REQUEST FOR INCIDENTAL HARASSMENT AUTHORIZATION FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM THE TRIDENT SUPPORT FACILITIES SECOND EXPLOSIVES HANDLING WHARF ON NAVAL BASE KITSAP AT BANGOR, WASHINGTON

Submitted to:

Office of Protected Resources,

National Marine Fisheries Service,

National Oceanographic and Atmospheric Administration

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
°N	North
°W	West
µPa	microPascal
BMP	Best Management Practice
BSS	Beaufort Sea State
CA	California
CERC	Coastal Engineering Research Center
CFR	Code of Federal Regulations
CISS	Cast-in-Steel-Shell
cu yd	cubic yard
CV	coefficient of variation
dB re 1µPa	decibels referenced at 1 microPascal
dB	decibel
dBA	decibel with A-weighting filter
DDESB	Department of Defense Explosives Safety Board
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
EHW	Explosives Handling Wharf
EHW-2	second Explosives Handling Wharf
ESA	Endangered Species Act
ft	feet
ft/sec	feet per second
Hz	hertz
IHA	Incidental Harassment Authorization
ILF	in-lieu fee
kHz	kilohertz
km	kilometer
kVA	kilovolt ampere
kW	kilowatt
m	meter
MHHW	mean higher high water
MLLW	mean lower low water
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
N/A	not available
NAU	nearshore assessment unit
Navy	United States Navy
NBK	Naval Base Kitsap
NMFS	National Marine Fisheries Service
NOSSA	Naval Ordnance Safety and Security Activity
OR	Oregon
Pa	pascal
PSU	practical salinity unit
PTS	permanent threshold shift
RMS	root-mean-square
SEL	sound exposure level
SFOBB	San Francisco-Oakland Bay Bridge

SMS	Sediment Management Standards
SQS	Sediment Quality Standards
SPL	sound pressure level
sq ft	square feet
sq mi	square mile
SSBN	OHIO Class ballistic missile submarine
SSGN	OHIO Class guided missile submarine
TL	transmission loss
TRIDENT	Trident Fleet Ballistic Missile
TTS	temporary threshold shift
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
W	watt
WA	Washington
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WSDOT	Washington State Department of Transportation
ZOI	zone of influence

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EXECUTIVE SUMMARY

The U.S. Navy (Navy) is applying for an Incidental Harassment Authorization (IHA) for the incidental take of marine mammals resulting from construction of a second Explosives Handling Wharf (EHW-2) on Naval Base Kitsap (NBK) at Bangor. NBK at Bangor, Washington, is located on Hood Canal approximately 20 miles west of Seattle, Washington, and provides berthing and support services to Navy OHIO Class ballistic missile submarines (SSBN), hereafter referred to as TRIDENT submarines. The purpose of the proposed action is to support future TRIDENT program requirements for the eight TRIDENT submarines currently homeported on NBK at Bangor and the TRIDENT II (D5) Strategic Weapons System. A second EHW (EHW-2) is needed because the existing EHW alone will not be able to support TRIDENT program requirements.

Vibratory and impact pile driving associated with construction of the EHW-2 are the proposed activities with the potential to affect marine mammals within the waterways adjacent to NBK at Bangor and that could result in harassment under the Marine Mammal Protection Act (MMPA) of 1972, as amended.

Six species of marine mammals may be present at various times of the year within the waters surrounding NBK at Bangor: the Steller sea lion (*Eumetopias jubatus*), the California sea lion (*Zalophus californianus*), the harbor seal (*Phoca vitulina*), the transient killer whale (*Orcinus orca*), the Dall's porpoise (*Phocoenoides dalli*), and the harbor porpoise (*Phocoena phocoena*). With the exception of the Steller and California sea lion, these species may occur year-round in Hood Canal, though Dall's porpoise and transient killer whales are only occasionally sighted. The Steller sea lion is only present from late fall to spring (October to mid April), and the California sea lion is only present from late summer to late spring (August to early June). Individuals of the six species potentially present during the project's timeline could be exposed to sound pressure levels associated with vibratory and impact pile driving. The Southern Resident killer whale (SRKW) 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.

The Navy proposes to construct and operate the EHW-2 adjacent to but separate from the existing EHW. The EHW-2 would consist of the wharf proper, or operations area, located approximately 600 feet offshore in water depths of 60 to 100 feet, and two trestles connecting the wharf to shore. Both the wharf and trestles would be pile-supported on up to 1,250 in-water steel pipe piles ranging in size from 24 to 48 inches in diameter. Construction would involve the temporary installation of up to 150 falsework piles used as an aid to guide the placement of permanent piles. Falsework piles would likely be steel piles ranging in size from 18 to 24 inches in diameter. All falsework piles would be removed upon installation of the permanent piles and would not increase the area of the seafloor affected by the project. The construction of an abutment where the trestle comes ashore at the shoreline cliff would require up to an additional 55 piles that would be driven on land. Falsework and abutment piles were accounted for in the overall construction schedule and pile driving duration, and in the analysis of impacts from pile installation on marine mammals. Under the preferred alternative, the duration of in-water pile driving would be 200 to 400 days. An additional 11 days of pile driving would be required on land to install the abutment piles. There would be a maximum of 195 days of pile driving during the first year of construction covered by this Incidental Harassment Authorization (IHA).

All piles would be driven with a vibratory pile driver for their initial embedment depths, and select piles (every four to five piles) will be impact driven for their final 10–15 feet for proofing.[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 attenuation measures (i.e., bubble curtain) would be used during all impact hammer operations. Marine mammal monitoring would be conducted during pile driving, and work would shut down when marine mammals came within distances (no less than 25 meters) where injury could potentially occur. Pile installation would involve the use of vibratory pile drivers to the greatest extent possible for all alternatives. It is anticipated that most piles will be vibratory driven to within several feet of the required depth. If difficult subsurface driving conditions (i.e., cobble/boulder zones) are encountered, it may be necessary to use an impact hammer to drive some piles for the remaining portion of their required depth. Up to three vibratory rigs would operate concurrently during construction of the EHW-2, but only one impact hammer rig would operate at a time. However, the construction schedule would require the operation of the impact rig at the same time as the vibratory rigs.

For pile driving activities, the Navy used National Marine Fisheries Service (NMFS)-promulgated thresholds for assessing pile driving impacts (NMFS 2005, 2009), outlined in Section 6. The Navy used the practical spreading loss equation and empirically measured source levels from other 30-inch to 66-inch steel pile driving events permitted through NMFS to estimate potential marine mammal exposures. Predicted exposures are outlined in Section 6. The calculations predicted no Level A harassments would occur associated with pile driving activities. The modeling predicts that 18,525 Level B harassments may occur during the first year of construction of the EHW-2 from underwater sound. No incidents of harassment were predicted from airborne sounds associated with pile driving. Conservative assumptions (including marine mammal densities and other assumptions) used to estimate the exposures are likely to overestimate the potential number of exposures and their severity.

Compensatory mitigation projects for impacts to marine habitats and prey populations will be undertaken within Hood Canal that will restore the habitat and prey base functions affected by the project. The Mitigation Action Plan (Appendix F of the EIS) describes the proposed compensatory habitat mitigation more fully, as well as the various proposed impact avoidance and minimization measures.

Pursuant to MMPA Section 101(a)(5)(D), the Navy submits this application to the NMFS for an IHA for the incidental, but not intentional, taking of six marine mammal species during pile driving activities in the first year of construction as part of the EHW-2 between July 16, 2012, and July 15, 2013. The taking would be in the form of non-lethal, temporary harassment and is expected to have a negligible impact to these species. In addition, the taking would not have an unmitigable adverse impact to the availability of these species for subsistence use.

Regulations governing the issuance of incidental take under certain circumstances are codified at 50 Code of Federal Regulations (CFR) Part 216, Subpart I (Sections 216.101 – 216.108).

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[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.

Section 216.104 sets out 14 specific items that must be addressed in requests for take pursuant to Section 101 (a)(5)(D) of the MMPA. These 14 items are addressed in Sections 1 through 14 of this IHA application.

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1 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 Proposed Action

This IHA application covers the first year of construction (July 16, 2012 through July 15, 2013) of the proposed EHW-2, during which a maximum of 195 days of pile driving would occur. This number of pile driving days is based on an estimated 6.5 pile driving days per week and 30 weeks during the in-water work season (July 16 through February 15).

This section of the application describes the proposed action in its entirety to provide a context for understanding the first year's construction activities, including construction actions other than pile driving that may affect marine mammals. This is also important for consistency with other environmental documentation for this project, including the EIS. It has not been determined exactly what parts of the project would be constructed during the first year, other than a maximum of 195 days of pile driving would occur, along with the general construction activities described below.

The EHW-2 would consist of two components: (1) the wharf proper (or Operations Area), including the warping wharf; and (2) two access trestles.[2] The Operations Area would include a support building and wharf cover. The warping wharf would be a long, narrow wharf extension used to position submarines prior to moving into the Operations Area. Access trestles would allow vehicles to travel between the Operations Area and the shore.

The wharf proper would lie approximately 600 feet offshore at water depths of 60 to 100 feet, and would consist of a main wharf, warping wharf, and lightning protection towers, all pile-supported. It would include a slip (docking area) for submarines, surrounded on three sides by operational wharf area. The warping wharf would extend out from the main wharf and be used to line up submarines to move into the slip. The main wharf would include an operations support building (25,700 square feet) providing office and storage space and mechanical/electrical system component housing. Additional facility support at the wharf would include heavy duty cranes suspended from the cover, power utility booms, six large lightning protection towers, and camels (operational platforms that float next to a moored vessel). The elevation of the top of the wharf deck would be 20.5 feet above mean lower low water (MLLW), and the bottom of the wharf deck would be 13 feet above MLLW. The six lightning towers would be steel frame structures, each 30 by 30 feet (total of 5,400 square feet).

The access trestles would connect the wharf to the shore. There would be an entrance trestle and an exit trestle; these would be combined over shallow water to reduce overwater area (Figures 1–1 and 1–2). The trestles would be pile-supported on 24-inch steel pipe piles driven approximately 30 feet into the seafloor. Spacing between bents (rows of piles) would be 25 feet. Concrete pile caps would be cast in place and would support pre-cast concrete deck sections.[3]

[2] A trestle is a framework of vertical, slanted supports and horizontal crosspieces supporting a bridge or road.
[3] Pile caps that are cast in place are constructed at their final location by placing wooden forms and rebar and pouring concrete. Once cured, the forms are removed. Pre-cast components are formed and poured at an offsite location. They are brought to the site in their finished form and placed with a crane in their final location.

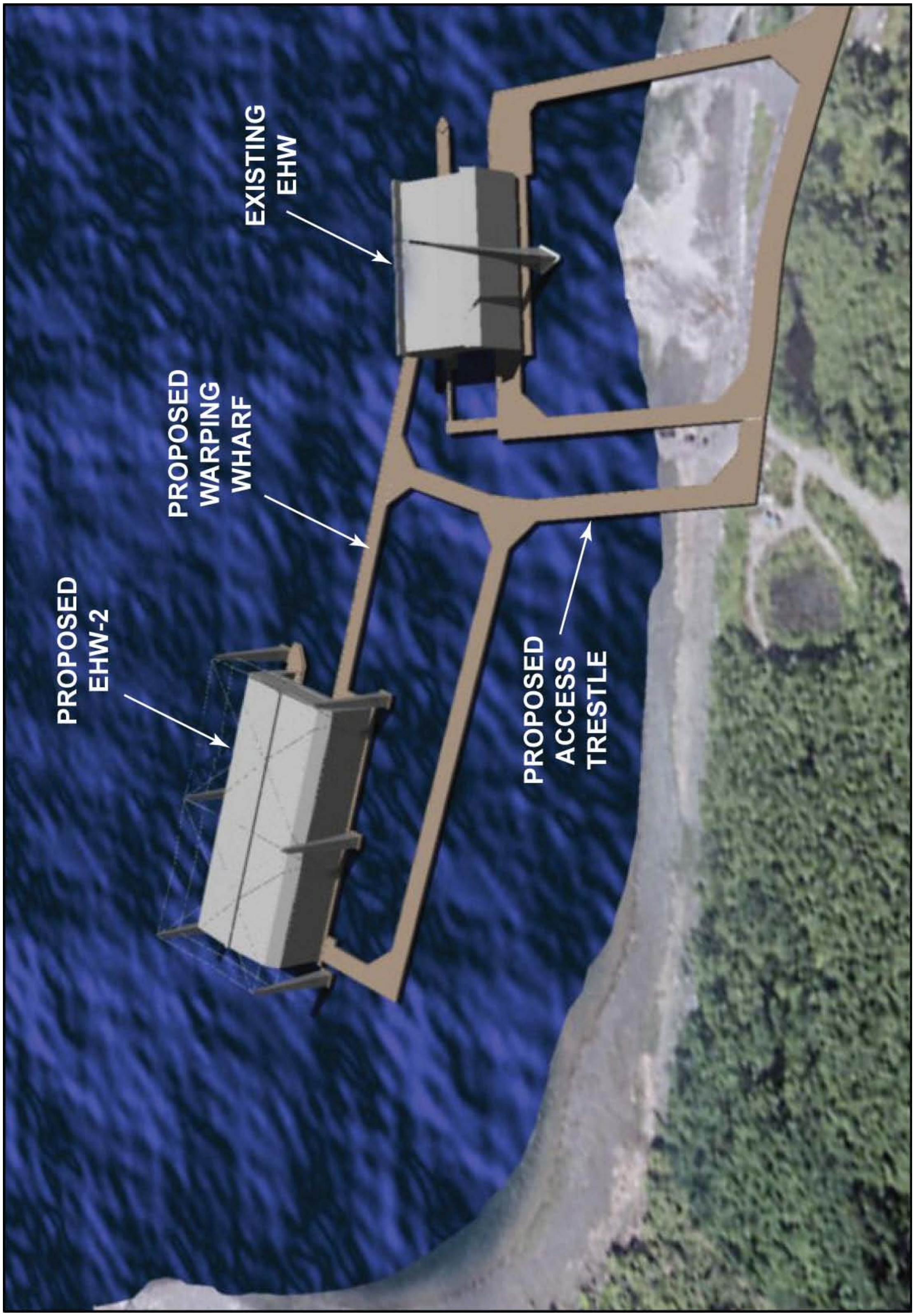

Figure 1–1. Conceptual View of Existing EHW and Proposed EHW-2

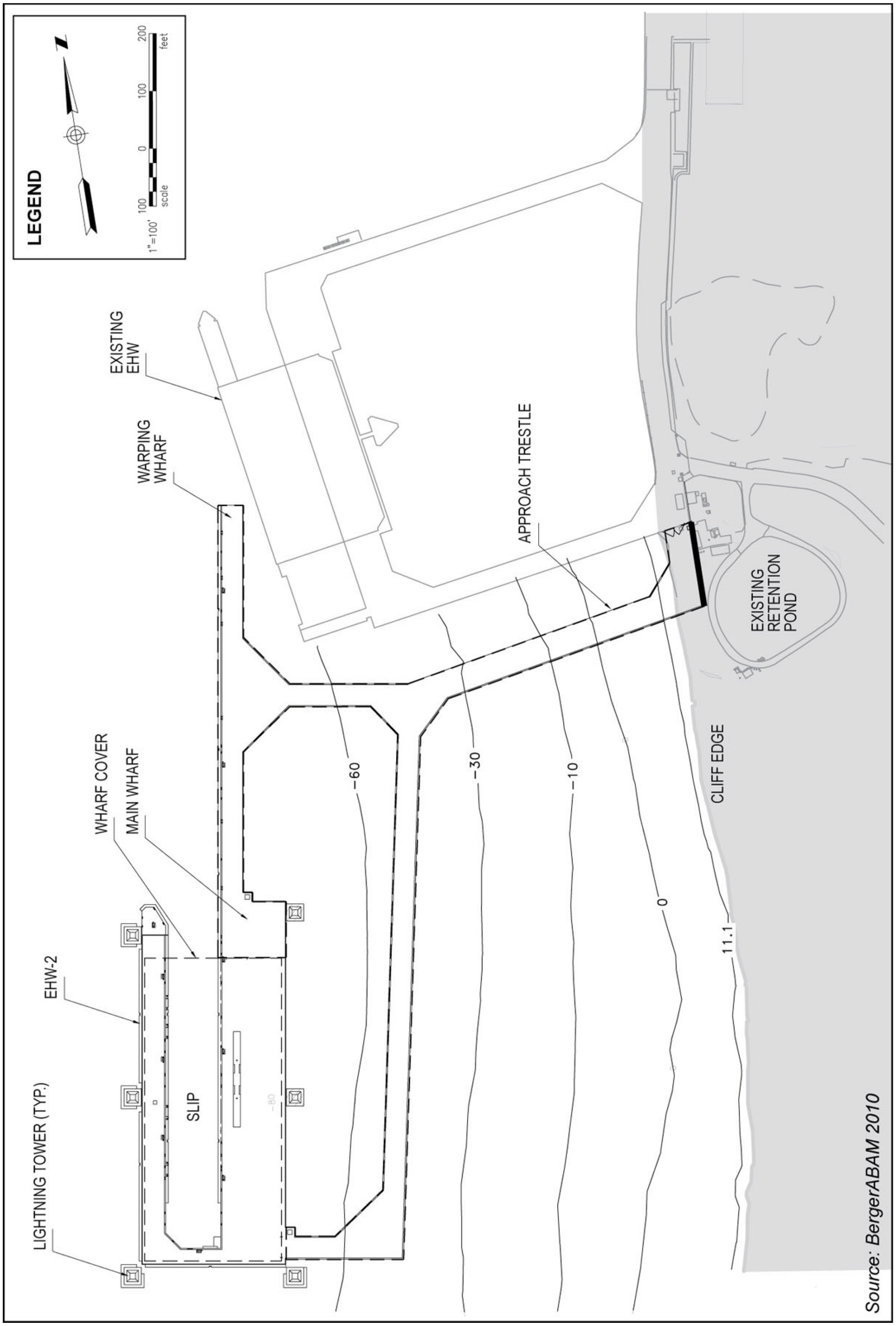

Figure 1–2. Bathymetric View of Proposed EHW-2

The top elevation of the trestle deck would vary between 20.5 feet above MLLW at the connection to the wharf to 28.0 feet above MLLW at the shore. The bottom deck elevation would vary between 15.2 feet above MLLW at the connection to the wharf to 22.7 above MLLW at the shore.

The use of grating in construction of the trestles was considered to allow additional light to penetrate to the water. Through the design process, the Navy determined that grating would be ineffective at transmitting light, due to the weight and thickness of grating required to support the operational vehicle load as required by the *Facility Design Criteria* (Lockheed Martin 2010). Additionally, it would not be possible to control stormwater runoff into Hood Canal if grating was used. Therefore, grating is not proposed for the EHW-2.

A total of up to 1,250 permanent piles ranging in size between 24 and 48 inches in diameter would be driven in water to construct the wharf (Section 1.1.1). Construction would also involve temporary installation of up to 150 falsework piles used as an aid to guide permanent piles to their proper locations (used like a template). Falsework piles would likely be steel pipe piles and would be driven and removed using a vibratory driver. Typically, falsework piles would be driven, extracted, and used as falsework at another location. At the end of their use on this project, the piles would be reused or recycled. These temporary falsework piles would be removed upon installation of the permanent piles and would not increase the area of seafloor occupied by piles. The falsework piles are accounted for in the in the overall construction schedule and pile driving duration and in the analysis of impacts from pile installation on noise, seafloor disturbance, and water quality.

The upland component of the proposed action includes an abutment as well as road and utility work at the site where the trestle comes ashore (Section 1.1.3). An additional 55 piles that are 24 inches in diameter would be driven "in the dry" for the shoreline abutment to be built where the trestle comes ashore Upland construction of the road and utility work would result in approximately 0.8 acre being permanently occupied by new roads, plus an additional 0.8 acre that would be temporarily disturbed by construction and revegetated with native species following construction. A separately located 5-acre laydown/staging area would also be cleared for construction use and revegetated following construction.

