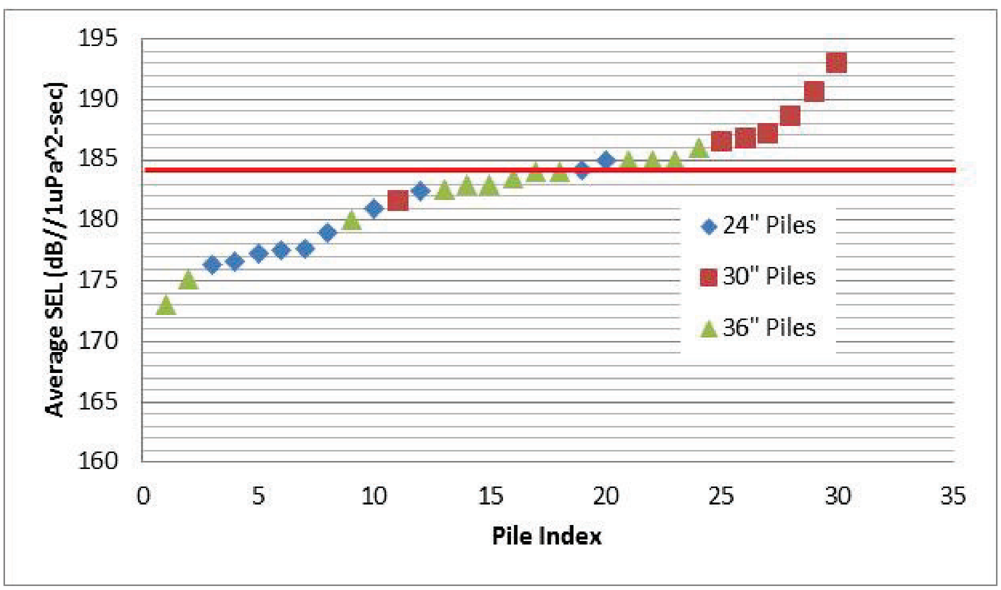

Figure B-16. Combined Analysis: 24, 30, 36-inch SEL Measurements

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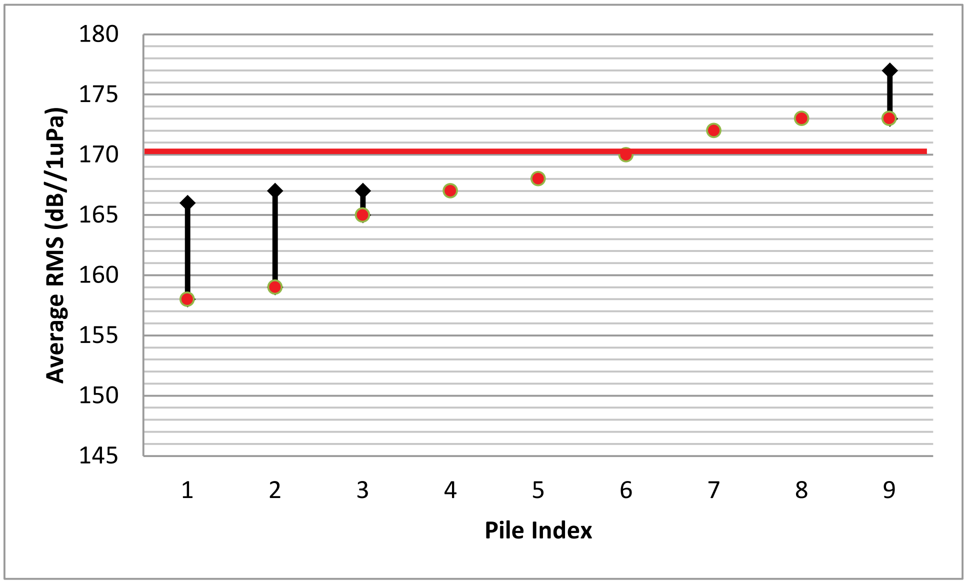

Figure B-17. Concrete 16, 18-inch RMS Measurements

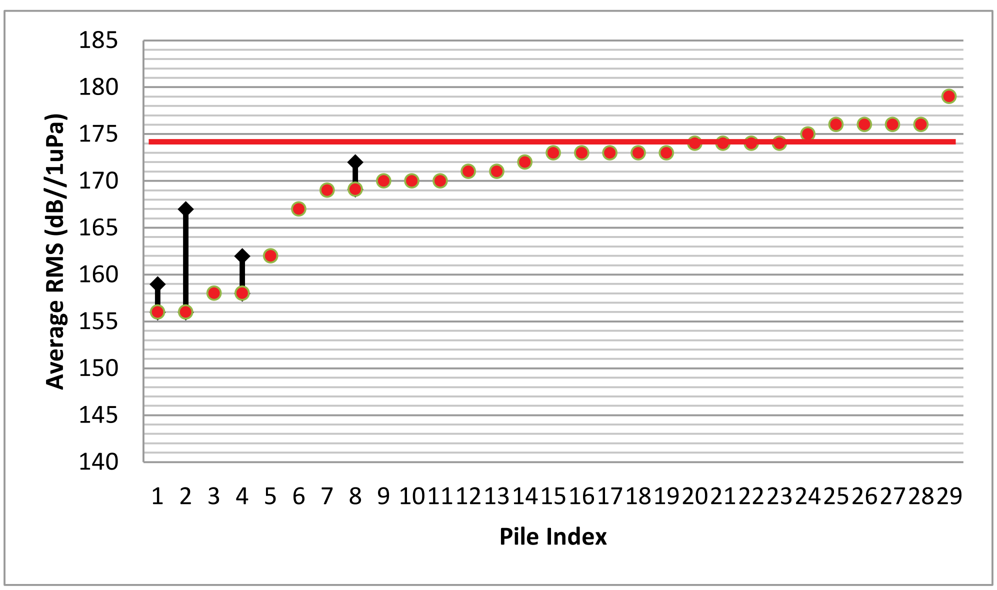

Figure B-18. Concrete 24-inch RMS Measurements

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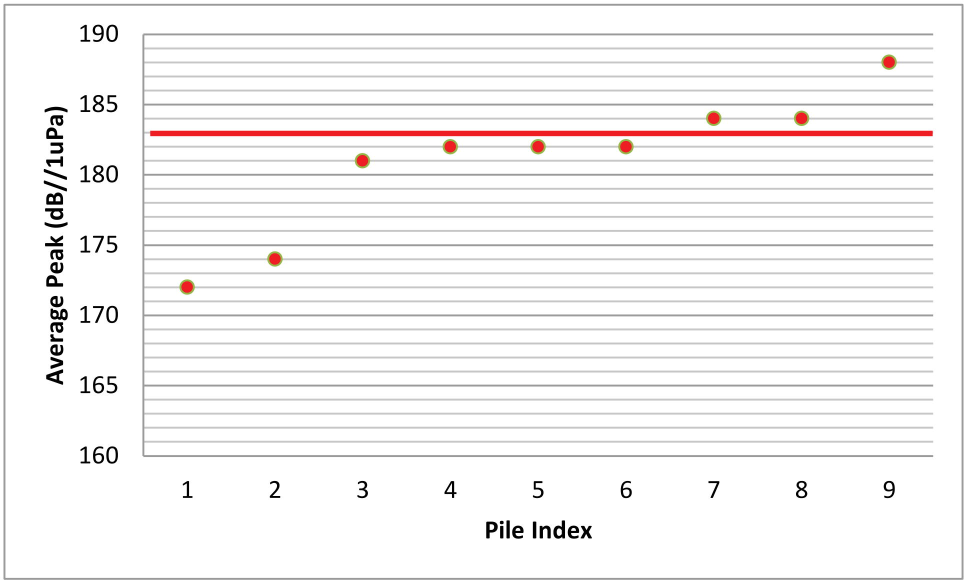