The proposed activities with the potential to affect marine mammals within the waterways adjacent to NBK at Bangor that could result in harassment under the MMPA of 1972, as amended in 1994, are vibratory and impact pile driving operations associated with construction of the EHW-2.

1.1.1 Description of Pile Driving Operations

The Navy anticipates using two types of equipment to install piles: a vibratory pile driver and an impact hammer.[4] Up to three vibratory rigs with one impact hammer rig could operate concurrently. Pile installation would utilize vibratory pile drivers to the greatest extent possible. It is anticipated that most piles will be vibratory driven to within several feet of the required depth.[5]

[4] Vibratory pile drivers use hydraulic-powered weights to vibrate a pile until the surrounding sediment liquefies; this enables the pile to be driven into the ground using the weight of the pile plus the pile driver. Impact hammers use a rising and falling piston to repeatedly strike a pile and drive it into the ground.

[5] Pile drivability is, to a large degree, a function of soil conditions and pile hammer. The soil conditions encountered during geotechnical explorations indicate existing conditions generally consist of fill or sediment of very dense

Unless difficult driving conditions are encountered, an impact hammer will only be used only to verify ("proof") the load-bearing capacity of approximately every fourth or fifth pile. The industry standard is to proof every pile with an impact hammer. However, in an effort to reduce blow counts, the engineer of record has agreed to only proof every fourth or fifth pile. Proofing involves striking a driven pile with an impact hammer to verify that it provides the required load-bearing capacity, as indicated by the number of hammer blows per foot of pile advancement. A maximum of 200 strikes would be required to proof each pile. Pile production rates are dependent upon required embedment depths, the potential for encountering difficult driving conditions, and the ability to drive multiple piles without a need to relocate the driving rig. For the shallow piles, driving in optimal conditions, using multiple driving rigs, it may be possible for the contractor to vibrate enough pilings that would require proofing up to five piles in a day. It is estimated that on most days, a single impact hammer would be used to proof up to five piles, with each pile requiring a maximum of 200 strikes. Under this likely scenario, it is estimated that up to a maximum of 1,000 strikes would be required per day.

If difficult subsurface driving conditions (i.e., cobble/boulder zones) are encountered that cause "refusal" with the vibratory equipment, it may be necessary to use an impact hammer to drive some piles for the remaining portion of their required depth. The worst-case scenario is that a pile will be driven for its entire length using an impact hammer. All piles will be driven into subsurface conditions that consist of glacial till with the large potential for encountering cobbles and boulders. Given the uncertainty in the types and quantities of erratics that may be encountered, and the depth at which they may be encountered, the number of strikes necessary to drive a pile its entire length could range from about 1,000 to 2,000 strikes per pile.

Under the likely pile driving scenario described above, less than 1,000 impact strikes would be required per day. A less likely, but possible scenario estimates driving three piles full length (2,000 strikes per pile) after the piles have become hung on large boulders early in the installation process, and the proofing of an additional two piles at 200 strikes each with an impact hammer. This worst-case scenario would result in a maximum of 6,400 strikes per day.

Depending on the type of piles being driven and the number of rigs operating, between one and eight piles would be driven per day. Up to three vibratory rigs and one impact rig would be used at a time. The number of in-water pile days for the project as a whole would range between 200 and 400 depending on pile driving scenarios (minimum and maximum impact driving). Pile production rate (number of piles driven per day) is affected by many factors: size, type (vertical vs. angled), and location of piles; weather; number of driver rigs operating; equipment reliability; sound mitigation requirements; geotechnical (subsurface) conditions; and work stoppages for security or environmental reasons (such as presence of marbled murrelets or marine mammals). It is possible that the contractor may have up to three rigs on site during the first in-water window. Due to space constraints, only one rig can maneuver in to drive the shallow piles while the other two rigs have room to maneuver in the deeper water. The minimum pile driving day

glacially overridden soils. Recent experience at two other construction locations along the Bangor waterfront at NBK indicates that the piles should be able to be driven with a vibratory hammer to proper embedment depth. However, difficulties during pile driving may be encountered as a result of obstructions that may exist throughout the project area. Such obstructions may consist of rocks or boulders within the glacially overridden soils. If difficult driving conditions occur, increased usage of an impact hammer will occur.

scenario was developed conservatively assuming up to three rigs operating at once and the following pile production rates:

- Shallow trestle piles (24 inches): 4 per day
- Other trestle piles (36 inches): 6 per day
- Lightning tower plumb (large vertical 36 inches) piles: 4 per day
- Lightning tower batter (angled 36 inches) piles: 2 per day
- Wharf/warping wharf plumb piles (48/36 inches): 3 to 4 per day
- Dolphin batter piles: 1 to 2 per day
- Fender piles (24 inches): 7 to 8 per day
- These assumptions result in an estimated 200 in-water pile driving days plus 11 land-based pile driving days (Section 1.1.3) for the entire project.

The maximum pile driving day scenario assumed no more than two rigs operating at once and the following production rates:

- Shallow trestle piles: 2 per day
- Other trestle piles: 3 per day
- Lightning tower plumb piles: 2 per day
- Lightning tower batter piles: 1 per day
- Wharf/warping wharf plumb piles: 2 per day
- Dolphin batter piles: 1 per day
- Fender piles: 5 per day.
- These assumptions result in an estimated 400 in-water pile driving days plus 11 land-based pile driving days (Section 1.1.3) for the entire project.

Pile driving would typically take place 6 days per week, but could occur 7 days per week. The allowable season for in-water work, including pile driving, on NBK at Bangor is July 16 through February 15, which was established by the regulatory agencies (Washington Department of Fish and Wildlife [WDFW] in coordination with NMFS and the U.S. Fish and Wildlife Service [USFWS]) to protect juvenile salmon. Impact pile driving during the first half of the in-water work window (July 16 to September 15) would only occur between 2 hours after sunrise and 2 hours before sunset to protect breeding marbled murrelets. Between September 16 and February 15, construction activities occurring in the water would occur during daylight hours (sunrise to sunset). Other construction would occur between 7:00 AM and 10:00 PM 6 days per week, but could occur 7 days per week.

Under either the 200-day or 400-day pile driving scenario, there would be no more than 195 in-water pile driving days in the first work season covered by this IHA application. This number was established by calculating the maximum the number of days available during the in-water work season (July 16, 2012, through February 15, 2013), assuming 6.5 days of pile driving activity per week and 30 weeks between July 16 and February 15.

The number of construction barges (derrick and material) on site at any one time would vary between two and eight depending on the type of construction taking place. The maximum number of eight barges would likely be present at the beginning of construction, with multiple rigs and their support barges required to complete the work at various areas of the wharf. As pile installation progresses, the area will become congested, limiting the space available to support the pile driving rigs and barges. Also, as sections of the wharf are completed (e.g., the abutment, trestle) the need for some of the rigs/barges will be reduced. As a result, fewer barges will likely be necessary in each subsequent construction window. Tug boats would tow barges to and from the construction site and position the barges for construction activity. Tug boats would leave the site once these tasks were completed and so would not be on site for extended periods; there would be no more than two tug boats on site at any one time. Up to six smaller skiff type boats (less than 30 feet in length) would be on site performing various functions in support of construction and sensitive species monitoring. Measures will be implemented to ensure that mooring lines do not drag on the seafloor or entangle vegetation.

1.1.2 Project Details

For the access trestles and wharf combined, total overwater area would be 273,108 square feet (6.3 acres). There would be up to 1,250 permanent piles displacing 9,015 square feet of seafloor (Table 1–1).

Total length of the access trestles would be 1,849 feet. Approximately 1,400 feet of this would be 40 feet wide (trestles separate) and 449 feet would be 48 feet wide (trestles combined). Total overwater area for the trestles would be 81,208 feet (1.9 acres). The length of trestle lying above -30 feet MLLW would be approximately 407 feet, with an area of 17,859 square feet (0.4 acre).

Table 1–1. Physical Features of the Proposed EHW-2

Facility Feature	Quantity/Dimensions
Main Wharf Dimensions and Area	632 x 250 feet: 158,000 sq ft (152,200 sq ft covered overwater area)
Warping Wharf Dimensions and Area	688 x 40 feet: 34,300 sq ft including connection to access trestle
Lightning Tower Dimensions and Area	Six, each 30 x 30 feet Total area 5,400 sq ft
Trestle Dimensions and Area	1,849 feet long; 40–48 feet wide: 81,208 sq ft
Total Overwater Area	273,108 sq ft (6.3 acres)
Overwater Area Shallower than -30 feet MLLW	17,859 sq ft (0.4 acre)
Total Number of In-Water Piles	Up to 1,250
Number and Size of Main Wharf Piles	140 24-inch 157 36-inch 263 48-inch
Number and Size of Warping Wharf Piles	80 24-inch 190 36-inch
Number and Size of Lightning Tower Piles	40 24-inch 90 36-inch
Number and Size of Trestle Piles	57 24-inch 233 36-inch

Facility Feature	Quantity/Dimensions
Number of Piles Shallower than -30 feet MLLW	Approximately 90
Falsework piles (temporary)	Up to 150, 18-inch to 24-inch.
Area of Seafloor Displaced by Piles	9,015 sq ft (0.2 acre)
Trestle Abutment at Shore	103 feet long with 69-foot wing wall on north end
Number of Abutment Piles (upland)	55 (all 24 inch)
Excavation for Abutment	2,760 cu yd, 300 cu yd below MHHW Armor rock: 520 cu yd
New Impervious Surface (paved road)	50 x 140 feet, 7,000 sq ft (0.16 acre)
Construction Laydown Area (temporary)	5 acres
Upland Area Disturbed	Temporary: 5.8 acres Permanent: 0.8 acre
Pile Driving Duration	Maximum of 195 pile driving days in first in-water work season covered by this IHA (July 16, 2012, through February 15, 2013). Total of 211–411 days over 2–3 in-water work seasons*
Total Construction Duration	42–48 months

MHHW = mean higher high water; sq ft = square feet
* In-water work season is July 16 to February 15.

A total of 290 trestle piles would be required, 90 of which would lie above -30 feet MLLW. Spacing between bents (rows of piles) would be 25 feet. Concrete pile caps would be cast in place (on site) and would support pre-cast (off site) concrete deck sections. Pile driving equipment would be a 4,400 inch-pound vibratory driver and a 122,435 foot-pound impact hammer. Pile driving for the trestle would require one large derrick barge (70 by 200 feet) and one pile barge (50 by 200 feet); deck construction would require one smaller derrick barge and one material barge (50 by 200 feet).

The main wharf would be approximately 632 feet by 250 feet. Total overwater area, including the covered area, would be 152,200 square feet (Figure 1–2) including 43,500 square feet for the slip. The warping wharf would be approximately 688 feet by 40 feet (34,300 square feet including the wider connection to the access trestle), for a total wharf overwater area of 186,500 square feet. In addition, the six lightning towers would each be 30 feet by 30 feet (total of 5,400 square feet). Total overwater area for the main wharf, warping wharf, lightning towers, and trestles would be 273,108 square feet (6.3 acres).

The wharf deck would consist of pre-cast concrete sections, supported on cast-in-place concrete pile caps. The elevation of the bottom of the wharf deck would be +13 feet MLLW. The cover of the operations area and the lightning towers would be steel frame structures.

The wharf would be supported on a combination of large diameter (48-inch) plumb (vertical) piles, and smaller (24- to 36-inch) plumb and batter (angled) piles, all of which would be located in greater than 60 feet of water (Figure 1–2).There would be 263 48-inch piles and 297 piles ranging in diameter from 24 to 36 inches (Table 1–1). Piles would be driven into the seafloor to a depth of approximately 60 feet. Spacing between bents (rows of piles) would range from 25 to 26 feet. The primary pile driving method would be vibratory pile driver (156,000 to 264,000 inch-pounds). Impact hammer (122,500 to 297,700 foot-pounds) pile driving would also be needed. Pile driving for the wharf portion would require one to two large derrick barges (approximately 70 by 200 feet) and one to two pile barges for the duration of pile driving. One derrick barge and two material barges would be needed for wharf deck construction; construction of the lightning towers would require one derrick barge and one material barge.

The combined duration (wharf and trestle) of pile driving would be 211 to 411 days, including 11 days for the upland abutment piles, over two to three in-water construction seasons. The combined duration of construction would be 42 to 48 months including three in-water construction seasons. In the first construction season covered by this IHA application, there would be a maximum of 195 pile driving days.

Operational lighting on the wharf and access trestles would range from 100-Watt (W) metal halide lights to 1,500W quartz lights. Lights over the surrounding water would consist of pulse-start metal halide lights, plus 1,500W quartz back-up lights.

The wharf would be provided with full hotel service capability including power, potable water, fire protection, sewage connections, Ship Overboard Drainage collection, telephone, cable, and Local Area Network service.

1.1.3 Upland Component

Except for the abutment piles discussed below, the upland component of the project would not affect marine mammals. This component is described here for completeness and to provide the context for the overall proposed action.

A permanent paved road extension would be built to connect the new trestle(s) to an existing road (Figure 1–3). This road would be 50 feet wide and 140 feet long, creating approximately 0.2 acre of new impervious surface. A security fence would extend the length of this road and out onto the trestle(s). A gate and guard house (80 square feet) would be installed on this road, near where it connects to the existing road. A new paved road would be built to provide access from Archerfish Road to the upland construction area along the shoreline, while avoiding the nearby retention pond. This road would be approximately 610 feet long and typically between 28 and 32 feet wide, but expanding to 115 feet wide in the turn-around area at the southern curve. The area of this road would be approximately 0.6 acre. A culvert would be installed under the road to provide drainage from a seep south of the road to Hood Canal. Following construction, this road would be left in place to provide maintenance access to water lines and other facilities. Therefore, there would be a total of 0.8 acre permanently occupied by new roads. An additional 0.8 acre would be temporarily disturbed for cut and fill for the access road and for work on stormwater facilities and other utility work. This 0.8-acre area would be revegetated with native species following construction. Upland construction would use standard construction techniques, equipment, and Best Management Practices (BMPs).

A concrete abutment would be built at the face of the shore cliff, under the trestle(s) where the trestle(s) comes ashore. This abutment would be 10 feet high and 103 feet long plus a 69-foot wing wall, and require 520 tons of armor rock. Excavation would be 2,760 cubic yards; all of this material would be used for backfill either at the abutment or at another part of the adjoining upland construction site. The abutment would be pile-supported and constructed from the land side. Following construction, the exposed part of the abutment would lie above MHHW, although excavation and pile installation below MHHW would be needed for construction. Beach contours would be restored to pre-construction conditions. The abutment would be supported by 55 24-inch steel piles, depending on the alternative. These piles would be installed

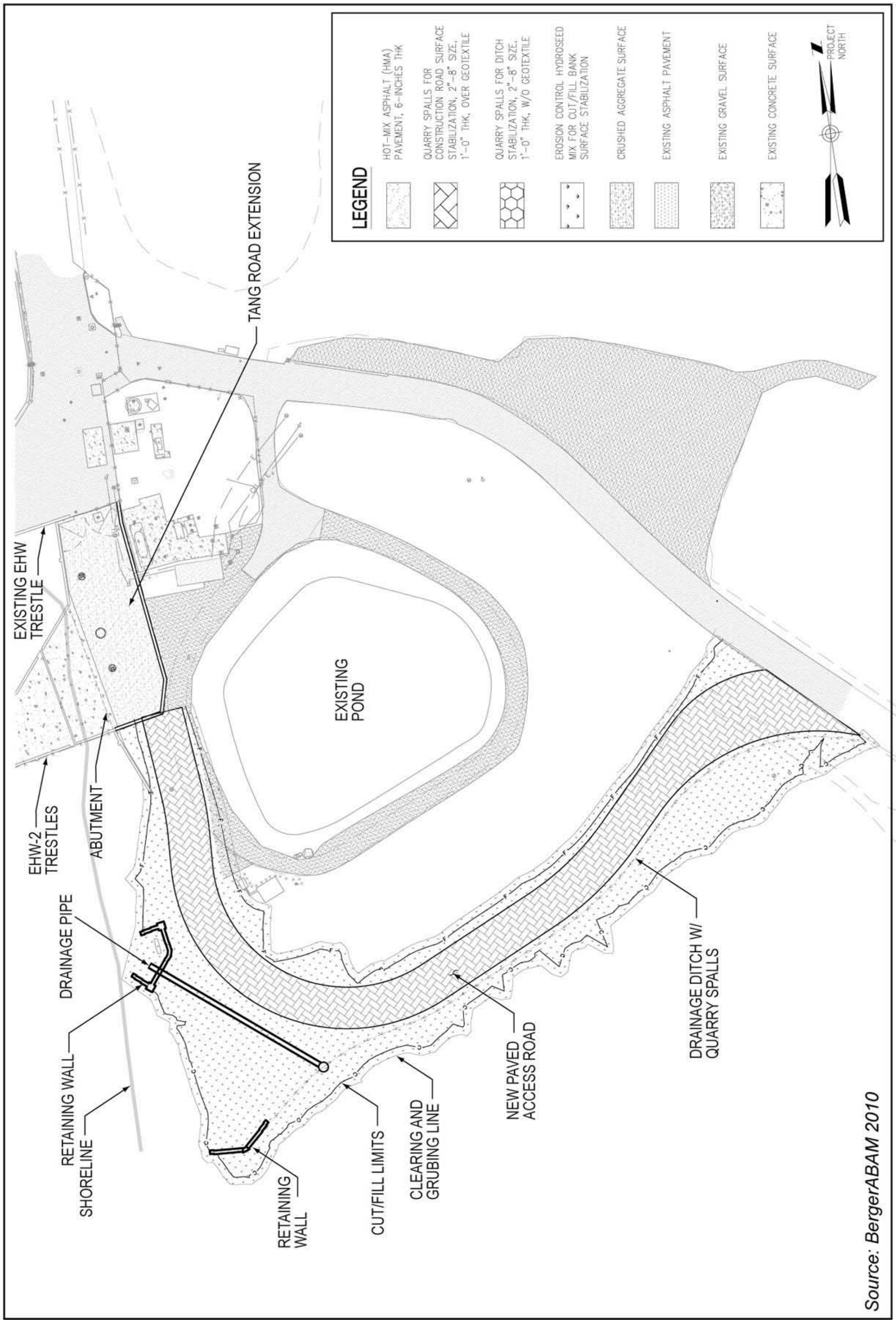

Figure 1–3. Upland Project Features

in the same manner as the in-water piles discussed above. Abutment construction would take about 20 days including 11 days for pile installation.

A 5-acre laydown area would be needed for the upland construction; the proposed site is vegetated, has no wetlands, and is located on the east side of Archerfish Road approximately 4,000 feet south of the proposed EHW-2. Storage of material and equipment as well as soil stockpiling would occur within the laydown area. Following construction, this area would be revegetated with native forest species. No new parking lots for construction parking or operational parking would be needed. Archerfish Road would be the primary haul route for construction.

New utility facilities for all alternatives would include the following:

- Two new 12-inch water lines, for domestic use and fire suppression, approximately 200 feet long to connect to an existing water line on Archerfish Road;
- Two new 20- by 20-foot backflow preventer vaults, to prevent backflow into the Navy domestic water system. One would be added at the northwest corner of the new gravel access road and Archerfish Road intersection. The second would be located approximately 5 feet west of the existing paved access road on the project site.
- One new underground 6-inch diameter Sanitary Sewer Forced Main for wharf sewer discharge. The main would extend approximately 220 feet, terminating at an existing manhole located approximately 40 feet east of the existing EHW and the end of Archerfish Road.
- One new underground 4-inch diameter Ship's Overboard Discharge Main. The main would be approximately 100 feet in length and would connect to the existing aboveground 10,000-gallon tank.
- Replacement of an aboveground 10,000-gallon oily wastewater tank with an underground tank of the same size in the same location to make room for the new security fence (an existing underground tank would not be impacted by the proposed action).
- One new 8-inch diameter storm drain to collect water runoff from the wharf, warping wharf, and trestle structures. The storm drain would be connected to approximately 18 catch basins with filter cartridges. The storm drain and catch basin would be located solely on the proposed structure.
- New 40- by 15-foot steel utility building that would replace an existing utility building. The new utility building would be located within the project site between the southeast corner of the existing EHW and the existing retention pond.
- Two new double-ended substations would be located on the wharf structure. One substation would contain two 2,500-kilovolt-ampere (kVA) transformers and the second would contain two 2,000 kVA transformers. Approximately 10 smaller transformers required to meet the energy needs of the new facility would be located on the wharf structure. The substation switchgear would be provided with circuit breakers with substation controls co-located with the transformers. One 200-kilowatt (kW) generator and one 125 kW generator are required and would be located on the wharf structure. The exact dimensions of the substations would be determined during the final design stage.