Figure B-19. Concrete 16, 18-inch Average Peak Measurements

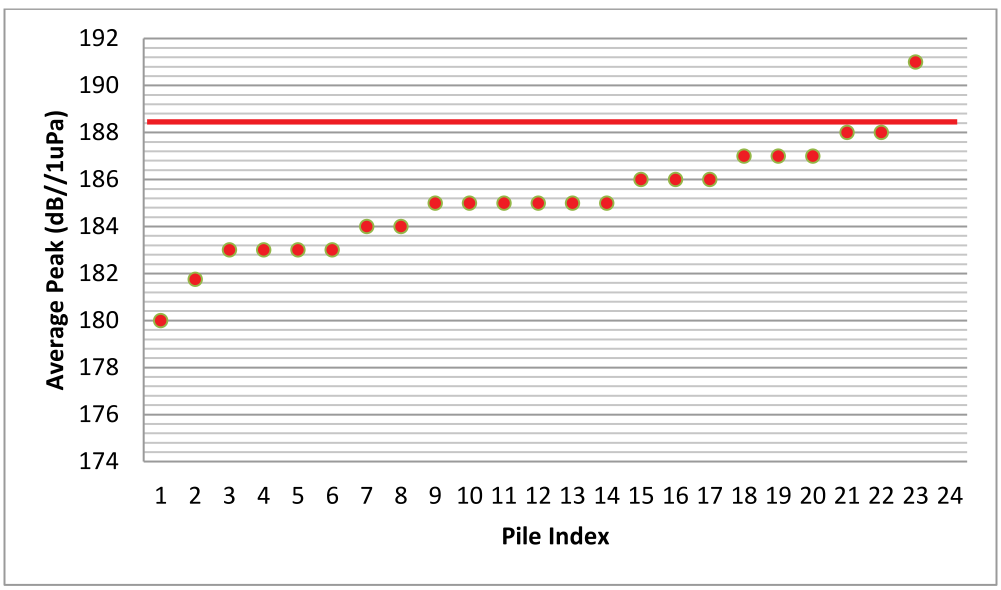

Figure B-20. Concrete 24-inch Average Peak Measurements

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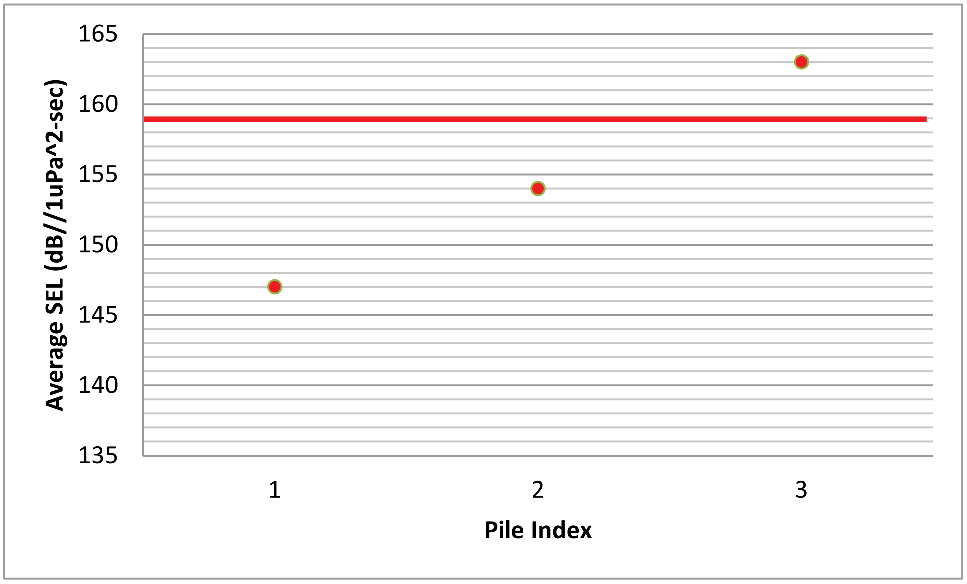