- Approximately 1,200 feet of new duct bank (an assembly of electrical and communication conduits encased in concrete ducting) that would replace 500 feet of existing ducting. Demolition of the old and installation of the new ducting would be confined between Archerfish Road, the existing retention pond, and the proposed project.
- Three new 8- by 10-foot utility manholes. Two of the new manholes would be located adjacent to the new utility building on the east side. The third would be located on the south side of the end of Archerfish Road.

Most of the upland construction would take place in the first 10 months of project construction. Non-pile driving construction would take place between 7:00 AM and 10:00 PM 6 days per week, but could occur 7 days per week. The number of construction workers would be approximately 100. Construction material would arrive via truck and barge. Construction debris would be hauled off of the site to an approved disposal facility.

As part of the proposed action, approximately 20 existing facilities and/or structures in proximity to the EHW-2 would be modified or demolished to comply with Department of Defense Explosives Safety Board (DDESB) and Naval Ordnance Safety and Security Activity (NOSSA) requirements to protect buildings located in the vicinity of explosives handling operations. The scope of facility modifications would primarily include replacement of doors and windows and possibly the modification or addition of building structural components, such as walls, interior and exterior columns, beams, and joists, and the replacement of existing roof systems. These modifications would not affect vegetated or undeveloped areas near the buildings to be modified.

Three new buildings would be constructed to house the functions of some of the buildings to be demolished. Three buildings would be at a single site at an existing parking lot on the Lower Base, approximately 2,500 feet from the shoreline (Figure 2–2). The buildings and associated roads, parking, and sidewalks would permanently occupy approximately 2.6 acres.

A fourth facility, the pure water facility, would be relocated to the landward end of the southern trestle to Delta Pier, about a mile south of the existing EHW. The new facility would cover approximately 0.5 acre.

1.1.4 Operations

Operation of the EHW-2 would not result in an increase in boat traffic along the Bangor waterfront on NBK. Rather, a portion of the ongoing operations and boat traffic at the existing EHW and other facilities within the Waterfront Restricted Area (e.g., Delta Pier and Marginal Wharf) would be diverted to the EHW-2. The EHW-2 may be used as a backup explosives handling facility for OHIO class guided missile submarines (SSGNs) currently homeported on NBK at Bangor when there are no TRIDENT operations at the existing EHW. The EHW-2 may also provide temporary berthing when no ordnance handling operations are occurring at either wharf. No increase in boat traffic would be required to achieve planned operations. The increase in future operations at the waterfront would only require that boats remain at an EHW longer when in port for maintenance and upgrades. The overall level of traffic and activity along the Bangor waterfront on NBK would not increase as a result of operating the EHW-2. Operation of the EHW-2 may require approximately 20 additional military and civilian personnel. The EHW-2 would be staffed 24 hours per day, 7 days per week.

Maintenance of the EHW-2 would include routine inspections, repair, and replacement of facility components as required. It would not be necessary to replace piles during the design life of the EHW-2. Fouling organisms would not be removed from piles.

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2 LOCATION AND DURATION OF ACTIVITIES

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

2.1 Region of Activity

NBK at Bangor is located on Hood Canal, which is a long, narrow, fjord-like basin of the western Puget Sound (Figure 2–1). 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 the headwaters at Belfair. Throughout its 67-mile length, the width of the canal varies from 1 to 2 miles and exhibits strong depth/elevation gradients and irregular seafloor topography in many areas. Although no official boundaries exist along the waterway, the northeastern section of the canal extending from the mouth of the canal at Admiralty Inlet to the southern tip of Toandos Peninsula is referred to as northern Hood Canal. The proposed project area is located within this region.

The proposed location for the EHW-2 is immediately south of the existing EHW (Figure 2–2). Two restricted areas are associated with NBK at Bangor, Naval Restricted Areas 1 and 2 (33 CFR 334.1220), which are depicted in Figure 2–3 relative to the project area. The regulations associated with Naval Restricted Area 1 indicated that no persons or vessels shall enter this area without permission from the Commander, Naval Submarine Base at Bangor, or his/her authorized representative. The regulations associated with Naval Restricted Area 2 indicate that Navigation will be permitted within that portion of the circular area not lying within Naval Restricted Area 1 at all times except when magnetic silencing operations are in progress.

2.2 Activity Area Description

2.2.1 Bathymetric Setting

In northern 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 depths shoal to approximately 160 feet over a moraine deposit. This deposit forms a sill across the short axis of the canal in the vicinity of Thorndyke Bay, which limits seawater exchange with the rest of Puget Sound. The Bangor waterfront on NBK 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 of the in-water project site are provided in Figure 2–4. The width of the canal is approximately 1.5 miles at the site, 2.2 miles at the northern end of NBK at Bangor, and constricts to approximately 1.1 miles near the southern end near Hazel Point. The furthest direct line of site from the project site is 8.4 miles to the north and 4.2 miles to the south (see Figure 2–4).

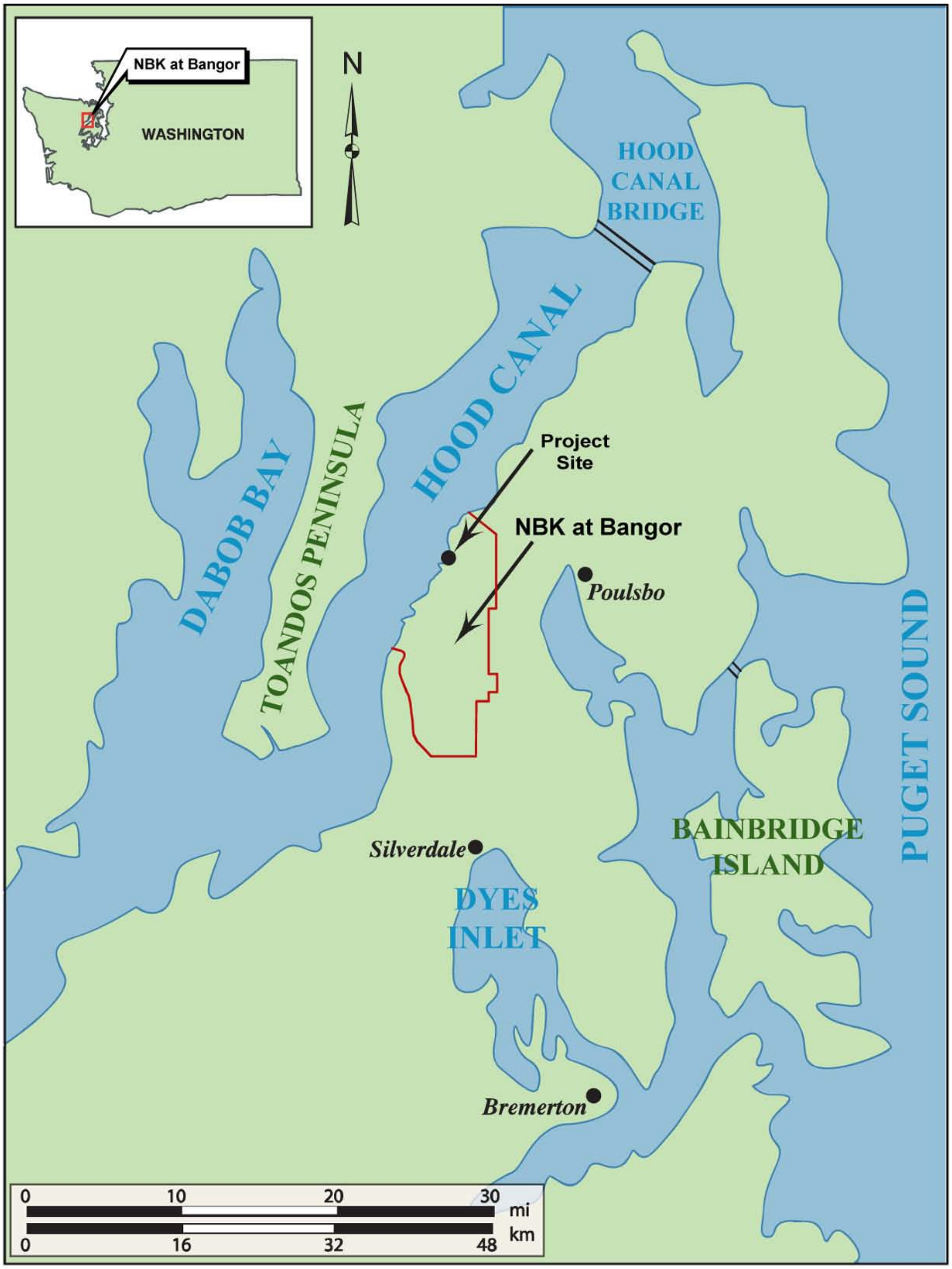


Figure 2–1. Vicinity Map

Figure 2–2. Location of the Proposed Project at the Bangor Waterfront

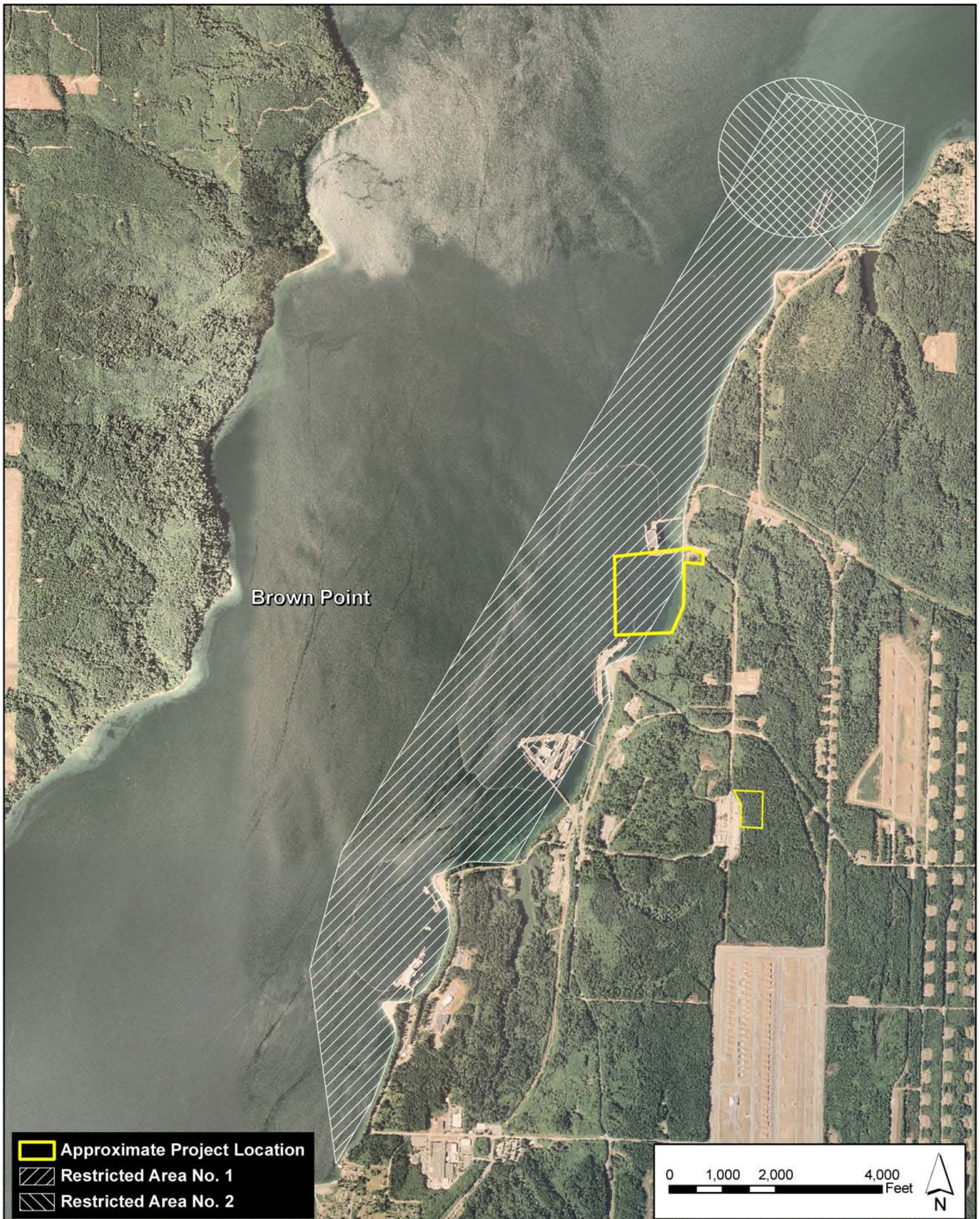


Figure 2–3. NBK at Bangor Restricted Areas

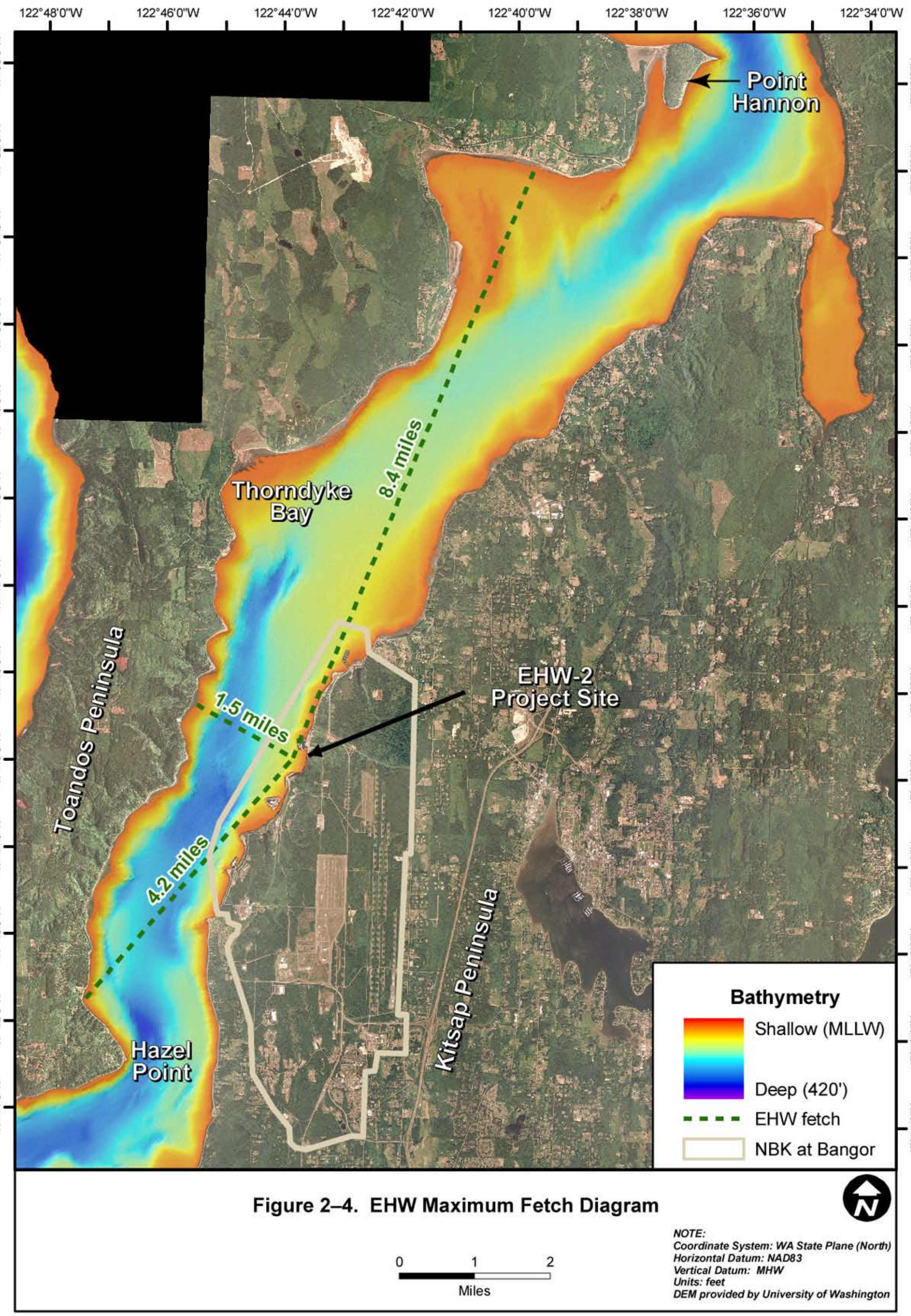


Figure 2–4. EHW Maximum Fetch Diagram

2.2.2 Tides

The tides in Hood Canal are mixed, diurnal-semidiurnal with a range directly dependent upon the phase and alignment of the lunar and solar gravitational influences on the regional tides (URS 1994; Morris et al. 2008). The astronomic influences (tides) on water level within Puget Sound and Hood Canal result in 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. As a result, higher high, lower high, higher low, and lower low water levels are recorded within each tide day.

Since the tides within Hood Canal are mixed diurnal-semidiurnal, this body of water 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 that can occur in this body of water, the actual seawater exchange volume for Hood Canal ranges from 1 percent during a minor tide to 4 percent during a major tide.

Despite considerable tidally driven seawater influx within the basin, some studies have estimated water residence time in the southern and middle portions of Hood Canal can be up to one year due to the natural limitation on seawater exchange (i.e., bathymetry) (Warner et al. 2001; Warner 2007). However, at the project site, the majority of the daily volume of seawater exchange flows directly across the Bangor waterfront area on NBK. As a result, the degree of flushing that occurs at the project area 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.

2.2.3 Circulation and Currents

Tidal currents and resulting circulation patterns within Hood Canal are complex due to the configuration of the basin, as well as the mixed diurnal-semidiurnal tidal regime. Current measurements obtained from the reaches of northern Hood Canal in the summer of 2007 indicate that tidal phase and range have a significant impact to the velocity of currents associated with the flood and ebb tides (Morris et al. 2008). The larger tidal ranges promote higher velocity currents and increased flushing of the basin, while small to moderate tidal ranges yield a diminished tidal current regime and limit the volume of seawater exchange between Hood Canal and Puget Sound. Seawater that enters the canal from Puget Sound 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 Puget Sound water has a tendency to sink to the bottom of the canal as it flows over the sill and 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) at the project area is primarily a function of tidal action based on the phase and range of each tide within the mixed diurnal-semidiurnal regime, 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 foot per second (ft/sec) within the 30- to 65-foot 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 ft/sec) 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 ft/sec range in the upper water column and less than 0.03 ft/sec in proximity to the seafloor.

The nearshore current observations at the project area and other NBK at 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 at the EHW-2 project site 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).

2.2.4 Sea State

Apart from larger impacts associated with large-scale changes in weather and ocean circulation in the Pacific Basin, seasonal variability in Hood Canal circulation can occur in the winter, when strong meteorological events (e.g., storms, high winds) are more prevalent. Regardless of direction, winds with velocities in excess of 25 knots occur relatively infrequently in the Puget Sound region (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, the project area is afforded some protection by the coastline of both Kitsap and Toandos Peninsulas (see Figure 2–4). Using a maximum fetch of 8.4 miles between the project area and the north shore of Thorndyke Bay to the north-northeast, estimates indicate that a 20-knot sustained wind has the capability to generate average wave heights of 1.9 feet (Beaufort Sea State [BSS] of 2) and a 30-knot wind event could produce wave heights of 3.1 feet (BSS=3) (Coastal Engineering Research Center [CERC] 1984). The maximum fetch to the southwest is one-half that to the northeast (4.2 miles), and could yield average waves of 1.3 feet in height (BSS=2) in a 20-knot wind, and 1.9 feet (BSS =2) in a 30 knot wind. Maximum wave heights that would be expected in these weather conditions would actually be 67 percent higher than average estimates reported above. Thus, a weather event capable of generating waves with an average height of 3.1 feet (BSS=3) could also yield waves with maximum heights of 5.1 feet (BSS=4) (CERC 1984).