Figure B-21. Concrete 16, 18-inch SEL Measurements

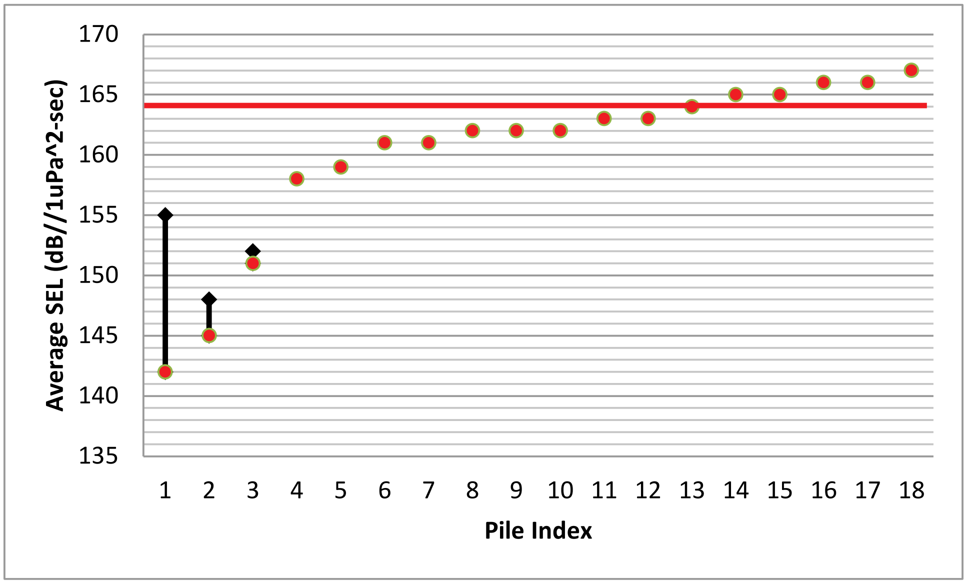

Figure B-22. Concrete 24-inch SEL Measurements

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Vibratory RMS

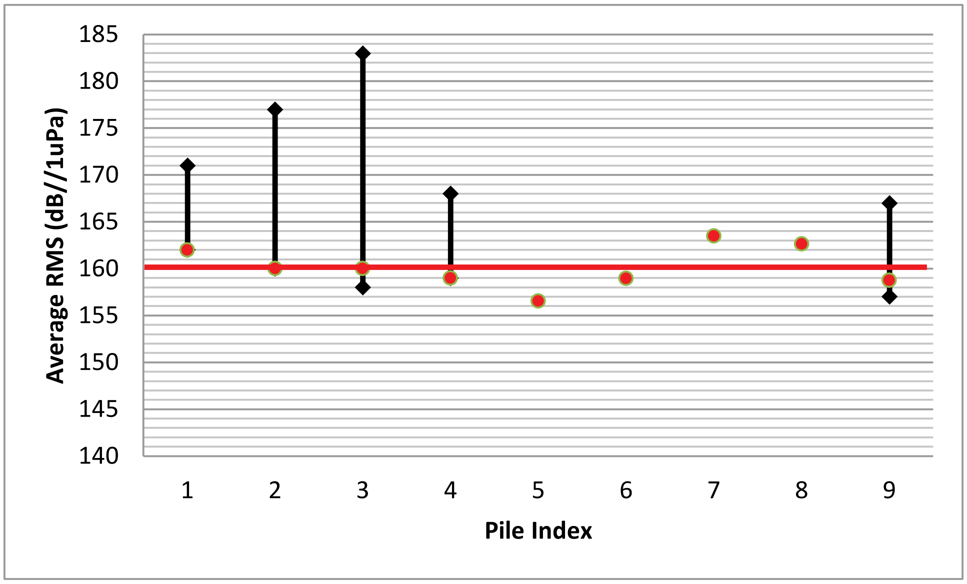

Figure B-23. 24-inch RMS Vibratory Measurements

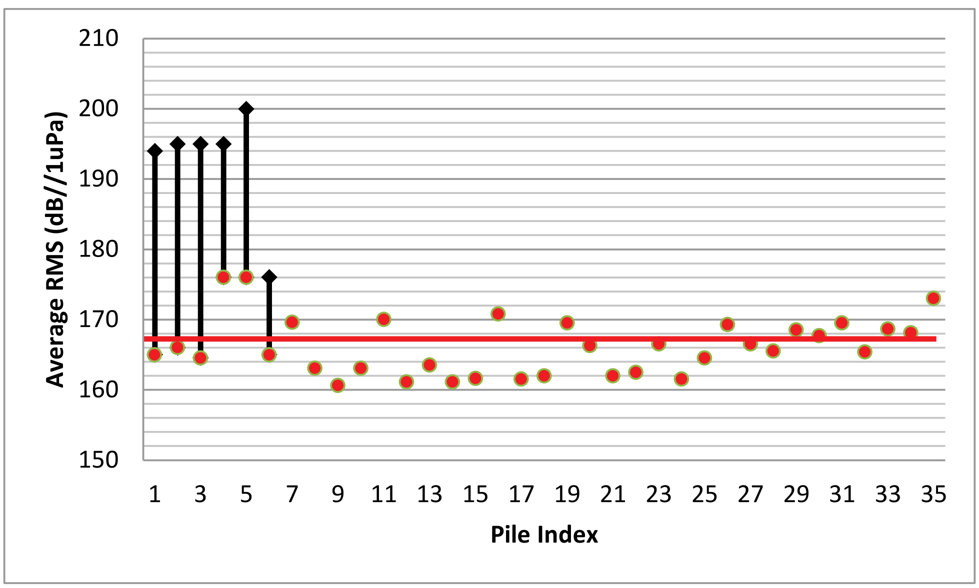

Figure B-24. 30-inch RMS Vibratory Measurements

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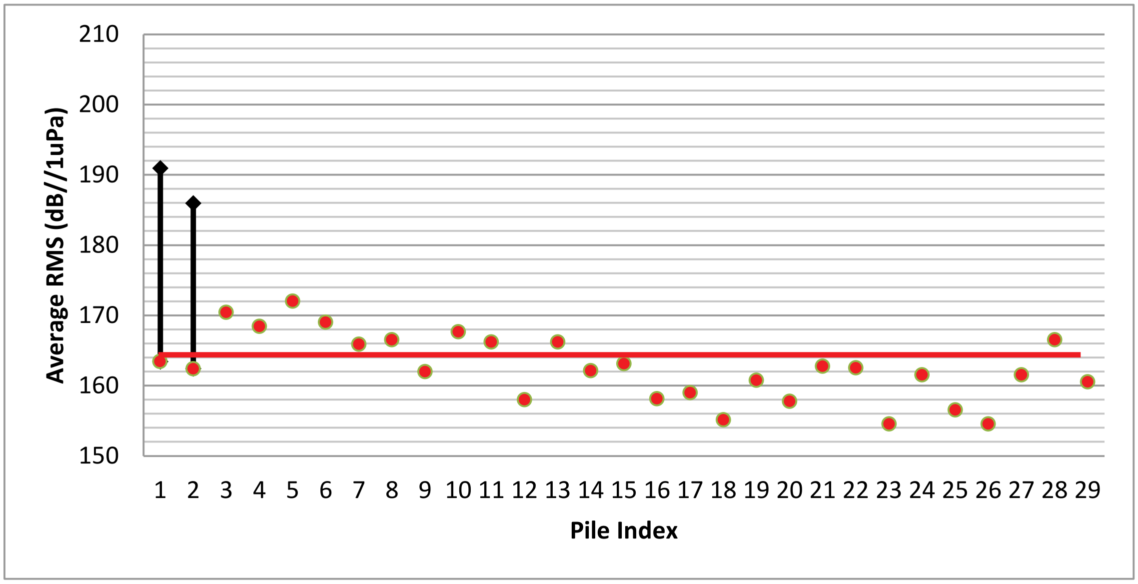

Figure B-25. 36-inch RMS Vibratory Measurement

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Appendix C

Marine Mammal Monitoring Plan

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Appendix C
Marine Mammal Monitoring Plan

1 Introduction

The U.S. Department of the Navy (Navy) proposes to construct a Transit Protection Program (TPP) Pier and upland support facilities at Naval Base Kitsap Bangor. This monitoring plan provides a protocol for marine mammal monitoring during in-water pile driving for the TPP construction that will ensure compliance with the Incidental Harassment Authorization (IHA) issued for this project by the National Marine Fisheries Service (NMFS) and the Endangered Species Act effects determinations on marine mammals described in this Biological Assessment.

Marine mammal monitoring will occur during in-water construction. Visual marine mammal monitoring will be conducted before, during, and after pile driving by experienced Marine Mammal Observers (MMOs) within zones that are estimated to encompass acoustic levels that could exceed injury or behavioral disturbance thresholds. To protect marine mammals, pile driving will not start, or will cease if underway, if marine mammals enter the Level A Injury Zone. In addition to the Level A shutdown protocol, if cetaceans are seen in the Level B Monitoring Zone, a pile driving shut down will occur.

2 Methods

2.1 Observer Qualifications

Monitoring will be conducted by qualified, trained observers. An observer may be a biologist with prior training and experience to meet the qualifications in conducting marine mammal monitoring or a professional MMO with certification (i.e., Protected Species Observer) or recognized membership in a professional organization (i.e., Marine Mammal Observer Association). An observer must have the ability to identify marine mammal species and describe relevant behaviors that may occur in proximity to in-water construction activities. At least one member of the observer team will have verifiable experience with marine mammal monitoring during pile driving construction.

An observer will be placed at the best vantage point(s) practicable (e.g., from a small boat, the pile driving barge, on shore, or any other suitable location) to monitor for marine mammals and implement shutdown/delay procedures when applicable by calling for the shutdown to the hammer operator. The observers will have no other construction related tasks while conducting monitoring.

A dedicated monitoring coordinator will be on-site during all construction days. The monitoring coordinator will oversee marine mammal observers. The monitoring coordinator will serve as the liaison between the marine mammal monitoring staff and the construction contractor to assist in the distribution of information.

2.2 Data Collection

Observers will use an NMFS-approved Marine Mammal Observation Record Form (Table C-1) which will be completed by each observer for each survey day. The data to be collected will include the following:

- Name of MMO
- Date and time that pile driving begins or ends
- Type of pile driving (impact or vibratory), pile size, and type (i.e., steel)
- Construction activities occurring during each sighting
- Weather parameters (e.g., rain, fog, percent cloud cover, percent glare, visibility)
- Water conditions (e.g., tidal state [incoming (flood), slack (neither direction), or outgoing (ebb)] and sea state). The Beaufort Sea State Scale shown in Table C-2 will be used to determine sea-state.
- Species, numbers, and if possible, sex and age class of marine mammals
- Time of sighting
- Marine mammal behaviors observed, including bearing from observer and direction of travel. If possible, include the correlation to construction activity for context.
    - Behavior patterns observed prior to soft starts or shutdown procedures to be included.
    - For pinnipeds, it will be noted if the animals are hauled out or in the water.
- Distance from pile driving activities to the observed marine mammal and distance from the marine mammal to the observation point. The distances may be estimated. If distances are to be estimated then daily calibrations for MMOs will be required.
- Descriptive locations of all marine mammals observed if possible (i.e., in the Behavioral or Injury Monitoring Zone, outside the Monitoring Zones). Local reference names will be used if possible (e.g., names of headlands, rocks, etc.).
- Other human activity in the area, with hull numbers of fishing vessels if possible.