2.2.5 Water Temperature

Water temperatures in the Strait of Juan de Fuca and Puget Sound typically range from 44 to 46 degrees Fahrenheit (°F) throughout the winter months (mid-December through mid-March). Surface waters slowly warm throughout the spring and summer due to increased solar heating, reaching temperatures of 50°F in mid-May or early June to a maximum temperature of 54°F during the month of August. Beginning in September, water temperatures begin to decrease over time, falling 6 to 8°F over the next 3 months due to decreasing levels of solar radiation. Occasionally, anomalies in this pattern of heating and cooling are detected in the data record, but are often short in duration (1 to 2 weeks). Monthly mean water temperatures along the Bangor waterfront on NBK in 2005–2006 are summarized in Table 2–1. Similar water temperature patterns were measured in 2007–2008 (Hafner and Dolan 2009). Nearshore areas (water depths range from 1 to 60 meters) are susceptible to greater temperature variations due to seasonal fluxes in solar radiation input.

Table 2–1. Monthly Mean Surface Water Temperatures (°C/°F)

Sampling Month	Nearshore Temperature	Offshore Temperature
July 2005	14.3°C (57.8°F)	11.6°C (52.9°F)
August 2005	13.8°C (56.8°F)	13.5°C (56.3°F)
September 2005	14.9°C (58.8°F)	11.6°C (52.9°F)
January 2006	8.2°C (46.8°F)	---
February 2006	8.1°C (46.6°F)	---
March 2006	8.5°C (47.3°F)	8.3°C (46.9°F)
April 2006	9.6°C (49.3°F)	9.3°C (48.7°F)
May 2006	10.9°C (51.6°F)	11.0°C (51.8°F)
June 2006	13.2°C (55.8°F)	---

Source: Phillips et al. 2009.

Data are from 13 nearshore and 4 offshore stations along the Bangor waterfront on NBK. Those stations near the EHW-2 project site are shown in Figure 2–5.

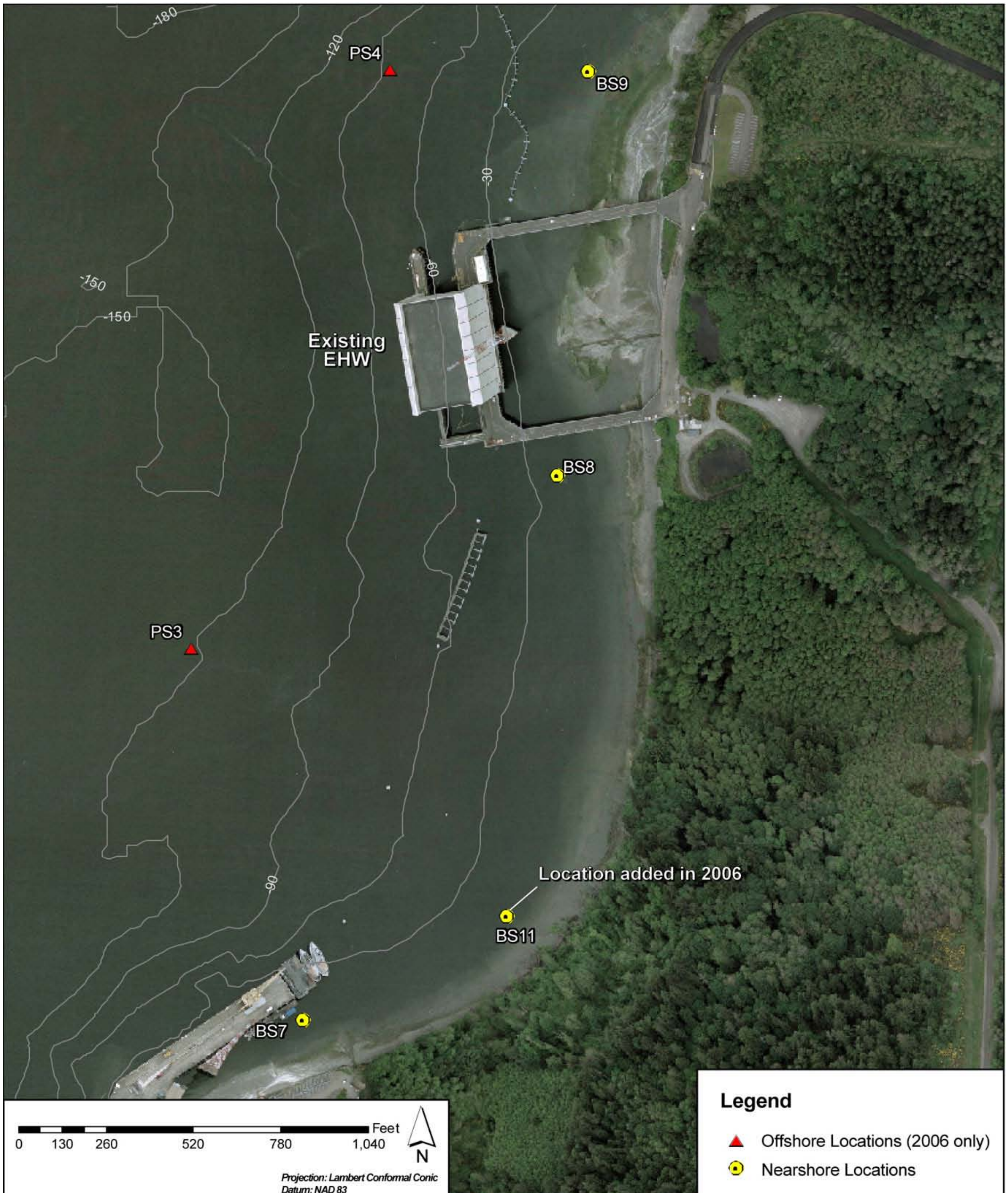
--- No data were collected at this depth during this sampling month.

2.2.6 Stratification and Salinity

The waters of Hood Canal surrounding the EHW-2 project site reflect a stratified water column with less saline surface water overlying cooler saline water with depth. The salinity of the upper water layer is sensitive to the amount of freshwater input and may become more diluted during heavy precipitation (URS 1994). Variances due to seasonal changes (such as freshwater input, wind-induced mixing, and solar heating) are common (URS 1994).

Freshwater input into Hood Canal comes from creeks, rivers, groundwater (including artesian wells [deep underground aquifer]), and stormwater outfalls. The freshwater inputs affect the salinity in Hood Canal. Artesian wells also contribute to freshwater inputs, with estimated flows of 2,000 to 2,500 gallons per minute (Washington Department of Ecology [WDOE] 1981). Overland flow from much of the western portion of NBK at Bangor is routed to Hood Canal through a series of stormwater outfalls. Saltwater and freshwater mixing zones exist at the mouths of each of these streams and outfalls (URS 1994).

During water quality surveys from 2005 through 2008, average surface water salinity levels along the NBK at Bangor waterfront ranged from 24 to 34 practical salinity units (PSU) (Phillips et al. 2009). Salinity measurements with depth reflected a stratified water column, with less saline surface water overlying cooler saline water at depth. The transition between the lower salinity surface waters and higher salinity subsurface waters occurred at a depth of about 33 feet (Phillips et al. 2009). The lowest surface water salinity (18.4 PSU) was measured in February 2007 when freshwater (low salinity) input may have been high due to winter storms and runoff (Hafner and Dolan 2009). The range of salinity along the Bangor waterfront on NBK is typical for marine waters in Puget Sound (Newton et al. 1998, 2002).



Source: Phillips et al. 2009

Figure 2–5. Water Quality Monitoring Stations for 2005 and 2006

2.2.7 Sediments

Existing sediment information is based on results from sampling at the project area during 2007 (Hammermeister and Hafner 2009); sampling locations are shown in Figure 2–6. Sediment quality at the project site is generally good; levels of contaminants meet applicable state standards. Marine sediments are composed of gravelly sands with some cobbles in the intertidal zone, transitioning to silty sands in the subtidal zone (Hammermeister and Hafner 2009).

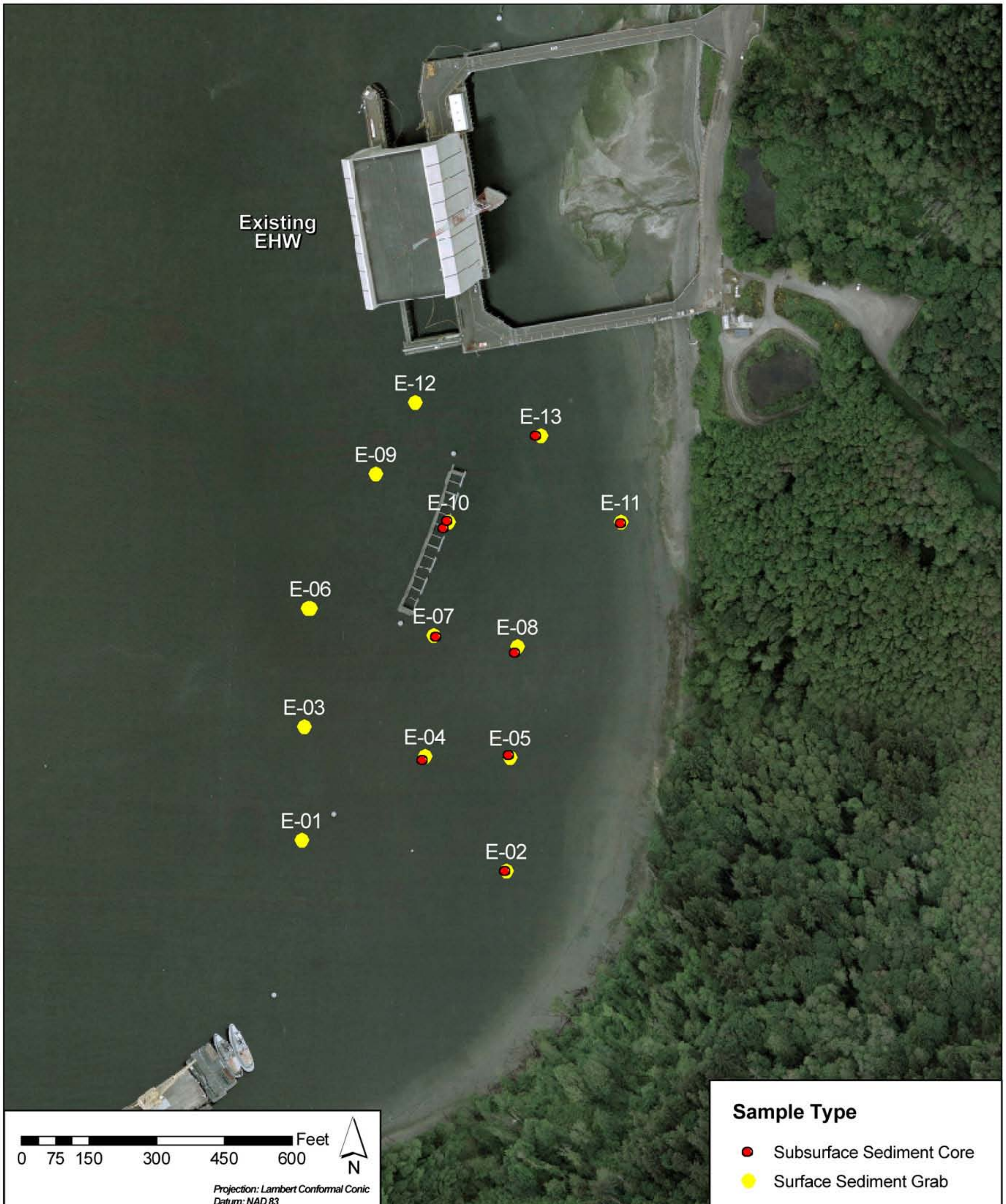
Subsurface coring studies conducted in 1994 found the presence of glacial till approximately 6 feet below mud line in the intertidal zone, increasing to over 10 feet in the subtidal zone (URS 1994). The composition of sediment samples from the project area ranged from 65 to 100 percent for sand, less than 1 to 7 percent for gravel, 2 to 32 percent silt, and 2 to 11 percent clay.

2.2.8 Ambient Underwater Soundscape

Underwater ambient noise at the project area is widely variable over time due to a number of natural and anthropogenic sources. A number of sources of underwater sound exist in the vicinity of the EHW-2 project site. Sources of naturally caused underwater noise include wind, waves, precipitation, and biological sources (such as shrimp, fish, and cetaceans). Noise derived from biological organisms can be absent or dominant over narrow and broad frequency ranges. Precipitation can 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 noise across most frequencies (Urick 1983). The highest noise levels occur in nearshore areas where the sound of surf can increase underwater noise levels by 20 dB or more within 200 yards from the surf zone in the 200 hertz (Hz) to 2 kilohertz (kHz) regime (Wilson et al. 1985). In addition, wakes from boat traffic cause breaking waves in the surf zone.

There is also human-generated noise from ship or boat traffic and other mechanical sources (Urick 1983). Small powerboats generate peak narrow band sound pressure levels of 150 to 165 decibels referenced at 1 microPascal (dB re 1µPa) at 3 feet in the 350 to 1,200 Hz region, with mean sound pressure levels of 148 dB re 1µPa at 3 feet (Barlett and Wilson 2002). Fishing vessels can generate peak spectral densities of 140 dB re 1µPa at 3 feet in the 250 to 1,000 Hz regime (Hildebrand 2004). Underwater sound from human activities includes ship traffic noise, use of sonar and echo sounders in commercial fishing to locate fish schools, industrial ship noise, and recreational boat use. Ship and small boat noise comes from propellers and other on-board rotating equipment. Other sources of underwater noise at industrial waterfronts could come from cranes, generators, and other types of mechanized equipment on wharves or the adjacent shoreline.

In the vicinity of the EHW-2 project site, average broadband ambient noise levels were measured at 114 dB re 1µPa between 100 Hz and 20 kHz (Slater 2009). Peak spectral noise from industrial activity was noted below the 300 Hz frequency, with maximum levels of 110 dB re 1µPa noted in the 125 Hz band. In the 300 Hz to 5 kHz range, average levels ranged between 83 and 99 dB re 1µPa. Wind-driven wave noise dominated the background noise environment at approximately 5 kHz and above, and ambient noise levels flattened above 10 kHz. The primary source of noise was due to industrial activity along the waterfront (such as at the existing EHW, Marginal Wharf, and Delta Pier), small boat traffic, and wind-driven wave noise. No substantial precipitation was noted during the study period, although this noise would be undoubtedly present during seasonal periods.



Source: Hammermeister and Hafner 2009

Figure 2–6. Sediment Sampling Locations

Carlson et al. (2005) measured the underwater baseline noise at Hood Canal Bridge and found that underwater noise levels ranged from 115 to 135 dB re 1µPa. The Washington State Department of Transportation (WSDOT) summarized underwater noise at ferry terminals with no construction activity as ranging from 135 dB at Mukilteo ferry terminal, 131 to 136 dB (peak levels) at Friday Harbor, and 151 dB (peak levels) at the Bainbridge Island terminal (WSDOT 2010). In a study conducted in Haro Strait, San Juan Islands, data showed that the ambient half-hourly SPL in Haro Strait ranged from 95 dB to 130 dB (Veirs and Veirs 2005), which demonstrates the range over which localized anthropogenic noise can vary by specific locations and time periods. Average underwater broadband noise levels measured at the EHW-2 project site, inclusive of existing human activities but in the absence of construction activities, fell within the minimum and maximum range of measurements taken at similar environments within Puget Sound. For the purposes of further noise analyses, the average background underwater noise levels at the project area were considered to be 114 dB re 1µPa between 100 Hz and 20 kHz.

2.3 Duration of Activities

For this IHA application covering the first year of construction, pile driving would begin on July 16, 2012, and conclude on February 15, 2013. There would be a maximum total of 195 days of pile driving during this period (an average of 6.5 days per week during this 30-week period). Non-in-water work would continue through July 15, 2013. Construction for the entire project is estimated to last for 42 to 48 months, concluding in 2016. A total of 1,250 piles ranging in diameter from 24 to 48 inches would be driven. An estimated 200 to 400 days of in-water pile driving (plus 11 days for land-based pile driving) are expected. Up to three vibratory and one impact hammer pile driving rigs would operate concurrently. The number of impact hammer strikes would range from 1,000 per day to a most-conservative case of 6,400 per day. Most of the pile driving would occur in the first in-water work season, with less pile driving in the second and third seasons. Most of the upland construction would occur in the first 10 months of project construction.

3 MARINE MAMMAL SPECIES AND NUMBERS

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

Six marine mammal species, three cetaceans and three pinnipeds, have been documented in the waters near NBK at Bangor in Hood Canal. These include the transient killer whale, harbor porpoise, Dall's porpoise, Steller sea lion, California sea lion, and harbor seal. The Steller sea lion is the only marine mammal in the project area that is listed under the Endangered Species Act (ESA); the U.S. Eastern stock/Distinct Population Segment (DPS) is listed as threatened. The southern resident killer whale stock, which is listed as endangered, resides primarily in Puget Sound but is being excluded from further analysis because it has not been seen in Hood Canal in over 15 years (Ford 1991; Unger 1997; NMFS 2008c). All marine mammal species are protected under the MMPA. Section 3 summarizes the species description and population abundance of these species, while Section 4 contains detailed life history information. Table 3–1 lists the marine mammal species that occur in the vicinity of NBK at Bangor.

Table 3–1. Marine Mammals Historically Sighted in Hood Canal in the Vicinity of NBK at Bangor

Species	Stock(s) Abundance [1]	Season(s) of Occurrence	Relative Occurrence [a]	Density (Individuals per sq km [b]) Within In-water Work Season [c]
Steller sea lion *Eumetopias jubatus* Eastern U.S. stock/DPS	58,334–72,223 [2]	Late fall to spring (October – mid April)	Common	0.028
California sea lion *Zalophus californianus* U.S. stock	238,000 [3]	Late summer to late spring (August – early June)	Common	0.63
Harbor seal *Phoca vitulina* WA inland waters stock	14,612 [3] (CV=0.15)	Year-round; resident species in Hood Canal	Common	1.3
Killer whale *Orcinus orca* West Coast transient stock	354 [2, d]	Year-round	Rarely present	0.04
Dall's porpoise *Phocoenoides dalli* CA/OR/WA stock	42,000 [3] (CV=0.33	Year-round	Rarely present	0.01
Harbor porpoise *Phocoena phocoena* WA inland waters stock	10,682 [3] (CV=0.38)	Year-round	Occasionally present	0.250

Sources: 1. NMFS marine mammal stock assessment reports at: http://www.nmfs.noaa.gov/pr/sars/species.htm; 2. Allen and Angliss 2011; 3. Carretta et al. 2011.

a. Common: Consistently present either year-round (harbor seal) or during non-breeding season (California sea lion and Steller sea lion); Occasionally present: Documented at irregular intervals; Rarely present: sporadic sightings, not occurring on a yearly basis.

b. See density calculations in Section 6.7.

c. In-water work season is the period from July 16– February 15.

d. Combined catalog counts for West Coast stock.

CA = California; CV = coefficient of variation; OR = Oregon; WA = Washington

The harbor seal is an abundant year-round resident of Hood Canal, and the cetacean species, although rarely present, may be encountered in any season (Table 3–1). The two sea lion species have seasonal peaks of abundance in Hood Canal. The Steller sea lion is a year-round resident of inland waters, but its use of Hood Canal extends from late fall to spring. The Steller sea lion is a seasonal visitor to the Bangor waterfront on NBK, but appears consistently during those times in small numbers (maximum number observed was 6 individuals). California sea lions observed on NBK at Bangor are adult and sub-adult males from the California breeding population that spend the non-breeding season in the Pacific Northwest. The species has been observed at haul-out locations on NBK at Bangor from August to early June.

3.1 ESA-Listed Marine Mammals

3.1.1 Steller Sea Lion

Species Description

Steller sea lions are the largest members of the Otariid (eared seal) family. Steller sea lions show marked sexual dimorphism, in which adult males are noticeably larger and have distinct coloration patterns from females. Males average approximately 1,500 pounds and 10 feet in length; females average about 700 pounds and 8 feet in length. Adult females have a tawny to silver-colored pelt. Males are characterized by dark, dense fur around their necks that appears like a mane and light tawny coloring over the rest of their body (NMFS 2008a).

Population Abundance

The eastern DPS of Steller sea lions includes the species distribution east of 144°W longitude (Loughlin 1997), including southeast Alaska, Canada, Washington, Oregon, and California (62 FR 30772). The eastern stock was estimated by NMFS in the *Recovery Plan for the Steller Sea Lion* to number between 45,000 to 51,000 animals (NMFS 2008a). This stock has been increasing approximately 3 percent per year over the entire range since the late 1970s (NMFS 2008a; Pitcher et al. 2007). The most recent population estimate for the Eastern stock ranges from 58,334 to 72,223 (Allen and Angliss 2011).

The Eastern stock is 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) (Angliss and Outlaw 2008; Olesiuk 2008). Steller sea lion numbers in southern and central California have declined from historic numbers, but they have been relatively stable since 1980. Although the population size has increased overall, the status of this stock relative to its optimum sustainable population is unknown (Angliss and Outlaw 2008).

Steller sea lions occupy major winter haul-out sites on the coast of Vancouver Island in the Strait of Juan de Fuca and the Georgia Basin (Bigg 1985; Olesiuk 2008); the closest breeding rookery to the project area is at Carmanah Point near the western entrance to the Strait of Juan de Fuca. In Washington inland waters, up to 10 animals have been observed at Toliva Shoals in south Puget Sound (Jeffries et al. 2000), and up to six individuals have been observed on NBK at Bangor (Bhuthimethee 2008, personal communication; Navy 2010).

3.2 Non-ESA Listed Marine Mammals

3.2.1 California Sea Lion

Species Description

California sea lions are also members of the Otariid family. The species *Zalophus californianus* includes three subspecies: *Z. c. wollebaeki* (on the Galapagos Islands), *Z. c. japonicus* (in Japan, but now thought to be extinct), and *Z. c. californianus* (found from southern Mexico to southwestern Canada; referred to here as the California sea lion) (Carretta et al. 2007a).

Population Abundance

California sea lions occur in the marine waters nearby NBK at Bangor. The entire population cannot be counted because all age and sex classes are never ashore at the same time, and population estimates are extrapolated from pup counts and counts of all age classes at rookeries and haul-out sites. The most recent estimate of population size is 238,000 individuals (Carretta et al. 2011). These numbers are derived from counts during the 2005 breeding season of animals that were ashore at the four major rookeries in southern California and at haul-out sites north to the Oregon/California border. Sea lions that were at-sea or hauled out at other locations were not counted (Carretta et al. 2011). An estimated 3,000 to 5,000 California sea lions migrate to Washington and British Columbia waters during the non-breeding season from September to May (Jeffries et al. 2000). Peak numbers of up to 1,000 sea lions occur in Puget Sound (including Hood Canal) during this time period (Jeffries et al. 2000).

3.2.2 Harbor Seal

Species Description

Pacific Ocean harbor seals, which are members of the family Phocidae ("true seals"), inhabit coastal and estuarine waters and shoreline areas from Baja California to western Alaska. For management purposes, differences in mean pupping date (i.e., birthing) (Temte 1986), movement patterns (Jeffries 1985; Brown 1988), pollutant loads (Calambokidis et al. 1985), and fishery interactions have led to the recognition of three separate harbor seal stocks along the west coast of the continental U.S. (Boveng 1988). The three distinct stocks are: (1) inland waters of Washington State (including Hood Canal, Puget Sound, and the Strait of Juan de Fuca out to Cape Flattery), (2) outer coast of Oregon and Washington, and (3) California (Carretta et al. 2007a). The inland waters of Washington state stock is the only stock that is expected to occur within the project area. Interchange between inland and coastal stock is unlikely, based on radiotelemetry results (Jeffries et al. 2003).

Population Abundance

Estimated population numbers for the Washington inland waters harbor seal stock are 14,612 (CV=0.15) individuals (Carretta et al. 2011). The harbor seal is the only species of marine mammal that is consistently abundant and considered resident in Hood Canal (Jeffries et al. 2003). The population of harbor seals in Hood Canal is a closed population, meaning they do not have much movement outside of Hood Canal (London 2006). The abundance of harbor seals in Hood Canal has stabilized in recent decades, and the population may have reached its carrying capacity in the mid-1990s with an approximate abundance of 1,000 harbor seals (Jeffries et al. 2003).

3.2.3 Killer Whale (Transient Type)

Species Description

Killer whales are members of the Delphinid (dolphin) family and are the most widely distributed cetacean (e.g., whales, dolphins, and porpoises) species in the world. Based on appearance, feeding habits, vocalizations, social structure, and distribution and movement patterns, there are three types of killer whales (Ford et al. 2000; Krahn et al. 2002). Three distinct forms or types of killer whales are recognized in the North Pacific Ocean: (1) residents, (2) transients, and (3) offshores. The resident and transient populations have been subdivided further into different subpopulations based primarily on genetic analyses, distribution, and social affiliations; not enough is known about the offshore whales to divide them into subpopulations (Krahn et al. 2004; Hoelzel et al. 1998, 2007).

Within the transient ecotype, association data (Ford et al. 2000; Ford and Ellis 1999; Matkin et al. 1999), acoustic data (Saulitis 1993; Ford and Ellis 1999), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirm that three communities of transient whales exist and represent three discrete populations. These populations include: (1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients; (2) AT1 transients; and (3) West Coast transients. Among the genetically distinct assemblages of transient killer whales in the northeastern Pacific, only the West Coast transient stock, which occurs from southern California to southeastern Alaska, may occur in the project area.

Population Abundance

The West Coast transient stock includes animals that occur in California, Oregon, Washington, British Columbia, and southeastern Alaska. Analysis of photographic data resulted in the following minimum counts for West Coast transient stock killer whales. In British Columbia and southeastern Alaska, 219 transients have been catalogued (Ford and Ellis 1999, Dahlheim et al. 1997). Off the coast of California, 105 transients have been identified (Black et al. 1997), 10 of which match photos of whales in other catalogs and the remaining 95 were linked by association. An additional 14 whales in southeastern Alaska and 16 whales off the coast of California have been provisionally classified as transient by association. Combined, these counts give a minimum number of 354 (219 + 95+10+14+16) individuals belonging to the West Coast transient stock (Allen and Angliss 2011). A recent mark-recapture estimate for the West Coast Transient population, excluding whales from California, resulted in an estimate of 243 (95% probability interval = 180-339) in 2006 (DFO 2009). This estimate applies to the population of West Coast Transient whales that occur in southeastern Alaska, British Columbia, and northern Washington (Allen and Angliss 2011). However, the number in Washington waters at any one time is probably fewer than 20 individuals (Wiles 2004).

3.2.4 Dall's Porpoise

Species Description

Dall's porpoises are members of the Phocoenid (porpoise) family and are common in temperate waters of the North Pacific Ocean. The distribution of Dall's porpoise through its range is highly variable between years and appears to be affected by oceanographic conditions (Forney 1997; Forney and Barlow 1998). The stock structure of eastern North Pacific Dall's porpoise is not known. For MMPA stock assessment reports, Dall's porpoises within the Pacific U.S. Exclusive Economic Zone (EEZ), i.e., a distance of 200 nautical miles out from the U.S. Pacific coast, are divided into two discrete, noncontiguous areas: (1) waters off California, Oregon, and Washington; and (2) those in Alaskan waters (Carretta et al. 2008). Individuals from the California/Oregon/Washington stock occur within the project area.

Population Abundance

The NMFS population estimate for the California/Oregon/Washington stock is the geometric mean of estimates from 2005 (Forney 2007) and 2008 (Barlow 2010), or 42,000 (CV=0.33) animals (Carretta et al. 2011). Additional numbers of Dall's porpoise occur in the inland waters of Washington state, but the most recent estimate obtained in 1996 (900 animals; CV=0.40) (Calambokidis et al. 1997) is not included in the overall estimate of abundance for this stock due to the need for more up-to-date information.

3.2.5 Harbor Porpoise

Species Description

Harbor porpoises belong to the Phocoenid (porpoise) family and are found extensively along the North Pacific coast. Recent preliminary genetic analyses of samples ranging from Monterey, California, to Vancouver Island, British Columbia, indicate that there is small-scale subdivision within the U.S./Vancouver Island, British Columbia, portion of this range (Chivers et al. 2002). These genetically distinguishable groupings are not geographically distinct by latitude, but results suggest a low mixing rate and limited movement of harbor porpoise along the west coast of North America. Survey data found significant differences in harbor porpoise mean densities between coastal Oregon/Washington waters and inland Washington/British Columbia waters (Calambokidis et al. 1993), although a specific stock boundary line cannot be identified based upon biological or genetic differences. Since harbor porpoise movements and rates of intermixing within the eastern North Pacific are restricted, and there was a significant decline in harbor porpoise sightings within southern Puget Sound from the 1940s until recently (Calambokidis 2010, personal communication), NMFS conservatively recognizes two stocks in Washington waters: the Oregon/Washington Coast stock and the Washington Inland Waters stock (Carretta et al. 2011). Individuals from the Washington Inland Waters stock are expected to occur in the project area.

Harbor porpoise sightings have increased in Puget Sound and northern Hood Canal in recent years and are now considered to regularly occur year-round in these waters (Calambokidis 2010, personal communication). This may represent a return to historical conditions, when harbor porpoises were considered one of the most common cetaceans in Puget Sound (Scheffer and Slipp 1948).

Population Abundance

Aerial surveys of the inside waters of Washington and southern British Columbia were conducted during August of 2002 and 2003 (J. Laake, unpublished data in Carretta et al. 2011). These aerial surveys included the Strait of Juan de Fuca, San Juan Islands, Gulf Islands, and Strait of Georgia, which includes waters inhabited by the Washington Inland Waters stock of harbor porpoise as well as harbor porpoises from British Columbia. An average of the 2002 and 2003 estimates of abundance in U.S. waters resulted in an uncorrected abundance of 3,123 (CV=0.10) harbor porpoises in Washington inland waters (J. Laake, unpublished data in Carretta et al. 2011). When corrected for availability and perception bias, using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake et al. 1997), the estimated abundance for the Washington Inland Waters stock of harbor porpoise is 10,682 (CV=0.38) animals (Carretta et al. 2011).

3.3 Marine Mammal Modeling Parameters

3.3.1 Spatial Distribution and Project-Area Survey Efforts

Density assumes that marine mammals are uniformly distributed within a given area, although this is rarely the case. Marine mammals are usually clumped in areas of greater importance, for example, areas of high prey abundance, safe calving or haul-out, areas with lower predation risk, etc. Available data on marine mammal populations in Hood Canal are sparse, with the exception of surveys of harbor seal haul-outs (Jeffries et al. 2000) and recent surveys on NBK at Bangor (Agness and Tannenbaum 2009; Tannenbaum et al. 2009, 2011; Navy 2010; Navy 2011a, in prep.), some of which covered a very limited area.

Beginning in April 2008, Navy personnel have recorded sightings of marine mammals including California sea lion, Steller sea lion, and harbor seal at known sea lion haul-outs along the Bangor waterfront on NBK, including Delta Pier, Marginal Wharf, Service Pier, K/B Dock, 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. These sightings took place frequently (average 14 per month) although without a formal protocol. 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), and other relevant notes. Surveys were conducted using binoculars and the naked eye from shoreline locations or the piers/wharves themselves. Data were compiled for the period from April 2008 through June 2010 for analysis in this IHA.

Boat-based opportunistic sightings along portions of the Bangor waterfront on NBK 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 and 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 on NBK (approximately 3.9 sq km) 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 haul-out 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 GPS, and, subsequently, analyzing these data with the coordinate geometry application available in ArcInfo to produce coordinates of the locations of all animals detected.

Recently, as part of the Test Pile Program, marine mammal monitoring was conducted on construction days for mitigation. In addition, on days where no pile driving activities occurred due to construction delays, security restrictions, or other factors, the Navy conducted vessel-based line transect surveys in Hood Canal and Dabob Bay to collect additional density data for species present in Hood Canal. The primary impetus for these surveys was observational data during construction monitoring, which 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). 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 for the data. Due to the recent execution of these surveys, not all data have been processed. Due to the unexpected abundance of harbor porpoises encountered during the Test Pile Program, data for this species were processed first and are available for inclusion in this IHA application. All other species data may be included in subsequent environmental compliance documents once all post processing is complete.

The cetacean species and the harbor seal appear to range throughout Hood Canal; therefore, the analysis in this IHA application assumes that harbor seal, transient killer whale, harbor porpoise, and Dall's porpoise are uniformly distributed in the project area. The remaining species that occur in the project area, Steller sea lion and California sea lion, do not appear to utilize most of Hood Canal. As described in Sections 4.1.1, Steller Sea Lion, and 4.2.1, California Sea Lion, these species appear to be attracted to the manmade haul-out opportunities along the Bangor waterfront on NBK and forage in the nearby waters. They have been seen seen leaving the piers and swimming south of the base towards the large river mouth areas by Dosewallips. The California sea lion was not reported during aerial surveys of Hood Canal (Jeffries et al. 2000), and the Steller sea lion has only been documented on NBK at Bangor (although NMFS [1997b] stated that the species is present in Hood Canal without providing numbers, locations, or sighting dates). Therefore, it is assumed in this IHA application that sea lion species are either hauled out on NBK at Bangor or are transiting or foraging from this area, and density calculations utilize the project impact area defined at the maximum area in which underwater noise disturbance would affect pinnipeds (see Section 6.5, Distance to Sound Thresholds, for discussion of density calculations).

3.3.2 Submergence

Cetaceans spend their entire lives in the water and spend most of their time (>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.

Seals and sea lions (pinnipeds) spend significant amounts of time out of the water during breeding, molting, and hauling out periods. Seals and sea lions have been sighted hauling out in the vicinity of NBK at Bangor. 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 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.

For the purpose of assessing impacts from underwater sound on NBK at Bangor, the Navy assumed that that all three cetacean species and two pinniped species that may be found in the vicinity of NBK at Bangor (Steller sea lion, California sea lion, killer whale, Dall's porpoise, and harbor porpoise) spend 100 percent of the time underwater. This approach could be considered 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. The harbor seal was the only species for which detailed information regarding the percentage of time spent underwater, in-water but at the surface, and hauled out was available (Jeffries et al. 2003; Huber et al. 2001). The application of these results to exposure calculations for harbor seals in this IHA application is described in detail in Section 6.7.3, Harbor Seal.

4 STATUS AND DISTRIBUTION OF MARINE MAMMAL SPECIES

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

There are six marine mammal species within the marine waters adjacent to NBK at Bangor with confirmed or historic occurrence in the project area. Only one of these species, the Steller sea lion, is listed as threatened or endangered under the ESA.

4.1 ESA-Listed Marine Mammals

4.1.1 Steller Sea Lion (*Eumetopias jubatus*), Eastern Stock

ESA Status and Management

The Steller sea lion was originally listed as threatened under the ESA in 1990. In 1997, NMFS reclassified Steller sea lions as two subpopulations based on genetics and population trends, listing the Western stock as endangered, and maintaining threatened status for the Eastern stock (NMFS 1997a). The Eastern stock, which occurs within the project area, includes the animals east of Cape Suckling, Alaska (144°W) (NMFS 1997a; Loughlin 2002; Angliss and Outlaw 2005). Steller sea lions west of 144°W longitude residing in the central and western Gulf of Alaska, Aleutian islands, as well as those that inhabit coastal waters and breed in Asia (e.g., Japan and Russia) are part of the Western stock. The Eastern stock breeds in rookeries located in southeast Alaska, British Columbia, Oregon, and California; there are no rookeries located in Washington. There is a final revised species recovery plan that addresses both stocks (NMFS 2008a).

Critical habitat has been designated for the Steller sea lion (NMFS 1993). Critical habitat includes so-called “aquatic zones” that extend 3,000 feet (0.9 kilometer [km]) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in Oregon and California (NMFS 2008a). Three major rookery sites in Oregon (Rogue Reef, Pyramid Rock, and Long Brown Rock and Seal Rock on Orford Reef at Cape Blanco) and three rookery sites in California (Ano Nuevo I, Southeast Farallon I, and Sugarloaf Island and Cape Mendocino) are designated critical habitat (NMFS 1993). There is no designated critical habitat for the species in Washington.

Distribution

Eastern stock Steller sea lions are found year-round along the coasts of British Columbia, Washington, Oregon, and northern California where they occur at breeding rookeries and numerous haul-out locations along the outer coastline and Vancouver Island (Jeffries et al. 2000; Scordino 2006; Olesiuk 2008). Male Steller sea lions often disperse widely from rookeries outside the breeding season. For example, males that attend breeding rookeries in northern California (St. George Reef) and southern Oregon (Rogue Reef) frequent winter feeding areas in Washington, British Columbia, and Alaska (Scordino 2006).

There are no known breeding rookeries in Washington State (NMFS 1992; Angliss and Outlaw 2005) but Eastern stock Steller sea lions are present year-round along the outer coast of Washington at four major haul-out sites (NMFS 2008a). Both sexes are present in Washington waters; these animals are likely immature or non-breeding adults from rookeries in other areas

(NMFS 2008a). In Washington, Steller sea lions primarily occur at haul-out sites along the outer coast from the Columbia River to Cape Flattery. In inland waters, Steller sea lions use haul-out sites along the Vancouver Island coastline of the Strait of Juan de Fuca (Jeffries et al. 2000; COSEWIC 2003; Olesiuk 2008). Numbers vary seasonally in Washington waters with peak numbers present during the fall and winter months (Jeffries et al. 2000). The highest breeding season Steller sea lion count at Washington haul-out sites was 847 individuals during the period from 1978 to 2001 (Pitcher et al. 2007). Non-breeding season surveys of Washington haul-out sites reported as many as 1,458 individuals between 1980 and 2001 (NMFS 2008a).

Steller sea lions are occasionally present at the Toliva Shoals haul-out site in south Puget Sound (Jeffries et al. 2000) and a rock 3 miles south of Marrowstone Island (NMFS 2010). Fifteen Steller sea lions have used this haul-out site. On NBK at Bangor, Steller sea lions have been observed hauled out on submarines at Delta Pier on several occasions from 2008 through 2011 during fall through spring months (October to April) (Bhuthimethee 2008, personal communication; Navy 2010) (see detailed discussion in Section 6.6.1). Other potential haul-out sites would include isolated islands, rocky shorelines, jetties, buoys, rafts, and floats (Jeffries et al. 2000). Steller sea lions likely utilize foraging habitats in Hood Canal similar to those of the California sea lion and harbor seal, which include marine nearshore and deeper water habitats.

Behavior and Ecology

Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple 2002). At sea, groups usually consist of female and subadult males; adult males are usually solitary while at sea (Loughlin 2002). In the Pacific Northwest, breeding rookeries are located in British Columbia, Oregon, and northern California. Steller sea lions form large rookeries during late spring when adult males arrive and establish territories (Pitcher and Calkins 1981). Large males aggressively defend territories while non-breeding males remain at peripheral sites or haul-outs. Females arrive soon after and give birth. Most births occur from mid-May through mid-July, and breeding takes place shortly thereafter. Most pups are weaned within a year. Non-breeding individuals may not return to rookeries during the breeding season but remain at other coastal haul-outs (Scordino 2006).

Steller sea lions are opportunistic predators, feeding primarily on fish and cephalopods, and their diet varies geographically and seasonally (Bigg 1985; Merrick et al. 1997; Bredesen et al. 2006; Guénette et al. 2006). Foraging habitat is primarily shallow, nearshore and continental shelf waters; freshwater rivers; and also deep waters (Reeves et al. 2008; Scordino 2010). Their prey in inland Washington waters is not well documented, but their expected prey, based on studies in British Columbia and Alaska, would include schooling fish such as herring, hake, sand lance, salmon, flounder, rockfish, squid, and octopus (Bigg 1985; Merrick and Loughlin 1997). Foraging habitats in Hood Canal would likely include nearshore and deeper waters.