The monitoring coordinator will complete a Marine Mammal Observation Record Form (Table C-1) for each day of monitoring. The summary form compiles information collected on the individual sighting forms and provides additional details about construction activities during marine mammal monitoring. The summary form will be provided to the Navy each day following monitoring. A chain of custody form (Table C-3) will be completed in the event that marine mammal remains are found in the vicinity of TPP Pier projects during construction.

2.3 Equipment

The following equipment will be required to conduct marine mammal monitoring:

- A survey boat will include the following minimum equipment: a means to keep electrical equipment dry, a fixed marine radio for the Captain to communicate on marine channels independent of observers communicating on a dedicated channel, depth finder, measuring tape, and GPS units that track the constant movement of the vessel. Vessels will comply with all Coast Guard regulations and be able to pass a Coast Guard safety inspection.
- Hearing protection for MMOs and boat operators working near heavy construction equipment

- At a minimum, portable marine radios with extra batteries and headsets for the observers to communicate with the monitoring coordinator, construction contractor, and other observer(s). Red and green flags can be added as back-up or in addition to the radios.
- Cellular phones that do not have a camera and the contact information for the other observer(s), monitoring coordinator, and Navy point of contact
- Nautical charts as relevant to the monitoring
- Daily tide tables for the project area
- Watch or chronometer
- Binoculars (quality 7 x 50 or better, can have built-in rangefinders or reticles)
- Rangefinder or other means of measuring or estimating distances
- Monitoring plan, IHA permit, and/or other relevant permit requirement specifications in sealed clear plastic cover
- Waterproof notebook
- Waterproof data sheets with Marine Mammal Observation Record Form (Table C-1) on non-bleeding paper (e.g., Rite-in-the-Rain). The MMO will put his/her name on each form used each day.
- A laminated color figure of the visual Monitoring Zones for impact and vibratory pile installation
- Marine mammal identification guides
- Clipboard
- Pen/pencil
- Angleboard, or other means of determining bearings
- Personal Protective Equipment relevant to the seasonal weather conditions and MMO location.

2.4 Pile Driving Visual Monitoring and Shutdown Zones

During all pile driving, qualified MMOs will visually monitor injury and behavioral disturbance threshold distances, and will ensure that pile driving is shut down when any marine mammal enters the Shutdown Zones listed in the Table C-4. These actions serve to protect marine mammals, allow for practical implementation of the MMMP, and reduce the risk of a take. The Navy will visually monitor Injury and Behavioral Disturbance Zones as follows:

- During pile driving, an **Injury Zone** shall be established and monitored to prevent injury to marine mammals from noise due to pile driving and physical interaction with construction equipment. During impact pile driving, Injury Zones will have a minimum Shutdown Zone of 355 meters for cetaceans (primarily for monitoring harbor porpoises), 160 meters for harbor seals, and 15 meters for sea lions (Table C-4) (Figure C-1). During vibratory pile driving, Injury Zones will have a minimum Shutdown Zone of 65 meters for cetaceans, 30 meters for harbor seals, and 10 meters for sea lions (Table C-4) (Figure C-1). Injury Zones are based on the maximum calculated distance to injurious noise exposure thresholds for cetaceans and pinnipeds during installation of 36-inch steel piles..
- During pile driving, a **Behavioral Disturbance Zone** shall be established that will encompass as much of the calculated distance to behavioral disturbance thresholds as possible (i.e., for impact

driving, the zone where impact pile driving levels are estimated to be at or above 160 dB re 1 µPa and for vibratory driving, the zone where vibratory pile driving noise levels are estimated to be at or above 120 dB RMS) (Table C-4) (Figure C-2). The Behavioral Disturbance Threshold will extend out to 541 meters for impact steel pile driving and 11,700 meters for vibratory pile driving.

During all pile driving, the Navy will implement Shutdown Zones as follows:

- The **Shutdown Zone for cetaceans** will include Injury and the portion of the Behavioral Disturbance Zone that can be practicably monitored from observer positions described in Section 2.5. If a cetacean approaches or enters the Shutdown Zone, pile driving will cease. See Figure C-3.
- The **Shutdown Zone for pinnipeds** will include the Injury Zone. If a pinniped enters the Shutdown Zone, pile driving will cease, but if it enters only the Behavioral Disturbance Zone, a take would be recorded and behaviors documented. That pile would be completed without cessation, unless the animal approaches or enters the Shutdown Zone, at which point all pile driving activities will be halted. See Figure C-4.
- If marine mammals are seen outside the Behavioral Disturbance Zone, these animals will also be recorded (not as a take) and their location identified.

Distances for all Monitoring Zones are provided in Table C-4.

2.5 Observer Monitoring Locations

When driving piles, to effectively monitor the Injury and Behavioral Disturbance Zones marine mammal observers will be positioned at the best practicable vantage points, taking into consideration security, safety, and space limitations at the waterfront. During steel pile impact driving, two observers will be positioned on the pier to monitor the Shutdown Zone and Behavioral Threshold areas. In addition to the two observers on the pier, one boat with an observer will be positioned at 200 meters to monitor the shutdown zones for all cetaceans (see Table C-4), and the behavioral (Level B) zone for harbor seals and sea lions. Figure C-1 depicts the representative monitoring locations of observers during impact driving. During vibratory pile driving, two observers will be positioned on the pier or shore to monitor the Shutdown Zones and a portion of the area exceeding the Behavioral Threshold (see Table C-4). Figure C-2 depicts the representative monitoring locations of observers during vibratory driving. Each MMO location will have a minimum of one dedicated MMO (not including boat operators) (see Figures C-1 and C-2). The exact number of MMOs and the observation locations are to be determined based upon site accessibility and line of sight for adequate coverage.

2.6 Monitoring Techniques

The MMOs will collect sighting data and behaviors of marine mammal species observed pre-, during, and post-driving period. The efficacy of visual detection depends on several factors including the observer's ability to detect the animal, the environmental conditions (visibility and sea state), and monitoring platforms. The following survey methodology will be implemented for all monitoring activities:

- Observers will survey the Injury and Behavioral Disturbance Zones. Monitoring will take place 30 minutes prior to initiation through 30 minutes post-completion of pile driving to ensure there are no marine mammals present.
- In case of reduced visibility due to weather or sea state, the observers must be able to see the Shutdown Zones or pile driving will not be initiated until visibility in these zones improves to acceptable levels.
- The Injury and Behavioral Disturbance Zones will be monitored throughout the time required to install a pile.
- Marine Mammal Observation Record Form (Table C-1) will be used to document observations.
- Any survey boats engaged in marine mammal monitoring will maintain speeds equal to or less than 10 knots.
- Observers will be trained and experienced marine mammal observers in order to accurately verify species sighted.
- Observers will use binoculars and the naked eye to search continuously for marine mammals.
- MMOs will have a means to communicate with each other to discuss relevant marine mammal information (e.g., animal sighted but submerged with direction of last sighting).
- MMOs will have the ability to correctly measure or estimate the animal's distance to the pile driving equipment such that records of any takes are accurate, relevant to the pile size and type.

2.6.1 Visual Survey Protocol – Pre-Activity Monitoring

The following survey methodology will be implemented prior to commencing pile driving:

- Visual surveys of the Injury and Behavioral Disturbance Zone will occur for at least 30 minutes prior to the start of construction.
- If marine mammal(s) are present within or approaching a Shutdown Zone prior to pile driving, the start of these activities will be delayed until the animal(s) leave the Shutdown Zone voluntarily and have been visually confirmed beyond the Shutdown Zone, or 15 minutes has elapsed without re-detection of the animal.
- If marine mammal(s) are not detected within a Shutdown Zone (i.e., the zone is deemed clear of marine mammals), the observers will inform the monitoring coordinator/construction contractor that pile driving can commence.
- If a marine mammal approaches or enters a Shutdown Zone, pile driving will be delayed until the animal(s) leave the zone. If pinnipeds are present within the Behavioral Disturbance Zone, pile driving would not need to be delayed, but observers would monitor and document, to the extent practical, the behavior of marine mammals that remain in the zone.

2.6.2 Visual Survey Protocol – During Activity Monitoring

The Injury and Behavioral Disturbance Zones will be monitored throughout pile driving. The following survey methodology will be implemented during pile driving:

- If a cetacean approaches or enters the Shutdown Zone for cetaceans, pile driving will cease until the animal(s) leave the zone. If a pinniped enters the Shutdown Zone for pinnipeds, pile driving will cease until the animal(s) leave the zone. If a pinniped is observed within or entering the

Behavioral Disturbance Zone during pile driving, a take would be recorded, behaviors documented, and the Shutdown Zone monitor alerted to the position of the animal. However, that pile segment would be completed without cessation, unless the animal approaches or enters the Shutdown Zone for pinnipeds, at which point all pile driving activities will be halted. The MMOs shall immediately radio to alert the monitoring coordinator/construction contractor. This action will require an immediate "all-stop" on pile operations.

- Once a shutdown has been initiated, pile driving and other in-water construction activities will be delayed until the animal has voluntarily left the Shutdown Zone and has been visually confirmed beyond the Shutdown Zone, or 15 minutes have passed without re-detection of the animal.
- Once the Shutdown Zone is deemed clear of marine mammals, the monitoring coordinator will inform the construction contractor that activities can re-commence.
- If shutdown and clearance procedures would result in an imminent concern for human safety, then the Navy point of contact will be notified prior to re-initiation of pile driving.

2.6.3 Visual Survey Protocol – Post-Activity Monitoring

Monitoring of the Shutdown Zones will continue for 30 minutes following completion of pile driving. These surveys will record marine mammal observations, and will focus on observing and reporting unusual or abnormal behavior of marine mammals. During these surveys, if any injured, sick, or dead marine mammals are observed, procedures outlined below in Section 3 should be followed.

3 Interagency Notification

In the event that the Navy needs to modify terms of this monitoring plan, the NMFS representative will be promptly contacted for discussion of the requested modification. In the event that personnel involved in the construction activities discover an injured or dead marine mammal, the IHA-holder shall report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and to the West Coast regional stranding coordinator (562-980-3230) as soon as feasible. If the death or injury was clearly caused by the specified activity, the IHA-holder must immediately cease the specified activities until NMFS is able to review the circumstances of the incident and determine what, if any, additional measures are appropriate to ensure compliance with the terms of the IHA. The IHA-holder must not resume their activities until notified by NMFS. The report must include the following information:

- Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
- Species identification (if known) or description of the animal(s) involved;
- Condition of the animal(s) (including carcass condition if the animal is dead);
- Observed behaviors of the animal(s), if alive;
- If available, photographs or video footage of the animal(s); and
- General circumstances under which the animal was discovered.

Care should be taken in handling dead specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In preservation of biological materials from a dead animal, the finder (i.e., marine mammal observer) has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed.

Primary points of contact for the Navy are:

- Tyler Yasenak – (360) 315-2452
- Greg Leicht – (360) 315-5411

The Navy primary point of contact will contact NMFS. The primary points of contact at NMFS are:

- Modification to protocol – (360) 753-5835
- Chief of the Permits and Conservation Division – (301) 427-8425
- Northwest Regional Stranding Coordinator – (206) 526-6550

4 Monitoring Reports

A draft report will be submitted to NMFS within 90 work days of the completion of marine mammal monitoring. A final report will be prepared and submitted to the NMFS within 30 days following receipt of comments on the draft report from the NMFS. At a minimum, the report shall include:

- General data:
  - Date and time of activities
  - Water conditions (e.g., sea-state, tidal state)
  - Weather conditions (e.g., percent cover, visibility)
- Specific pile data:
  - Description of the pile driving activities including the size and type of pile
  - Installation methods used for each pile and the duration each method was used per pile
  - Impact or vibratory hammer force used to drive/extract piles
  - Detailed description of the sound attenuation system, including the design specifications
  - Depth of water in which the pile was driven
  - Depth into the substrate that the pile was driven
- Specific pile removal data:
  - Description of the pile removal activities being conducted
    - Size and type of piles
    - The machinery used for removal
    - Duration each pile removal method was used
  - The vibratory driver force
- Pre-activity observational survey-specific data:
  - Dates and time survey is initiated and terminated
  - Description of any observable marine mammal behavior in the immediate area during monitoring

- If possible, the correlation to underwater sound levels occurring at the time of the observable behavior
- Actions performed to minimize impacts to marine mammals

- During-activity observational survey-specific data:
  - Description of any observable marine mammal behavior within Monitoring Zones or in the immediate area surrounding Monitoring Zones including the following:
    - Distance from animal to source
    - Reason why/why not shutdown implemented
    - If a shutdown was implemented, behavioral reactions noted and if they occurred before or after implementation of the shutdown
    - If a shutdown is implemented, the distance from animal to source at the time of the shutdown
    - Behavioral reactions noted during soft starts[1] and if they occurred before or after implementation of the soft start
    - Distance to the animal from the source during soft start
  - Actions performed to minimize impacts to marine mammals
  - Times when pile driving is stopped due to presence of marine mammals within the Shutdown Zones and time when pile driving resumes
- Post-activity observational survey-specific data:
  - Results, which include the detections of marine mammals, species and numbers observed, sighting rates and distances, behavioral reactions within and outside of Monitoring Zones
  - A refined take estimate based on the number of marine mammals observed during the course of construction

[1] The objective of a soft-start is to provide a warning and/or give animals in close proximity to pile driving a chance to leave the area prior to an impact driver operating at full capacity thereby, exposing fewer animals to loud underwater and airborne sounds.

Appendix C

Tables

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Table C-1. Marine Mammal Observation Record Form

Project Name: ______________________________ Monitoring Location______________________________ Page ___________ of _____________
(Pier Location, Vessel based, Land Location, other)

Date: ______________________________ Vessel Name: ______________________________ Time Effort Initiated:_______________

Time Effort Completed:_____________

Sighting Data

Event Code	Sighting Number (1 or 1.1 if resight)	Time/Duration watching sighting (Start/End time if continuous)	WP # (every time a sighting is made)	Observer	Sighting cue	Species	Dist/ Dir to Animal (from Observer)	Dist to Pile (btwn animal & pile)	# of Animals Group Size (min/max/best)# of Calves	Relative Motion/and Behavior Code (see code sheet)	Const Type During Sighting	Miti gation used during sighting?	Miti gation Type?	Visibility	% Glare	Weath Cond	Sea State and Wave Ht	Swell Dir	Behavior Change/ Response to Activity/Comments
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E			Light Mod Heavy	N or S W or E	
		: : : :					m or km °	m or km	/ / __ calves	opening closing parallel none	PRE POST SSV SSI V I PC DP ST NONE	Y N	DE SD	B P M G E				N or S W or E	

Sighting #=chronological number of sightings, If resight of same animal, then 1.1, 1.2, etc. WP (Waypoint)=GPS recording of lat/long, time/date stamp. Critical for vessel observers.

[Obtain most recent version of sighting form prior to use.]