Acoustics

Like all pinnipeds, the Steller sea lion is amphibious; while all foraging activity takes place in the water, breeding behavior is carried out on land in coastal rookeries (Mulsow and Reichmuth 2008). On land, territorial male Steller sea lions regularly use loud, relatively low-frequency calls/roars to establish breeding territories (Schusterman et al. 1970; Loughlin et al. 1987). The calls of females range from 0.03 to 3 kHz, with peak frequencies from 0.15 to 1 kHz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Pups also produce bleating sounds. Individually distinct vocalizations exchanged between mothers and pups are thought to be the main modality by which reunion occurs when mothers return to crowded rookeries following foraging at sea (Mulsow and Reichmuth 2008).

Mulsow and Reichmuth (2008) measured the unmasked aerial hearing sensitivity of one male Steller sea lion. The range of best hearing sensitivity was between 5 and 14.1 kHz. Maximum sensitivity was found at 10 kHz, where the subject had a mean threshold of 7 dB re 20 µPa. The underwater hearing threshold of a male Steller sea lion was significantly different from that of a female. The peak sensitivity range for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1µPa-m) at 1 kHz. The range of best hearing for the female was from 16 to above 25 kHz, with maximum sensitivity (73 dB re 1µPa-m) at 25 kHz. However, because of the small number of animals tested, the findings could not be attributed to either individual differences in sensitivity or sexual dimorphism (Kastelein et al. 2005).

4.2 Non-ESA Listed Marine Mammals

4.2.1 California Sea Lion (*Zalophus californianus*), U.S. Stock

Distribution

The geographic distribution of California sea lions includes a breeding range from Baja California to southern California. During the summer, California sea lions breed at rookeries on islands from the Gulf of California to the Channel Islands and seldom travel more than about 31 miles (50 km) from the islands (Bonnell et al. 1983).

The non-breeding distribution extends from Baja California north to Alaska for males, and encompasses the waters of California and Baja California for females (Maniscalco et al. 2004; Reeves et al. 2008). In the non-breeding season, an estimated 3,000 to 5,000 adult and sub-adult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island from September to May (Jeffries et al. 2000) and return south the following spring (Mate 1975; Bonnell et al. 1983). Along their migration, they are occasionally sighted hundreds of miles offshore (Jefferson et al. 1993). Females and juveniles tend to stay closer to the breeding rookeries (Bonnell et al. 1983).

Behavior and Ecology

California sea lions are gregarious during the breeding season and social at haul-out sites during other times. They prefer to breed on sandy, remote beaches (Le Boeuf 2002) near productive upwelling zones where prey is easily available to lactating females (Heath 2002). Females give birth in May and June, and mating follows. During the most recent aerial survey population counts for California sea lion within the inland waters of Washington State, no regular haul-outs were documented to exist within the Hood Canal (Jeffries et al. 2000). However, recent anecdotal information, such as observations by Navy personnel at the waterfront on NBK, has documented that they haul out opportunistically at areas within Hood Canal. Within their geographic range, California sea lions have been known to utilize manmade structures such as piers, jetties, offshore buoys, oil platforms, and navigational buoys (Riedman 1990; Jeffries et al. 2000). Dedicated surveys on NBK at Bangor have reported as many as 58 California sea lions hauled out daily from late August through the early June on manmade structures (submarines, buoys, pontoons of the floating security fence, and barges) on NBK at Bangor (Agness and Tannenbaum 2009; Tannenbaum et al. 2009; Navy 2010) (see detailed discussion in Section 6.6.2). Most documented haul-outs of California sea lions along NBK at Bangor have been on submarines docked at Delta Pier and on pontoons of the security fence in that vicinity, located approximately one mile south of the EHW-2 project site. California sea lions were also observed swimming in Hood Canal in the vicinity of the EHW-2 project site on several occasions (Tannenbaum et al. 2009; Navy 2010) and likely forage in both nearshore marine and inland marine deeper water habitats in the vicinity.

California sea lions are opportunistic foragers whose diet varies by season and location. The diet throughout their range includes a wide variety of prey, including many species of fish and squid (Everitt et al. 1981; Roffe and Mate 1984; Antonelis et al. 1990; Lowry et al. 1991). In the Puget Sound region, they feed primarily on Pacific hake and Pacific herring (Olesiuk et al. 1993; Everitt et al. 1981; London 2006). In some locations California sea lions feed on returning adult and out-migrating juvenile salmonids (review in London 2006; Scordino 2010).

Acoustics

On land, California sea lions make raucous barking sounds with most of their energy at less than 2 kHz (Schusterman 1974). Males vary both the number and rhythm of their barks depending on the social context; the barks appear to control the movements and other behavior patterns of nearby conspecifics (Schusterman 1977). Females produce barks, squeals, belches, and growls in the frequency range of 0.25 to 5 kHz, while pups make bleating sounds at 0.25 to 6 kHz. California sea lions produce two types of underwater sounds: clicks (or short-duration sound pulses) and barks (Schusterman et al. 1966, 1967; Schusterman and Baillet 1969). All underwater sounds have most of their energy below 4 kHz (Schusterman et al. 1967).

California sea lions appear to be better adapted for in-air hearing than underwater hearing at frequencies below 64 kHz (Kastak and Schusterman 1998). The range of maximal hearing sensitivity underwater is between 1 and 28 kHz (Schusterman et al. 1972). Functional underwater high frequency hearing limits are between 35 and 40 kHz, with peak sensitivities from 15 to 30 kHz (Schusterman et al. 1972). The California sea lion shows relatively poor hearing at frequencies below 1 kHz (Kastak and Schusterman 1998). Peak hearing sensitivities in air are shifted to lower frequencies; the effective upper hearing limit is approximately 36 kHz (Schusterman 1974). The best range of sound detection is from 2 to 16 kHz (Schusterman 1974). Kastak and Schusterman (2002) determined that hearing sensitivity generally worsens with depth—hearing thresholds were lower in shallow water, except at the highest frequency tested (35 kHz), where this trend was reversed.

4.2.2 Harbor Seal (*Phoca vitulina*), Washington Inland Waters Stock

Distribution

The geographic distribution of harbor seals includes the U.S. west coast from Baja California north to British Columbia and coastal Alaska, including southeast Alaska, the Aleutian Islands, the Bering Sea, and the Pribilof Islands (Carretta et al. 2007b). The harbor seal is the only pinniped species that breeds in inland Washington waters, including Hood Canal, and is consistently abundant and widespread (Jeffries et al. 2003). The population of harbor seals in Hood Canal is a closed population, meaning they do not have much movement outside of Hood Canal (London 2006). The abundance of harbor seals in Hood Canal has stabilized, and the population may have reached carrying capacity in the mid-1990s (approximate abundance in Hood Canal is 1,000 harbor seals) (Jeffries et al. 2003). The mean population size in 1999 for harbor seals in all inland waters of Washington was estimated from 9,550 to 14,612 harbor seals (Jeffries et al. 2003). Thus, up to 10 percent of the Puget Sound harbor seal population occurs in Hood Canal. The abundance of harbor seals in Hood Canal may have been influenced by the recent occurrences of transient killer whales in Hood Canal, which feed on harbor seals; however, no change in abundance was detected in subsequent survey efforts (Jeffries et al. 2003; London 2006).

Harbor seals have been observed swimming in the waters along NBK at Bangor in every month of surveys conducted from 2007 to 2010 (Agness and Tannenbaum 2009; Tannenbaum et al. 2009, 2011). Harbor seals use all marine habitats: the intertidal zone and manmade structures are used for haul-out sites, and subtidal nearshore marine, inland marine deeper water habitats, and the lower reaches of rivers are used for foraging (Reeves et al. 2008). Along the Bangor waterfront on NBK, harbor seals have not been observed hauling out in the intertidal zone but have been observed hauled out on manmade structures such as the floating security fences, wavescreen at Carderock Pier, buoys, barges, marine vessels, and logs (Agness and Tannenbaum 2009; Tannenbaum et al. 2009, 2011). Most documented occurrences of harbor seals opportunistically hauling out along the Bangor waterfront were on pontoons of the security fence close to Delta Pier, which is about one mile south of the EHW-2 project site. The main dedicated haul-out locations for harbor seals in Hood Canal (Figure 4–1) are located on river delta and tidal exposed areas at Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Skokomish River mouths, with the closest haul-out area 10 miles southwest of NBK at Bangor at the Dosewallips River mouth (London 2006).

Behavior and Ecology

Although generally solitary in the water, harbor seals come ashore at communal haul-out sites for resting, thermoregulation, birthing, and nursing pups. Major haul-out sites are relatively consistent from year to year. Haul-out areas can include intertidal and subtidal rock outcrops, mudflats, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and recreational floats (Wilson 1978; Prescott 1982; Gilbert and Guldager 1998; Jeffries et al. 2000). Harbor seals mate at sea and females in most areas give birth during the spring and summer, although the “pupping season” varies considerably in the Pacific Northwest. The Hood Canal population has the latest pupping season in the region: pupping typically extends from mid-July through December (Ferrero and Fowler 1992). Suckling harbor seal pups spend as much as 40 percent of their time in the water (Bowen et al. 1999). On August 5, 2011, a harbor seal gave birth on the wavescreen dock at Carderock Pier, several miles south of the EHW2 project site. This was the first documented birth at NBK at Bangor.

Harbor seals are opportunistic feeders that adjust their patterns to take advantage of locally and seasonally abundant prey (Payne and Selzer 1989; Baird 2001; Bjørge 2002). Diet consists of fish and invertebrates (Bigg 1981; Roffe and Mate 1984; Orr et al. 2004). In the Puget Sound region, the diet is diverse but primarily consists of Pacific hake, walleye pollock, and Pacific herring (Lance and Jeffries 2006, 2007; London 2006; Luxa 2008). In some locations harbor seals feed on returning adult and out-migrating juvenile salmonids (London et al. 2002; Lance and Jeffries 2006, 2007; London 2006; Scordino 2010). Harbor seals in Hood Canal feed on returning adult salmon, including threatened summer-run chum salmon (London et al. 2002); the other top prey species found in Hood Canal harbor seal scats were Pacific hake and Pacific herring (London 2006). Telemetry studies in the San Juan Islands showed no consistent diurnal or nocturnal pattern for foraging behavior (Suryan and Harvey 1998), and observations in Hood Canal at river mouths indicated that feeding on fish occurred during both day and night, and was most influenced by tidal stage (London 2006).

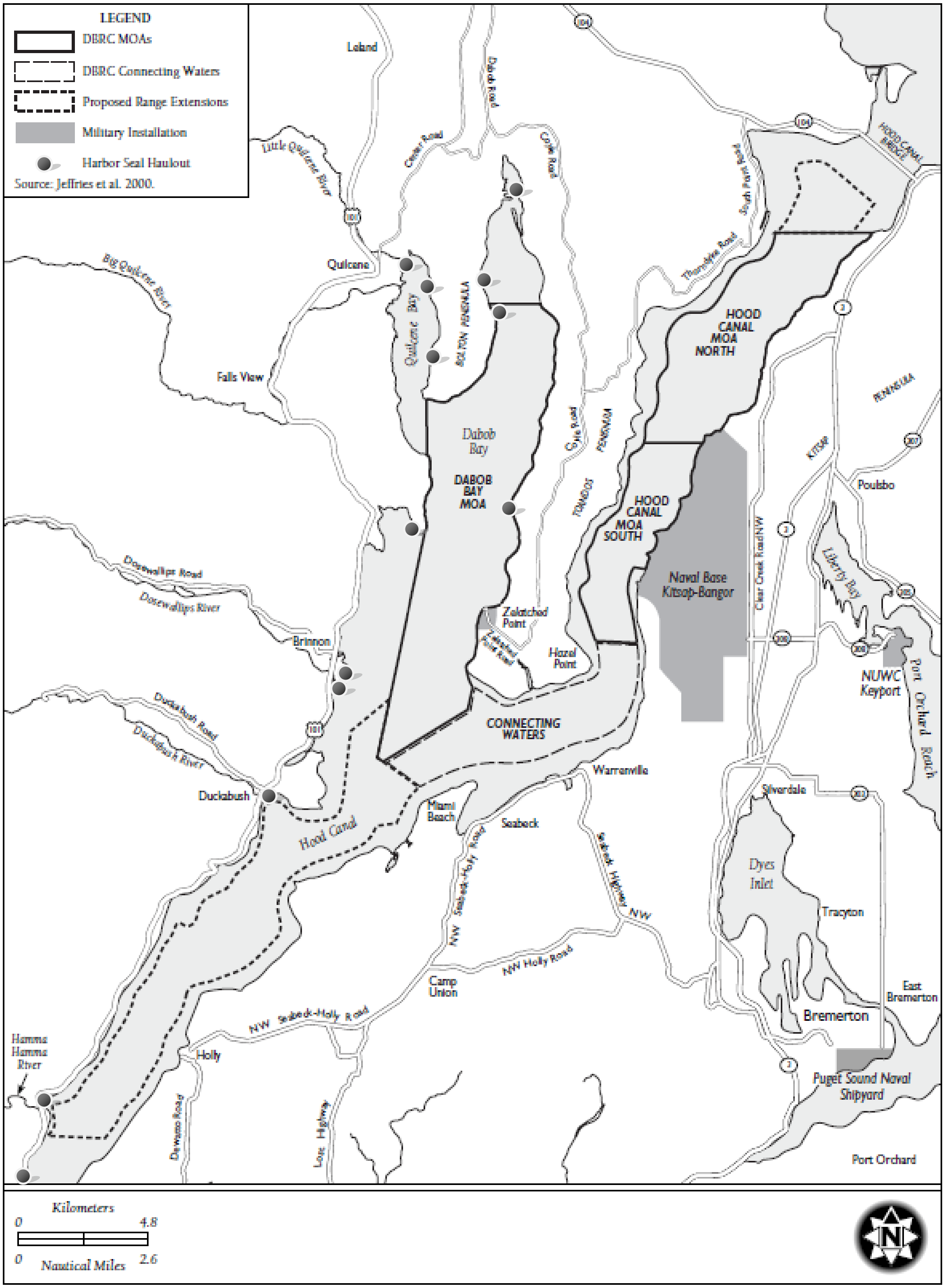


Figure 4–1. Harbor Seal Haul-outs within the Vicinity of NBK at Bangor

<u>Acoustics</u>

In the air, male harbor seals produce a variety of relatively low-frequency vocalizations, including snorts, grunts, and growls in the frequency range 100 to 1,000 Hz (Richardson et al. 1995). Harbor seals hear almost equally as well in air as underwater and have lower underwater sound detection thresholds at lower frequencies (below 64 kHz) than California sea lions (Kastak and Schusterman 1998). This difference is thought to make harbor seals more vulnerable to low-frequency manmade sounds such as ships and oil platforms. In air, harbor seals have functional hearing of frequencies from 75 Hz to 30 kHz (Southall et al. 2007) and are most sensitive from 6 to 16 kHz (Richardson 1995; Wolski et al. 2003).

Adult males also produce low frequency underwater grunts, growls, and roars during the breeding season that typically range up to 4 kHz (Hanggi and Schusterman 1994). In water, their functional hearing ranges from 75 Hz to 75 kHz, with peak sensitivities between 700 Hz and 20 kHz (Southall et al. 2007).

4.2.3 Killer whale (*Orcinus orca*), West Coast Transient Stock

<u>Distribution</u>

The geographical range of West Coast stock transient killer whales includes the northeast Pacific, with a preference for coastal waters of southern Alaska and British Columbia. Groups of West Coast stock transients regularly visit waters off the coast of central California (Krahn et al. 2002; Black 2011). 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 2010) but several studies have shown peaks in occurrences: Morton (1990) found bimodal peaks in spring (March) and fall (September to November) for transients on the northeastern coast of British Columbia. Baird and Dill (1995) found some transient groups frequenting the vicinity of harbor seal haul-outs 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 appear to be unpredictable. In 2003 and 2005, small groups of transient killer whales (11 and 6 individuals, respectively) entered Hood Canal to feed on harbor seals and remained in the area for significant periods of time (59 and 172 days, respectively) between the months of January and July. Killer whales have not had a significant presence in Hood Canal within the past 30 years, although both mammal-eating and fish-eating killer whales have been previously observed in Hood Canal (London 2006). For both types, occurrences have been extremely rare and most last less than one or two days (London 2006).

<u>Behavior and Ecology</u>

Transient killer whales show great variability in habitat use, with some groups spending most of their time foraging in shallow waters close to shore while others hunt almost entirely in open water (Felleman et al. 1991; Baird and Dill 1995; Matkin and Saulitis 1997). West Coast transient killer whales feed on marine mammals and some seabirds, and do not consume fish (Morton 1990; Baird and Dill 1996; Ford et al. 1998, 2005; Ford and Ellis 1999). While present in Hood Canal in 2003 and 2005, transient killer whales preyed on harbor seals in the subtidal zone of the nearshore marine and inland marine deeper water habitats (London 2006). Other observations of foraging transient killer whales indicate they prefer to forage on pinnipeds in shallow, protected waters (Heimlich-Boran 1988; Saulitis et al. 2000). Transient killer whales travel in small matrilineal groups, but they typically contain fewer than 6 animals and their social organization generally is more fluid than the resident killer whale (Morton 1990; Ford and Ellis 1999). Differences in social organization may be adaptations to differences in feeding specializations (Ford and Ellis 1999; Baird and Whitehead 2000). There is no information on the reproductive behavior of killer whales in this area.

Acoustics

Killer whales produce several types of underwater sounds, including: (1) clicks used for echolocation, (2) highly variable whistles produced while whales socialize, and (3) pulsed signals generated at high repetition rates (Ford 1987). Both behavioral and auditory brainstem response measurements indicate killer whales can hear in a frequency range of 1 to 100 kHz and are most sensitive at 20 kHz. This is one of the lowest maximum-sensitivity frequencies known among toothed whales (Szymanski et al. 1999).

Killer whales are "mid-frequency" cetaceans; that is, their echolocation signals use a frequency range that is somewhat lower than some of the other odontocetes such as Dall's porpoise and harbor porpoise. Source levels of echolocation signals range between 195 and 224 dB re 1μPa-m peak-to-peak, with dominant frequencies ranging from 20 to 60 kHz (Au et al. 2004). Social signals generally use a lower frequency range. Whistles range from 1.5 to 18 kHz (dominant frequency range 6 to 12 kHz) (Richardson et al. 1995). Pulsed sounds have frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Ford 1987; Richardson et al. 1995). Source levels associated with social sounds have been calculated to range between 131 and 168 dB re 1μPa-m and vary with vocalization type (Veirs 2004). The most abundant and characteristic sound type produced by killer whales is pulsed signals, which are highly repetitive and fall into distinctive structural categories (Ford 1987). These are referred to as discrete calls, and one of their potential functions may be to help whales maintain contact while they are out of sight of each other (Ford and Ellis 1999).

The discrete call repertoire of Pacific Northwest transients is smaller than the repertoire of resident whales, with only four to six calls, none of which is used by resident whales. Every transient group shares at least two discrete calls, and most have all calls in common (Ford and Ellis 1999), although some regional differences exist. The lack of a well-developed dialect system in transients (compared to residents) may result from the fluidity of their social structure (Ford and Ellis 1999). Moreover, transients are far quieter than residents when foraging, suggesting that transients must remain relatively silent to avoid alerting their prey because other marine mammals are highly sensitive to sounds in the frequency range of transients' sonar clicks (Barrett-Lennard et al. 1996).

4.2.4 Dall's Porpoise (*Phocoenoides dalli*), California/Oregon/Washington Stock

Distribution

Dall's porpoises are found in temperate waters from northern Baja California, Mexico, north to the northern Bering Sea and south to southern Japan (Jefferson et al. 1993). The species is only common between 32°N and 62°N in the eastern North Pacific (Morejohn 1979; Houck and Jefferson 1999). North-south movements in California, Oregon, and Washington have been suggested. Dall's porpoises shift their distribution southward during cooler-water periods (Forney and Barlow 1998). Norris and Prescott (1961) reported finding Dall's porpoises in southern California waters only in the winter, generally when the water temperature was less than 15°C. Seasonal movements have also been noted off Oregon and Washington, where higher densities of Dall's porpoises were sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992).

In Washington, they are most abundant in offshore waters. They are year-round residents in Washington (Green et al. 1992), but their distribution is highly variable between years likely due to changes in oceanographic conditions (Forney and Barlow 1998). Dall's porpoises are observed throughout the year in Puget Sound north of Seattle (Osborne et al. 1988) and are seen occasionally in southern Puget Sound. Dall's porpoises may also occasionally occur in Hood Canal (Jeffries 2006, personal communication); one was observed in deeper water on NBK at Bangor in summer 2008 (Tannenbaum et al. 2009).

Behavior and Ecology

Groups of Dall's porpoises generally include fewer than 10 individuals and are fluid in composition, probably aggregating for feeding (Jefferson 1990, 1991; Houck and Jefferson 1999). Dall's porpoises become sexually mature at 3.5 to 8 years of age (Houck and Jefferson 1999) and give birth to a single calf after 10 to 12 months. Breeding in Puget Sound typically occurs in the spring and summer (Angell and Balcomb 1982). In the North Pacific, there is a strong summer calving peak from early June through August (Ferrero and Walker 1999), and a smaller peak in March (Jefferson 1990).

Dall's porpoises can be opportunistic feeders but primarily consume schooling forage fish. They are known to eat squid, crustaceans, and fishes such as eelpout, herring, pollock, whiting, and sand lance (Walker et al. 1998).

Acoustics

Like the harbor porpoise, Dall's porpoise is a "high-frequency" cetacean; that is, its auditory range includes very high frequencies (estimated auditory bandwidth for this category is 200 Hz to 180 kHz) (Southall et al. 2007). Only short duration pulsed sounds have been recorded for Dall's porpoise (Houck and Jefferson 1999); this species apparently does not whistle often (Richardson et al. 1995). Dall's porpoises produce short duration (50 to 1,500 μs), high-frequency narrow band clicks, with peak energies that range from 120 to 160 kHz (Jefferson 1988; Hatakeyama and Soeda 1990). There is little published data on the hearing abilities of this species.

4.2.5 Harbor Porpoise (*Phocoena phocoena*), Washington Inland Waters Stock

Distribution

Harbor porpoises are generally found in cool temperature to subarctic waters over the continental shelf in both the North Atlantic and North Pacific (Read 1999). This species is seldom found in waters warmer than 17°C (Gaskin et al. 1993) or south of Point Conception (Barlow and Hanan 1995). Harbor porpoises can be found year-round primarily in the shallow coastal waters including harbors, bays, and river mouths (Green et al. 1992). Along the Pacific coast, harbor porpoises occur from Monterey Bay, California, to the Aleutian Islands and west to Japan (Reeves et al. 2008). Harbor porpoises are known to occur in Puget Sound year-round (Osmek et al. 1996, 1998; Carretta et al. 2007b); indeed, harbor porpoise observations in Puget Sound including northern Hood Canal have increased in recent years (Calambokidis 2010, personal communication). A harbor porpoise was seen in deeper water on NBK at Bangor during 2010 field observations (Tannenbaum et al. 2011). Based on observations during line transect surveys conducted to date as part of the Test Pile Program, harbor porpoises have been seen commonly during surveys with the number of individuals sighted in the deeper waters of the Hood Canal ranging from 0 to 11 individuals, with an average of approximately 6 animals sighted per day (Navy, in prep.).

Behavior and Ecology

Harbor porpoises are usually seen in small groups of 2 to 5 animals. Little is known about their social behavior. Studies of harbor porpoises in the Gulf of Maine showed that they mature at an earlier age, reproduce more frequently, and live for shorter periods than other toothed whales (Read and Hohn 1995). Females reach sexual maturity at 3 to 4 years and may give birth every year for several years in a row. Calves are born in late spring (Read 1990; Read and Hohn 1995). Dall's and harbor porpoises appear to hybridize relatively frequently in the Puget Sound area (Willis et al. 2004).

Harbor porpoises can be opportunistic foragers but primarily consume schooling forage fish (Osmek et al. 1996; Bowen and Siniff 1999; Reeves et al. 2008). Along the coast of Washington, harbor porpoises primarily feed on Pacific herring (C*lupea pallasii*), market squid, and smelts (Gearin et al. 1994).

Acoustics

The harbor porpoise, like killer whales and Dall's porpoise, uses high-frequency sounds for echolocation, and lower frequency signals for social interactions (Southall et al. 2007). Harbor porpoise vocalizations include clicks and pulses with peak energy at frequencies from 120 to 140 kHz (Tyack and Clark 2000; Hansen et al. 2008). Electrophysiological tests of the hearing range of harbor porpoises showed that the high frequency range may be as great as 130 kHz (Bibikov 1992). Popov et al. (1986) found evidence for two frequency ranges of best sensitivity: 20 to 30 kHz and 120 to 130 kHz. More recent psycho-acoustic studies found the range of best hearing to be 16 to 140 kHz, with a reduced sensitivity around 64 kHz (Kastelein et al. 2002). Maximum sensitivity occurs between 100 and 140 kHz (Kastelein et al. 2002). Peak echolocation frequencies were in the range of 120 to 130 kHz (Bibikov 1992; Kastelein et al. 2002), which corresponds to their maximum hearing sensitivity range (100 to 140 kHz) (Kastelein et al. 2002).

5 HARASSMENT 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.

Under Section 101 (a)(5)(D) of the MMPA, the Navy requests an IHA for the take of marine mammals incidental to construction of a second EHW on NBK at Bangor, Washington. The Navy requests an IHA for the incidental take described in this application for the first year of construction: July 16, 2012, through February 15, 2013, for pile-driving and other in-water work, and through July 15, 2013, for non-in-water work. Although the proposed action is not expected to result in injury (Level A harassment), a subsequent Letter of Authorization application would be submitted for future years of construction through 2016, in order to preclude the necessity to submit IHA applications annually. The Navy is taking the approach of applying for an IHA for the first year of construction and a subsequent Letter of Authorization for the remaining years of construction because it is unlikely that NMFS would be able to issue a Letter of Authorization prior to the proposed start of construction on July 16, 2012.

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).

Level A is the more severe form of harassment because it may result in injury, whereas Level B only results in disturbance without the potential for injury (Norberg 2007a, personal communication).

5.1 Take Authorization Request

Under Section 101 (a)(5)(D) of the MMPA, the Navy requests an IHA from NMFS for: Level B harassment (behavioral harassment) of marine mammals described within this application as a result of in-water pile driving activities. The Navy requests the IHA to begin coverage on July 16, 2012 and extend through July 15, 2013.

The exposure assessment methodology taken in this IHA request attempts to quantify potential exposures to marine mammals resulting from pile driving. Section 6 presents a detailed description of the acoustic exposure assessment methodology. Results from this approach tend to provide an overestimation of exposures because all animals are assumed to be available to be exposed 100 percent of the time, and the formulas used to estimate transmission loss used idealized parameters, which are unrealistic in nature. Densities of marine mammals in Hood Canal vary throughout the year due to seasonal migrations of several species. Modeling was conducted for the seven months in the proposed construction season (July 16 through February 15). The modeling estimated exposures based on the densities of marine mammal species and the expected number of pile driving days for each month over the projected maximum of 195 days of pile driving for the first year of construction.

The proposed action may affect the prey of marine mammals and may represent a partial barrier to the movement of marine mammals. However, none of these effects is expected to rise to the level of take.

The modeling results for the EHW-2 predict 18,525 potential exposures (see Section 6 for estimates of exposures by species and season) from pile driving for the first year of construction (maximum of 195 pile driving days) that could be classified as Level B harassment as defined under the MMPA. The Navy's mitigation procedures, presented in Section 11, include monitoring of mitigation (shutdown) zones prior to the initiation of pile driving, the use of noise attenuating devices (e.g., bubble curtain) on all impact driven piles, and instantaneous in-situ hydroacoustic recordings. These mitigation measures decrease the likelihood that marine mammals will be exposed to sound pressure levels that would cause Level B harassment, although the amount of that decrease cannot be quantified.

The Navy does not anticipate that 18,525 actual harassment incidents will result from pile driving activities within Hood Canal. However, to allow for scientific uncertainty regarding the exact mechanisms of the physical and behavioral effects, and as a conservative approach, the Navy is requesting authorization for behavioral disturbance (Level B harassment) of 18,525 marine mammals over the first year of construction covered by this IHA application.

5.2 Method of Incidental Taking

Although the proposed action may affect the prey and other habitat features of marine mammals, none of these effects is expected to rise to the level of take. Pile driving activities associated with construction of the EHW-2 as outlined in Sections 1 and 2 have the potential to disturb or displace marine mammals. Specifically, the proposed activities may result in Level B harassment (behavioral disturbance) only from airborne or underwater sounds generated from pile driving. Level A harassment is not anticipated given the methods of installation and measures designed to minimize the possibility of injury to marine mammals. Specifically, vibratory pile drivers will be the primary method of installation, which are not expected to cause injury to marine mammals due to the relatively low source levels (<190 dB). Also, impact pile driving will not occur without a noise attenuation measure (such as a bubble curtain or other attenuating device) in place, and pile driving will either not start or be halted if marine mammals approach the shutdown zone. See Section 11 for more details on the impact reduction and mitigation measures proposed. Furthermore, the pile driving activities analyzed are similar to those undertaken in the past for the building of the existing EHW facility and for other nearby construction activities within Hood Canal, for instance, test piles driven in 2005 for the Hood Canal Bridge (SR-104) constructed by WSDOT, which have taken place with no reported injuries or mortality to marine mammals.

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 identified in [Section 5], and the number of times such takings by each type of taking are likely to occur.

6.1 Introduction

The NMFS application for an IHA requires applicants to determine the number of marine mammals that are expected to be incidentally harassed by an action and the nature of the harassment (Level A or Level B). Section 5 defines MMPA Level A and Level B and Section 6 below presents how these definitions were relied on to develop the quantitative acoustic analysis methodologies used to assess the potential for the proposed action to affect marine mammals.

The project construction and operation as outlined in Sections 1 and 2 have the potential to affect marine mammals by harassment only, primarily through construction activities involving in-water pile driving. Other activities are not expected to result in take as defined under the MMPA.

In-water pile driving would temporarily increase the local underwater and airborne noise environment in the vicinity of the project area. Research suggests that increased noise may impact marine mammals in several ways and depends on many factors. This is discussed in more detail in Section 7. The following text provides a background on underwater sound, description of noise sources in the project area, applicable noise criteria, and the basis for the calculation of Level B harassment exposures. Level A harassment of cetaceans and pinnipeds for this project is not expected to occur; therefore, Level A harassment is not discussed in this application.

6.2 Fundamentals of Underwater Noise

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water. Sound is generally characterized by several factors, including frequency and intensity. Frequency describes the sound's pitch and is measured in hertz (Hz), while intensity describes the sound's loudness. Due to the wide range of pressure and intensity encountered during measurements of sound, a logarithmic scale is used. In acoustics, the word "level" denotes a sound measurement in decibels. A decibel (dB) expresses the logarithmic strength of a signal relative to a reference. Because the decibel is a logarithmic measure, each increase of 20 dB reflects a ten-fold increase in signal amplitude (whether expressed in terms of pressure or particle motion), i.e., 20 dB means ten times the amplitude, 40 dB means one hundred times the amplitude, 60 dB means one thousand times the amplitude, and so on. Because the decibel is a relative measure, any value expressed in decibels is meaningless without an accompanying reference. In describing underwater sound pressure, the reference amplitude is usually 1 microPascal (μPa, or 10^{-6} Pascals), and is expressed as "dB re 1μPa." For in-air sound pressure, the reference amplitude is usually 20 μPa and is expressed as "dB re 20 μPa."

The method commonly used to quantify airborne sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects human hearing, which is less sensitive at low frequencies and extremely high frequencies than at the mid-range frequencies. This is called A-weighting, and the decibel level measured is called the A-weighted sound level (dBA). A filtering method that reflects hearing of marine mammals has not yet been developed. Therefore, underwater sound levels are not weighted and measure the entire frequency range of interest. In the case of marine construction work, the frequency range of interest is 10 to 10,000 Hz (WSDOT 2010).

Table 6–1 summarizes commonly used terms to describe underwater sounds. Two common descriptors are the instantaneous peak sound pressure level (SPL) and the root-mean-square (RMS) SPL (dB_{RMS}) during the pulse or over a defined averaging period. The peak pressure is the instantaneous maximum or minimum overpressure observed during each pulse or sound event and is presented in Pascals (Pa) or dB referenced to a pressure of 1 microPascal (dB re 1µPa). The RMS level is the square root of the energy divided by a defined time period. All underwater sound levels throughout the remainder of this application are presented in dB re 1µPa unless otherwise noted.

6.3 Description of Noise Sources

Underwater sound levels are comprised of multiple sources, including physical noise, biological noise, and anthropogenic noise. Physical noise includes waves at the surface, precipitation, earthquakes, ice, and atmospheric noise. Biological noise includes sounds produced by marine mammals, fish, and invertebrates. Anthropogenic noise consists of vessels (small and large), dredging, aircraft overflights, and construction noise. Known noise levels and frequency ranges associated with anthropogenic sources similar to those that would be used for this project are summarized in Table 6–2. Details of each of the sources are described in the following text.

In-water construction activities associated with the proposed project would include impact pile driving and vibratory pile driving. The sounds produced by these activities fall into one of two sound types: pulsed and non-pulsed (defined below). Impact pile driving produces pulsed sounds, while vibratory pile driving produces non-pulsed (or continuous) sounds. The distinction between these two general sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (e.g., Ward 1997 as cited in Southall et al. 2007).

Pulsed sounds (e.g., explosions, gunshots, sonic booms, seismic airgun pulses, and impact pile driving) are brief, broadband, atonal transients (ANSI 1986; Harris 1998) and occur either as isolated events or repeated in some succession (Southall et al. 2007). Pulsed sounds are all 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). Pulsed sounds generally have a greater capacity to induce physical injury compared with sounds that lack these features (Southall et al. 2007).

Non-pulse (intermittent or continuous sounds) can be tonal, broadband, or both (Southall et al. 2007). Some non-pulse sounds can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time) (Southall et al. 2007). Examples of non-pulse sounds include vessels, aircraft, and machinery operations such as drilling, dredging, and vibratory pile driving (Southall et al. 2007). The duration of such sounds, as received at a distance, can be greatly extended in highly reverberant environments.

Table 6–1. Definitions of Acoustical Terms

Term	Definition
Decibel (dB)	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 microPascal (µPa) and for air is 20 µPa (approximate threshold of human audibility).
Sound Pressure Level (SPL)	Sound pressure is the force per unit area, usually expressed in microPascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure. Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	Frequency is expressed in terms of oscillations, or cycles, per second. Cycles per second are commonly referred to as hertz (Hz). Typical human hearing ranges from 20 Hz to 20,000 Hz.
Peak Sound Pressure (unweighted), dB re 1µPa	Peak sound pressure level is based on the largest absolute value of the instantaneous sound pressure over the frequency range from 20 Hz to 20,000 Hz. This pressure is expressed in this application as dB re 1µPa.
Root-Mean-Square (RMS), dB re 1µPa	The RMS level is the square root of the energy divided by a defined time period. For pulses, the RMS has been defined as the average of the squared pressures over the time that comprise that portion of waveform containing 90 percent of the sound energy for one impact pile driving impulse.[6] For non-pulsed energy or continuous sound, RMS energy represents the average of the squared pressures over the measurement period and is not limited by the 90 percent energy criterion.
Sound Exposure Level (SEL), dB re 1µPa^2 sec	Sound exposure level is a measure of energy. Specifically, it is the dB level of the time integral of the squared-instantaneous sound pressure, normalized to a 1-second period. It can be an extremely useful metric for assessing cumulative exposure because it enables sounds of differing duration to be compared in terms of total energy.
Waveforms, µPa over time	A graphical plot illustrating the time history of positive and negative sound pressure of individual pile strikes shown as a plot of µPa over time (i.e., seconds).
Frequency Spectra, dB over frequency range	A graphical plot illustrating the frequency content over a given frequency range. Bandwidth is generally defined as linear (narrowband) or logarithmic (broadband) and is stated in frequency (Hz).
A-Weighting Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the low and high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective human reactions to noise.
Ambient Noise Level	The background sound level, which is a composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.

[6] Underwater sound measurement results obtained by Illingworth & Rodkin (2001) for the Pile Installation Demonstration Project in San Francisco Bay indicated that most impact pile driving impulses occurred over a 50 to 100-millisecond period. Most of the energy was contained in the first 30 to 50 milliseconds. Analyses of that underwater acoustic data for various pile strikes at various distances demonstrated that the acoustic signal measured using the standard “impulse exponential time-weighting” on the sound level meter (35-millisecond rise time) correlated to the RMS level measured over the duration of the pulse.

Table 6–2. Representative Noise Levels of Anthropogenic Sources

Noise Source	Frequency Range (Hz)	Underwater Noise Level (dB re 1μPa)	Reference
Small vessels	250 – 1,000	151 dBRMS at 1 m	Richardson et al. 1995
Tug docking gravel barge	200 – 1,000	149 dBRMS at 100 m	Blackwell and Greene 2002
Vibratory driving of 72-inch steel pipe pile	10 – 1,500	180 dBRMS at 10 m	Illingworth and Rodkin 2007
Impact driving of 36-inch steel pipe pile	10 – 1,500	195 dBRMS at 10 m	WSDOT 2007
Impact driving of 66-inch cast in steel shell (CISS) piles	100 – 1,500	195 dBRMS at 10 m	Reviewed in Hastings and Popper 2005

m = meter

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."

Since 1997, NMFS has used generic sound exposure thresholds to determine when an activity in the ocean that produces sound might result in impacts to a marine mammal such that a take by harassment might occur (NMFS 2005). 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. Current NMFS practice regarding exposure of marine mammals to high underwater level sounds is that cetaceans and pinnipeds exposed to impulsive sounds ≥180 and 190 dBRMS, respectively, are considered to have been taken by Level A (i.e., injurious) harassment. Level A injury thresholds have not been established for continuous sounds such as vibratory pile driving, but the Navy has applied the threshold values for impulsive sounds to vibratory sound in this analysis (Table 6–3).

Behavioral harassment (Level B) is considered to have occurred when marine mammals are exposed to underwater sounds ≥ 160 dBRMS for impulse sounds (e.g., impact pile driving) and 120 dBRMS for continuous noise (e.g., vibratory pile driving), but below injurious thresholds. Level A (injury) and Level B (disturbance) thresholds are provided in Table 6–3.

As described above for underwater sound injury and harassment thresholds, 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 EHW-2 project site. 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 dBRMS (unweighted) and for all other pinnipeds is 100 dBRMS (unweighted).

Table 6–3. Injury and Disturbance Thresholds for Underwater and Airborne Sounds

Marine Mammals	Airborne Marine Construction Criteria (Impact & Vibratory Pile Driving) (re 20 μPa)[1]	Underwater Vibratory Pile Driving Criteria (non-pulsed/continuous sounds) (re 1μPa)		Underwater Impact Pile Driving Criteria (pulsed sounds) (re 1μPa)	
	Disturbance Guideline Threshold (Haul-out)[2]	Level A Injury Threshold	Level B Disturbance Threshold	Level A Injury Threshold	Level B Disturbance Threshold
Cetaceans (whales, dolphins, porpoises)	Not applicable	180 dBRMS	120 dBRMS	180 dBRMS	160 dBRMS
Pinnipeds (seals, sea lions, walrus, except harbor seal)	100 dBRMS (unweighted)	190 dBRMS	120 dBRMS	190 dBRMS	160 dBRMS
Harbor seal	90 dBRMS (unweighted)	190 dBRMS	120 dBRMS	190 dBRMS	160 dBRMS

1. Airborne disturbance thresholds do not specify pile driver type.
2. Sound level at which pinniped haul-out disturbance has been documented. Not an official threshold, but used as a guideline.