Table C-1. Marine Mammal Observation Record Form

Sighting Codes
(Sighting Cue and Behavior Codes)

Behavior Code

Code	*Behavior*	*Definition*
BR	Breaching	Leaps clear of water
CD	Change direction	Suddenly changes direction of travel
CH	Chuff	Makes loud, forceful exhalation of air at surface
DI	Dive	Forward dives below surface
DE	Dead	Shows decomposition or is confirmed as dead by investigation
DS	Disorientation	An individual displaying multiple behaviors that have no clear direction or purpose
FI	Fight	Agonistic interactions between two or more individuals
FO	Foraging	Confirmed by food seen in mouth
MI	Milling	Moving slowly at surface, changing direction often, not moving in any particular direction
PL	Play	Behavior that does not seem to be directed toward a particular goal; may involve one, two, or more individuals
PO	Porpoising	Moving rapidly with body breaking surface of water
SL	Slap	Vigorously slaps surface of water with body, flippers, tail, etc.
SP	Spyhopping	Rises vertically in the water to “look” above the water
SW	Swimming	General progress in a direction; note general direction of travel when last seen (example: “SW [N]” for swimming north)
TR	Traveling	Traveling in an obvious direction; note direction of travel when last seen (example: “TR [N]” for traveling north)
UN	Unknown	Behavior of animal undetermined, does not fit into another behavior
Pinniped only		
EW	Enter water (from haul out)	Enters water from a haul out for no obvious reason
FL	Flush (from haul out)	Enters water in response to disturbance
HO	Haul out (from water)	Hauls out on land
RE	Resting	Resting onshore or on surface of water
LO	Look	Is upright in water “looking” in several directions or at a single focus
SI	Sink	Sinks out of sight below surface without obvious effort (usually from an upright position)
VO	Vocalizing	Animal emits barks, squeals, etc.
Cetacean only		
LG	Logging	Resting on surface of water with no obvious signs of movement

Table C-1. Marine Mammal Observation Record Form

Marine Mammal Species

Code	*Marine Mammal Species*
CASL	California sea lion
HSEA	Harbor seal
STSL	Steller sea lion
HPOR	Harbor porpoise
DPOR	Dall's porpoise
ORCA	Killer whale
HUMP	Humpback whale
UNLW	Unknown large whale
RIVO	River otter (not a marmam)
OTHR	Other
UNKW	Unknown

Event

Code	*Activity Type*
E ON	Effort on
E OFF	Effort off
PRE	Pre watch
POST	Post watch
SSV	Soft start vibratory
SSI	Soft start impact
WC	Weather condition/change
S	Sighting
M-DE	Mitigation delay
M-SD	Mitigation shutdown

Construction Type

Code	*Activity Type*
SSV	Soft start vibratory
SSI	Soft start impact
V	Vibratory pile driving (installation and extraction)
I	Impact pile driving
PC	Pneumatic chipping
DP	Dead pull
ST	Stabbing
NONE	No pile driving

Mitigation Code

Code	*Activity Type*
DE	Delay onset of pile driving
SD	Shut down pile driving

Visibility

Code	*Distance Visible*
B	Bad (<0.5 km)
P	Poor (0.5 – 1.5 km)
M	Moderate (1.5 – 10 km)
G	Good (10 – 15 km)
E	Excellent (>15 km)

Glare

Percent glare should be total glare of observer's area of responsibility. Are they covering 90 degrees or 180 degrees? Total glare for that area and write that area down on the datasheet so we know later what percentage of the field of view was poor due to glare.

Weather Condition

Code	*Weather Condition*
S	Sunny
PC	Partly cloudy
L	Light rain
R	Steady rain
F	Fog
OC	Overcast

Sea State and Wave Height

Use Beaufort Sea State Scale for Sea State Code. This refers to the surface layer and whether it is glassy in appearance or full of white caps. In the open ocean, it also takes into account the wave height; but in inland waters, the wave heights (swells) may never reach the levels that correspond to the correct surface white cap number. Therefore, include wave height for clarity.

Code	*Wave Height*
Light	0 – 3 feet
Moderate	4 – 6 feet
Heavy	>6 feet

Swell Direction

Swell direction should be where the swell is coming from (S for coming from the south). If possible, record direction relative to fixed location (pier). Choose this location at beginning of monitoring project.

Table C-2. Beaufort Sea State Scale

U.S. Navy and Beaufort Sea State Codes

(http://ioc.unesco.org and http://www.wrh.noaa.gov/pqr/info/beaufort.php)

Beaufort Sea State	Wind Speed (knots)	Wind Description	Wave Height (ft) Beaufort	Sea State – Beaufort	Notes Specific to On-water Seabird Observations	Photos Indicating Beaufort Sea State
0	<1	Calm	0	Calm; like a mirror	Excellent conditions, no wind, small or very smooth swell. You have the impression you could see anything.	
1	1–3	Light air	¼ < ½	Ripples with appearance of scales; no foam crests	Very good conditions, surface could be glassy (Beaufort 0), but with some lumpy swell or reflection from forests, glare, etc.	

Table C-2. Beaufort Sea State Scale

Beaufort Sea State	Wind Speed (knots)	Wind Description	Wave Height (ft) Beaufort	Sea State – Beaufort	Notes Specific to On-water Seabird Observations	Photos Indicating Beaufort Sea State
2	4–6	Light breeze	½–1 (max 1)	Small wavelets; crests with glassy appearance, not breaking	Good conditions, no whitecaps; texture/lighting contrast of water make murrelets hard to see. Surface could also be glassy or have small ripples, but with a short, lumpy swell, thick fog, etc.	
3	7–10	Gentle breeze	2–3 (max 3)	Large wavelets; crests begin to break; scattered whitecaps	Fair conditions, scattered whitecaps, detection of murrelets definitely compromised; a hit-or-miss chance of seeing them owing to water choppiness and high contrast. This could also occur at lesser wind with a very short wavelength, choppy swell.	

Table C-2. Beaufort Sea State Scale

Beaufort Sea State	Wind Speed (knots)	Wind Description	Wave Height (ft) Beaufort	Sea State – Beaufort	Notes Specific to On-water Seabird Observations	Photos Indicating Beaufort Sea State
4	11–16	Moderate breeze	3½–5 (max 5)	Small waves becoming longer, numerous whitecaps	Whitecaps abundant, sea chop bouncing the boat around, etc.	
5	17–20	Fresh breeze	6–8 (max 8)	Moderate waves, taking longer form; many whitecaps; some spray		

Table C-3. Chain of Custody Record

<table>
<tr><td colspan="6">Chain of Custody Record</td></tr>
<tr><td colspan="2">Date and Time of Collection:</td><td colspan="2">Duty Station:</td><td colspan="2">Collection By:</td></tr>
<tr><td colspan="3">Source of Specimen (Person and/or Location):

Found At:</td><td colspan="3">Project Name:</td></tr>
<tr><td>Item No:</td><td colspan="5">Description of Specimen (Include Species and Tag Number):</td></tr>
<tr><td rowspan="2">Item No:</td><td>From: (Print Name, Agency)</td><td>Release Signature:</td><td>Release Date:</td><td rowspan="2" colspan="2">Delivered via:
FEDEX
U.S. Mail
In Person
Other:</td></tr>
<tr><td>To: (Print Name, Agency)</td><td>Receipt Signature:</td><td>Receipt Date:</td></tr>
</table>

Table C-3. Chain of Custody Record

Chain of Custody Record				
Item No:	From: (Print Name, Agency)	Release Signature:	Release Date:	Delivered via: FEDEX U.S. Mail In Person Other:
	To: (Print Name, Agency)	Receipt Signature:	Receipt Date:	
Item No:	From: (Print Name, Agency)	Release Signature:	Release Date:	Delivered via: FEDEX U.S. Mail In Person Other:
	To: (Print Name, Agency)	Receipt Signature:	Receipt Date:	
Item No:	From: (Print Name, Agency)	Release Signature:	Release Date:	Delivered via: FEDEX U.S. Mail In Person Other:
	To: (Print Name, Agency)	Receipt Signature:	Receipt Date:	
Item No:	From: (Print Name, Agency)	Release Signature:	Release Date:	Delivered via: FEDEX U.S. Mail In Person Other:
	To: (Print Name, Agency)	Receipt Signature:	Receipt Date:	

Table C-4. Monitoring and Shutdown Zone Distances

Marine Mammal Group	Vibratory Pile Driving				Impact Pile Driving			
	Behavioral Disturbance Threshold	Injury Threshold	Monitoring Zone	Shutdown Zone[2]	Behavioral Disturbance Threshold	Injury Threshold	Monitoring Zone	Shutdown Zone
Cetaceans	11.7 km	64 m	200 m	65 m	541 m	351 m	355 m	355 m
Harbor Seal	11.7 km	26 m	200 m	30 m	541 m	157.5 m	355 m	160 m
Sea Lions	11.7 km	2 m	200 m	10 m	541 m	11.5 m	355 m	15 m

Key: km = kilometer; m = meter

[2] The shutdown encompasses the injury zone. Additionally, a Behavioral Disturbance Monitoring Zone will be established that will encompass as much of the Behavioral Disturbance Zone that can be practicably monitored from observer positions described in Section 2.5. All pile driving shall cease should any cetaceans be detected within the behavioral disturbance zone.

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Appendix C

Figures

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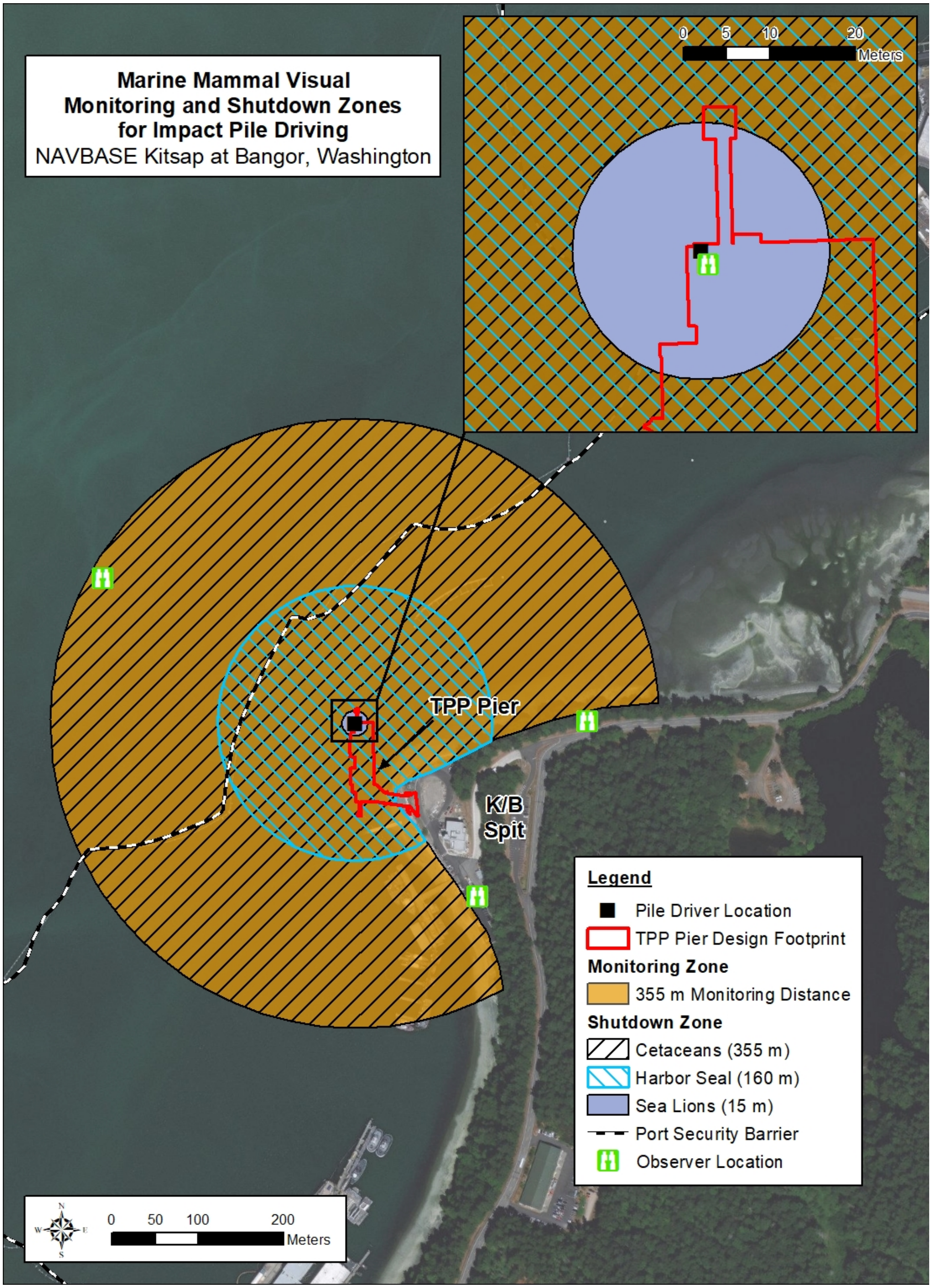


Figure C-1. Example of Marine Mammal Visual Monitoring Zone with Representative Monitoring Locations Indicated for Impact Pile Driving

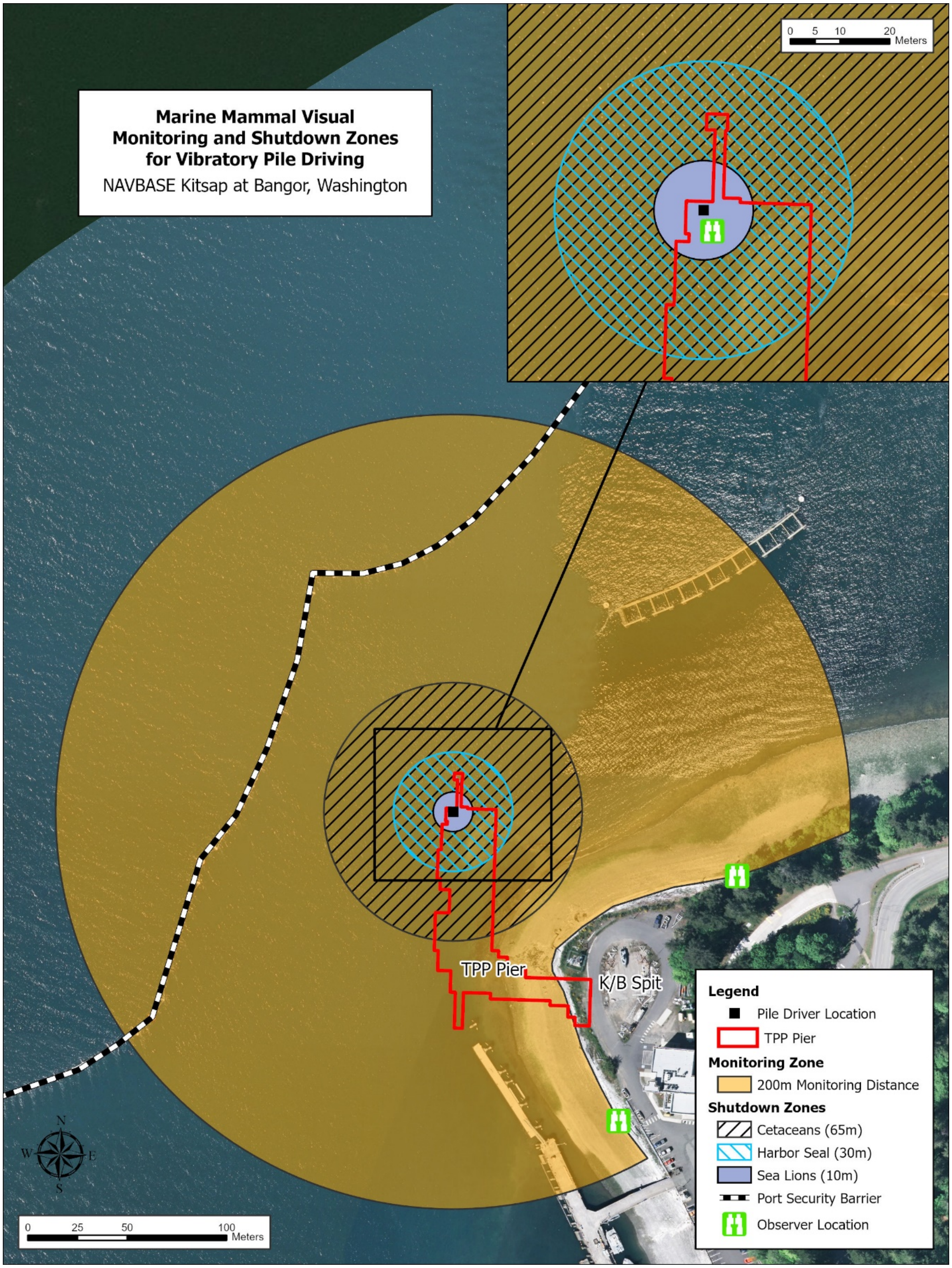


Figure C-2. Example of Marine Mammal Visual Monitoring Zone with Representative Monitoring Locations Indicated for Vibratory Pile Driving

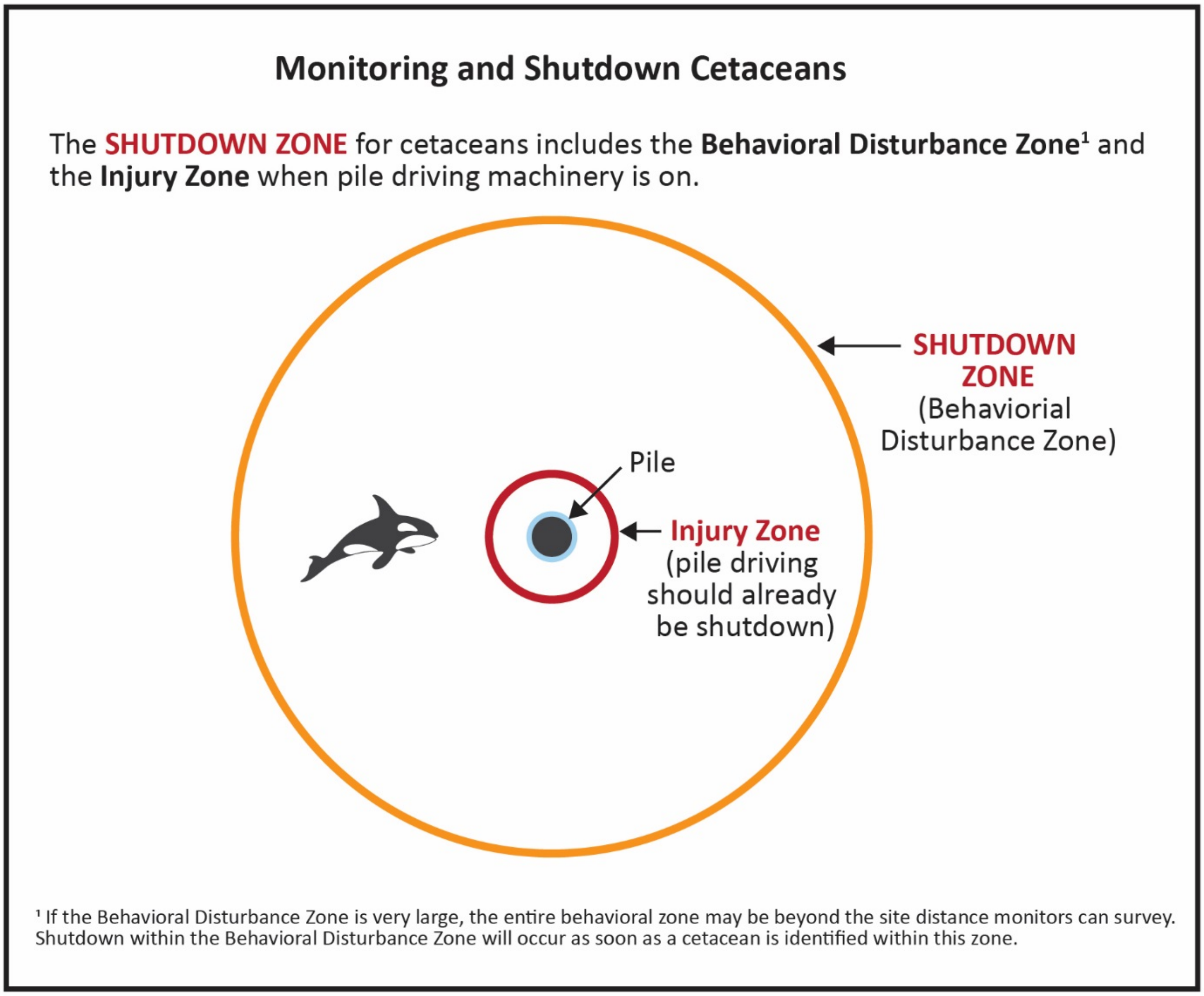
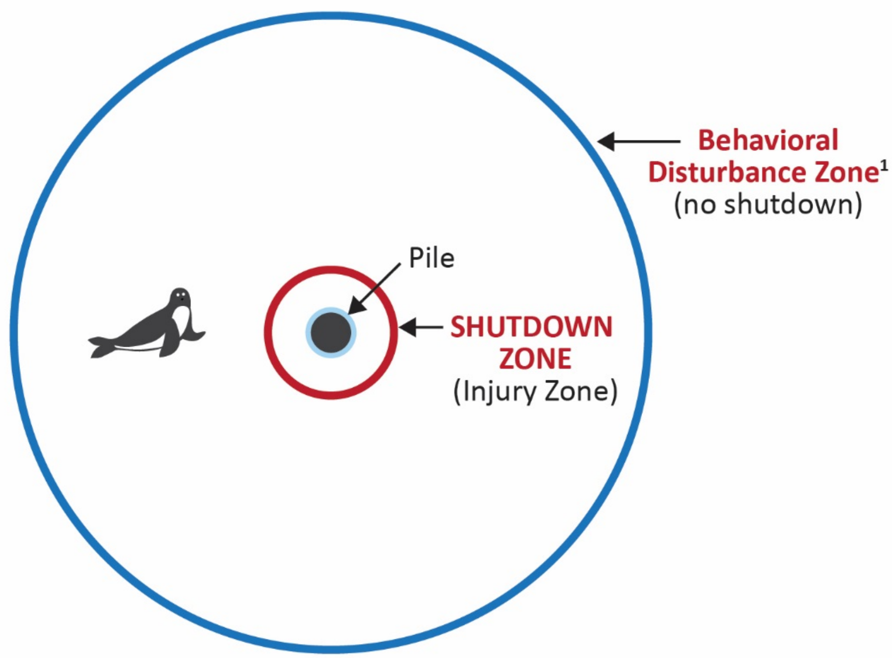


Figure C-3. Monitoring and Shutdown Zones for Cetaceans

Monitoring and Shutdown Pinnipeds

The **SHUTDOWN ZONE** for pinnipeds is the **Injury Zone** for pile driving. Shutdown will also occur within the **Behavioral Disturbance Zone** if the pinniped is swimming toward the pile driving equipment that is turned on/in use, to avoid potential injury to a pinniped swimming toward the Injury Zone. If the pinniped is within the Behavioral Disturbance Zone, construction will be allowed to continue, and marine mammal monitors will **document behavior and location and will track** animal to ensure that it does not enter the Shutdown Zone.



¹ If the Behavioral Disturbance Zone is very large, the entire behavioral zone may be beyond the site distance monitors can survey.

Figure C-4. Monitoring and Shutdown Zones for Pinnipeds