6.4.1 Limitations of Existing Noise Criteria

The application of the 120 dBRMS threshold can sometimes be problematic because this threshold level can be either at or below the ambient noise level of certain locations. As a result, this threshold level is subject to ongoing discussion (NMFS 2009 74 FR 41684). NMFS is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized (Southall et al. 2007). The 120 dBRMS threshold level for continuous noise originated from research conducted by Malme et al. (1984, 1988) for California gray whale response to continuous industrial sounds such as drilling operations. (The 120 dB *continuous* sound threshold should not be confused with the 120 dB *pulsed* sound criterion established for migrating bowhead whales in the Arctic as a result of research in the Beaufort Sea [Richardson et al. 1995; Miller et al. 1999]).

To date, there is no research or data supporting a response by pinnipeds or odontocetes to continuous 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 continuous sounds under various conditions, and concluded that those limited studies suggest that exposures between 90 dB and 140 dBRMS re 1μPa generally do not appear to induce strong behavioral responses.

6.4.2 Ambient Noise

Ambient noise by definition is background noise and it has no single source or point (Richardson et al. 1995). Ambient noise varies with location, season, time of day, and frequency. Ambient noise is continuous, but with much variability on time scales ranging from less than one second to one year (Richardson et al. 1995). Ambient underwater noise at the EHW-2 project site is widely variable over time due to a number of natural and anthropogenic sources. Sources of naturally occurring underwater noise include wind, waves, precipitation, and biological noise (such as shrimp, fish, and cetaceans). There is also human-generated noise from ship or boat traffic and other mechanical means (Urick 1983). Other sources of underwater noise include cranes, generators, and other types of mechanized equipment in use at the existing EHW or on wharves to the south of the project area.

In the vicinity of Marginal Wharf to the south of the EHW-2 project site, the average broadband ambient underwater noise levels were measured at 114 dB re 1µPa between 100 Hz and 20 kHz (Slater 2009). Peak spectral noise from industrial activity was noted below the 300 Hz frequency, with maximum levels of 110 dB re 1µPa noted in the 125 Hz band. In the 300 Hz to 5 kHz range, average levels ranged between 83 and 99 dB re 1µPa. Wind-driven wave noise dominated the background noise environment at approximately 5 kHz and above, and ambient noise levels flattened above 10 kHz.

Maximum noise levels are produced by common industrial equipment, including trucks, cranes, compressors, generators, pumps, and other equipment that might typically be employed along NBK at Bangor's industrial waterfront and at the ordnance handling areas. Airborne noise measurements were taken during a two-day period in October 2010 within the waterfront industrial area near the project site. During this period, daytime noise levels ranged from 60 dBA 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. These higher noise levels are produced by a combination of sound sources including heavy trucks, forklifts, cranes, marine vessels, mechanized tools and equipment, and other sound-generating industrial/military activities. Measured levels were comparable to estimated noise levels from literature. Per published literature, presuming multiple sources of noise may be present at one time, maximum combined levels may be as high as 99 dBA. This estimates that two similar sources combined together will increase noise levels by 3 dB over the level of a single piece of equipment by itself (WSDOT 2007). These maximum noise levels are intermittent in nature and not present at all times. Existing maximum baseline noise conditions at the waterfront during a typical work week are expected to be approximately 99 dBA due to typical truck, forklift, crane, and other industrial activities. Average baseline noise levels are expected to be in the 70 to 90 dBA range, consistent with urbanized or industrial environments where equipment is operating.

6.5 Distance to Sound Thresholds

6.5.1 Underwater Sound Propagation Formula

Pile driving would 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. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water depth, water chemistry, and bottom composition and topography. A practical sound propagation modeling technique was used to estimate the range from the pile driving activity to various expected sound pressure levels in the water. 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 sound pressure level at some distance away from the source (e.g., driven pile) is governed by a measured source level, minus the transmission loss of the energy as it dissipates with distance. The formula for underwater transmission loss (TL) is:

$TL = 15 * \log_{10}(R_1/R_2)$, where
R_1 = the distance of the modeled sound pressure level from the driven pile, and
R_2 = 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 in-water structures and sediments. In a perfectly unobstructed (free-field) environment not limited by depth or water surface, noise follows the spherical spreading law, resulting in a 6 dB reduction in noise level for each doubling of distance from the source [20*log(range)]. Cylindrical spreading occurs in an environment wherein noise propagation is bounded by the water surface and sea bottom. In this case, a 3 dB reduction in noise level is observed for each doubling of distance from the source [10*log(range)]. The propagation environment along the Bangor waterfront on NBK is neither free-field nor cylindrical; as the receiver moves away from the shoreline, the water increases in depth, resulting in an expected propagation environment that would lie between spherical and cylindrical spreading loss conditions. Since no empirical propagation loss studies have been conducted along the Bangor waterfront on NBK to measure the propagation environment, a practical spreading loss model was adopted to approximate the environment for noise propagation between the cylindrical and spherical methods. The practical spreading loss method uses a 4.5 dB reduction in noise level for each doubling of distance from the source [15*log(range)], and has been accepted by NMFS and USFWS. The approach for estimating noise levels generated by pile driving is described in detail in the Appendix. Monitoring results from the Test Pile Project will be used to confirm the validity of using the practical spreading model for estimating acoustic propagation in the project area.

6.5.2 Underwater Noise from Pile Driving

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. In order to determine reasonable sound pressure levels and their associated effects on marine mammals that are likely to result from pile driving on NBK at Bangor, studies with similar properties to the proposed action were evaluated. Studies which met the following parameters were considered:

1. Pile materials: steel pipe piles (30–72-inch diameter);
2. Pile driver type: vibratory and impact; and
3. Physical environment: shallow depth (<100 feet).

Tables 6–4 and 6–5 detail representative pile driving activities (impact hammer and vibratory driver, respectively) that have occurred in recent years. Due to the similarity of these actions and the Navy's proposed action, they represent reasonable sound pressure levels that could be anticipated. For the impact hammer, a source value of 195 dB RMS re 1µPa at 10 m was the average value reported from the listed studies (Table 6–4). This value matches the values from the larger sized pile projects including values obtained during the Carderock Pier pile driving project on the Bangor waterfront, which had similar pile materials (42-inch hollow steel piles), water depth, and substrate type as the EHW-2 project site. For the vibratory source level (180 dB RMS re 1µPa at 10 m, no data were available for 48-inch and 60-inch piles. Given the paucity of vibratory data, the Navy selected the most conservative value (72-inch piles) as the worst-case condition.

Underwater noise levels during the worst-case multiple-rig scenario (up to three vibratory and one impact hammer rig concurrently) would be higher than those observed with a single rig operating due to the additive effects of multiple noise sources. Noise from multiple simultaneous sources produces an increase in the overall noise field.

Table 6–4. Sound Pressure Levels from Pile Driving Studies Using Impact Hammers

Project	Location	Pile Type	Hammer Type	Water Depth	Distance	Measured Sound Levels (RMS)
Eagle Harbor Maintenance Facility[1]	Bainbridge Island, WA	Steel Pipe/ 30-inch	Diesel Impact	10 m	10 m/33 feet	192 dB re 1 µPa
Friday Harbor Ferry Terminal[2]	Friday Harbor, WA	Steel Pipe/ 30-inch	Diesel Impact	10 m	10 m/33 feet	196 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Impact	~10 m	10 m/33 feet	193 dB re 1 µPa
Mukilteo Test Piles	WA	Steel Pipe/ 36-inch	Impact	7.3 m (24 ft)	10 m/33 feet	195 dB re 1 µPa
Anacortes Ferry	WA	Steel Pipe/ 36-inch	Impact	12.8 m (42 ft)	10 m/33 feet	199 dB re 1 µPa
Carderock Pier, NBK at Bangor[4]	WA	Steel Pipe/ 42-inch	Impact	14-22 m (48–70 ft)	10 m/33 feet	195 dB re 1 µPa
Russian River	Russian River, CA	Steel Pipe/ 48-inch	Diesel Impact	2 m (6.6 feet)	10 m/33 feet 20 m/65 feet 45 m/148 feet 65 m/213 feet	195 dB re 1 µPa 190 dB re 1 µPa 185 dB re 1 µPa 175 dB re 1 µPa
Unknown	CA	Steel CISS/ 60-inch	Impact	~10 m	10 m/33 feet	195 dB re 1 µPa
Richmond-San Rafael Bridge	San Francisco Bay, CA	Steel Pipe/ 66-inch	Diesel Impact	4 m	4 m/13 feet 10 m/33 feet 20 m/65 feet 30 m/98 feet 40 m/131 feet 60 m/197 feet 80 m/262 feet	202 dB re 1 µPa 195 dB re 1 µPa 189 dB re 1 µPa 185 dB re 1 µPa 180 dB re 1 µPa 169 dB re 1 µPa 170 dB re 1 µPa

1. JASCO Research Ltd. (2005)
2. Laughlin (2005)
3. Adapted from Compendium of Pile Driving Data report to the California Department of Transportation - Illingworth & Rodkin, Inc. (2007)
4. Navy (2009). Source level at 10 m estimated based on measurements at distances of 48 to 387 m.

Table 6–5. Sound Pressure Levels from Pile Driving Studies Using Vibratory Hammers

Project	Location	Pile Type	Hammer Type	Water Depth	Distance	Measured Sound Levels (RMS)
Vashon Terminal[1]	WA	Steel Pipe/ 30-inch	Vibratory	~6 m	11 m/36 feet	165 dB re 1 µPa
Keystone Terminal[2]	WA	Steel Pipe/ 30-inch	Vibratory	~5 m	10 m/33 feet	164 dB re 1 µPa
Keystone Terminal[2]	WA	Steel Pipe/ 30-inch	Vibratory	~8 m	10 m/33 feet	165 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Vibratory*	~5 m	10 m/33 feet	170 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Vibratory**	~5 m	10 m/33 feet	175 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 72-inch	Vibratory*	~ 5 m	10 m/33 feet	170 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 72-inch	Vibratory**	~ 5 m	10 m/33 feet	180 dB re 1 µPa

1. Laughlin 2010a; RMS noise levels reported in terms of the 30-second average continuous sound level and computed from the Fourier transform of pressure waveforms in 30-second time intervals. Average of measured values at 11 meters.
2. Laughlin 2010b; RMS noise levels reported in terms of the 30-second average continuous sound level and computed from the Fourier transform of pressure waveforms in 30-second time intervals.
3. Compendium of Pile Driving Data report to the California Department of Transportation - Illingworth & Rodkin, Inc. (2007); *RMS impulse level used duration of (35 msec), typical. **RMS impulse level used duration of (35 msec), loudest.

For the multiple-source analysis, a two-dimensional grid of closely spaced points was created, and noise levels were computed from individual sources at each grid point, then incoherently summed together to estimate the combined noise field. This analysis provides a robust means to estimate the additive effects of noise levels with multiple pile drivers simultaneously operating. RMS calculations were made for both equivalent continuous sound and impulsive sound. In order to evaluate the contribution of the impact rig to the vibratory rigs, the impulsive wave form was converted to an equivalent continuous sound. Since the impulsive noise only exists for a short duration, a time-weighting factor was calculated to determine the effective continuous sound level to apply to the impulsive source level.

For the case of continuous underwater noise, the effects of impulsive impact noise were added to continuous vibratory piling noise to provide the most conservative estimate of the equivalent continuous sound field. This process involved converting the impact noise to an equivalent continuous root-mean-square (RMS) noise level by computing a time-weighting factor account for the ratio of time duration the noise persisted compared to the time it was silent. Using this methodology, the equivalent continuous noise level from the impact driving is computed as the sound pressure level of a steady sound source containing the same energy as the impact driver. Calculations for this assumed that the impact noise persisted for 100 milliseconds, which is representative of the longest duration impact waveforms (ICF Jones and Stokes and Illingworth and Rodkin 2009) reported for impact driving waveforms. Furthermore, it was assumed that the pile driving rate was one hammer impact per second. The equivalent continuous noise factor was then computed as the ratio of "on" time vs. "total" time, or 10*log10(on/total), or 10*log10(100msec/1sec), resulting in a 10 dB reduction in the intensity of the impact pile driving sound when converted to an equivalent continuous waveform.

The use of a bubble curtain or other noise attenuating device during all impact driving will result in an additional reduction in the source level by another 10 decibels (see below). Therefore, the initial source level for an impulsive sound of 195 dB RMS re 1 µPa at 10 meters is equivalent to a continuous source level of 175 db re 1µPa at 10 meters with consideration for sound attenuation measures. This was summed with the continuous noise levels from the vibratory drivers (180 dB re 1 µPa at 10 meters) to establish the combined equivalent continuous noise level.

In order to evaluate the contribution of the three vibratory rigs to the impulsive waveform produced by the impact rig, vibratory RMS levels were added directly to the impulsive RMS sound pressure levels (SPL) of the impact driver. The maximum impulsive noise was computed as the additive sum of continuous vibratory energy and the impulsive RMS energy over the duration of the impact strike. Since this is only computed over the duration of each pile strike, the impulsive RMS SPL for multiple rigs operating are always higher than continuous equivalent RMS sound pressure levels.

Use of a bubble curtain or other noise attenuating device to mitigate noise levels would be employed to minimize the noise levels during impact pile driving operations. The Navy is considering the use of both unconfined and confined sound attenuation systems. Unconfined bubble curtain attenuators (Type I) emit a series of bubbles around a pile to introduce a high-impedance boundary through which pile driving noise is attenuated. Noise reduction results using an unconfined bubble curtain from several projects performed (Illingworth and Rodkin 2001; WSDOT 2010) indicate a wide variance of results, with very little measurable attenuation in some cases and high attenuation in other cases. Reductions of 85 percent (approximately 17 dB, computed as $20 \cdot \log_{10}$ the ratio of peak pressure reduced by 85 percent with the use of a bubble curtain) or more have been reported with the proper use of a Type II (confined) bubble curtain (Longmuir and Lively 2001), although reductions of 5 to 15 dB are more typical (Laughlin 2005). A confined bubble curtain places a shroud around the pile to hold air bubbles near the pile, ensuring they are not washed away by currents or tidal action. For impact analysis, an average SPL reduction of 10 dB was used as an average value that can be reasonably achieved. The Navy will analyze data from the Test Pile Program to confirm the level of noise reduction using site-specific conditions.

All noise exposure modeling for impact pile driving used the distances calculated assuming a bubble curtain or similar noise attenuating device was in place. Calculations for the marine mammal noise criteria for vibratory pile driving were done based on in-situ recordings of vibratory installation/extraction data from Illingworth and Rodkin (2007), which indicated an SPL of 180 dB re 1μPa at 10m. This concurred with published literature from other studies (Table 6–5). Worst-case scenario calculations assuming one impact pile driver and three vibratory drivers simultaneously operated are presented in this analysis. This analysis is conservative because it incorporates all sound energy at a given sensitive receptor location when all of the pile drivers are operating concurrently. All calculated distances to underwater marine mammal noise thresholds are provided in Table 6-6.

Table 6–6. Calculated Distance(s) to Underwater Marine Mammal Noise Thresholds due to Pile Driving and Areas Encompassed by Noise Thresholds

	Injury Pinnipeds (190 dBRMS) [2]	Injury Cetaceans (180 dBRMS) [2]	Behavioral harassment Cetaceans & Pinnipeds (160 dBRMS and 120 dBRMS) [2,3]
Distance to Threshold[1]	4.9 meters (impulsive)[4] 2.1 meters (continuous)[5]	22 meters (impulsive)[4] 10 meters (continuous)[5]	13.8 km [6]
Area Encompassed by Threshold	0.0001 sq km	0.002 sq km	41.4 sq km

1. Distance to threshold calculation is based on concurrent operation of one impact hammer and three vibratory drivers.
2. Bubble curtain or other sound attenuating device assumed to achieve 10 dB reduction in sound pressure levels. Sound pressure levels used for calculations were: 185 dB re 1 μPa at 33 feet for impact hammer with noise attenuator and 180 dB re 1 μPa for vibratory driver for 48-inch hollow steel pile. All sound levels are expressed in dBRMS re 1 μPa (see Section 3.4.2.1).
3. Distance to the 160 dBRMS behavioral harassment zone for impulsive noise is combined with distance to the 120 dBRMS behavioral harassment zone for continuous noise.
4. Threshold distance for noise produced by multiple pile driving rigs treated as impulsive noise.
5. Threshold distance for noise produced by multiple pile driving rigs treated as continuous noise.
6. Calculated range (over 222 km) is greater than actual sound propagation through Hood Canal due to intervening land masses. 13.8 km (8.6 miles) is the greatest line-of-sight distance from pile driving locations unimpeded by land masses, which would block further propagation of sound.

The 120 dB RMS threshold in Table 6–6 is shorter than the distance actually calculated using the practical spreading formula due to the irregular contour of the waterfront, the narrowness of the canal, and the maximum fetch (furthest distance sound waves travel without obstruction [i.e., line of site]) at the project area. For this reason, the maximum affected range at the 120 dBRMS threshold would be approximately 8.6 miles (13.8 km) from the driven pile, which is bounded by the furthest line-of-sight distance from the EHW-2 location to the northern shore of Suquamish Harbor. Further propagation is limited by land mass. Figure 6–1 depicts the effect of land masses on sound propagation for the 120 dBRMS threshold.

For the analysis of injury-level noise exposure of marine mammals, the combined sounds of the two pile driver types were treated as impulsive noise, because noise generated by the impact hammer this close to the pile driving activity would dominate over noise produced by the vibratory hammers. Using this approach, when multiple pile-driving rigs are operating concurrently, and assuming a properly functioning bubble curtain or other noise attenuating device is in place on the impact hammer rig, then construction of the EHW-2 would likely result in noise-related injury to pinnipeds and cetaceans within 4.9 meters and 22 meters from an impact-driven pile, respectively (Table 6–6). A representative scenario of areas affected by above-threshold noise levels for multiple pile driving rigs is shown in Figure 6–1. The analysis modeled the expected sound field of spatially separated sources because it is not realistic to locate all pile drivers at a single physical point. The larger injury threshold circle shown in Figure 6–1 represents the threshold around the impact pile driver, which is expected to be larger than the area around the vibratory drivers, even in a concurrent multiple pile driving rig analysis. Placement of pile driving rigs at other locations on the EHW-2 would generate above-threshold noise levels in other portions of the project area. Marine mammals are unlikely to be injured by pile driving noise at these short distances because the high level of human activity and vessel traffic would cause them to avoid the immediate construction area. Cetaceans in particular are unlikely to swim this close to manmade structures. Marine mammal monitoring during construction would further serve to render exposure to injury from pile driving noise very unlikely.

For the analysis of behavioral harassment of marine mammals due to construction of the EHW-2, combined sounds of the two pile driver types would be dominated by impulsive noise from the impact pile hammer at locations closer to the pile driving activity, but the contribution of vibratory drivers would increase with increasing distance. At the 160 dB behavioral harassment threshold (approximately 724 meters from the source) the influence of vibratory drivers would roughly equal the influence of the impact hammer. Beyond this distance, noise from the vibratory drivers would dominate out to the 120 dBRMS threshold. Since the 160 dB threshold and the 120 dB threshold both indicate behavioral harassment, pile driving effects in the two zones can be combined to estimate exposures of marine mammals to behavioral harassment.

Using this approach, when multiple pile-driving rigs are operating concurrently, assuming a properly functioning bubble curtain or other noise attenuating device is in place on the impact driver, then construction of the EHW-2 would likely result in behavioral harassment to pinnipeds and cetaceans within 13.8 km (Table 6–6). The calculated distance is much greater than 13.8 km (Table 6–6), but this is not realistic because intervening land masses would truncate the propagation of underwater pile driving sound (Figure 6–1). The area encompassed by the truncated threshold distance is approximately 41.4 sq km around the pile drivers (Table 6–6). Marine mammals within this area would be susceptible to behavioral harassment due to pile driving operations.

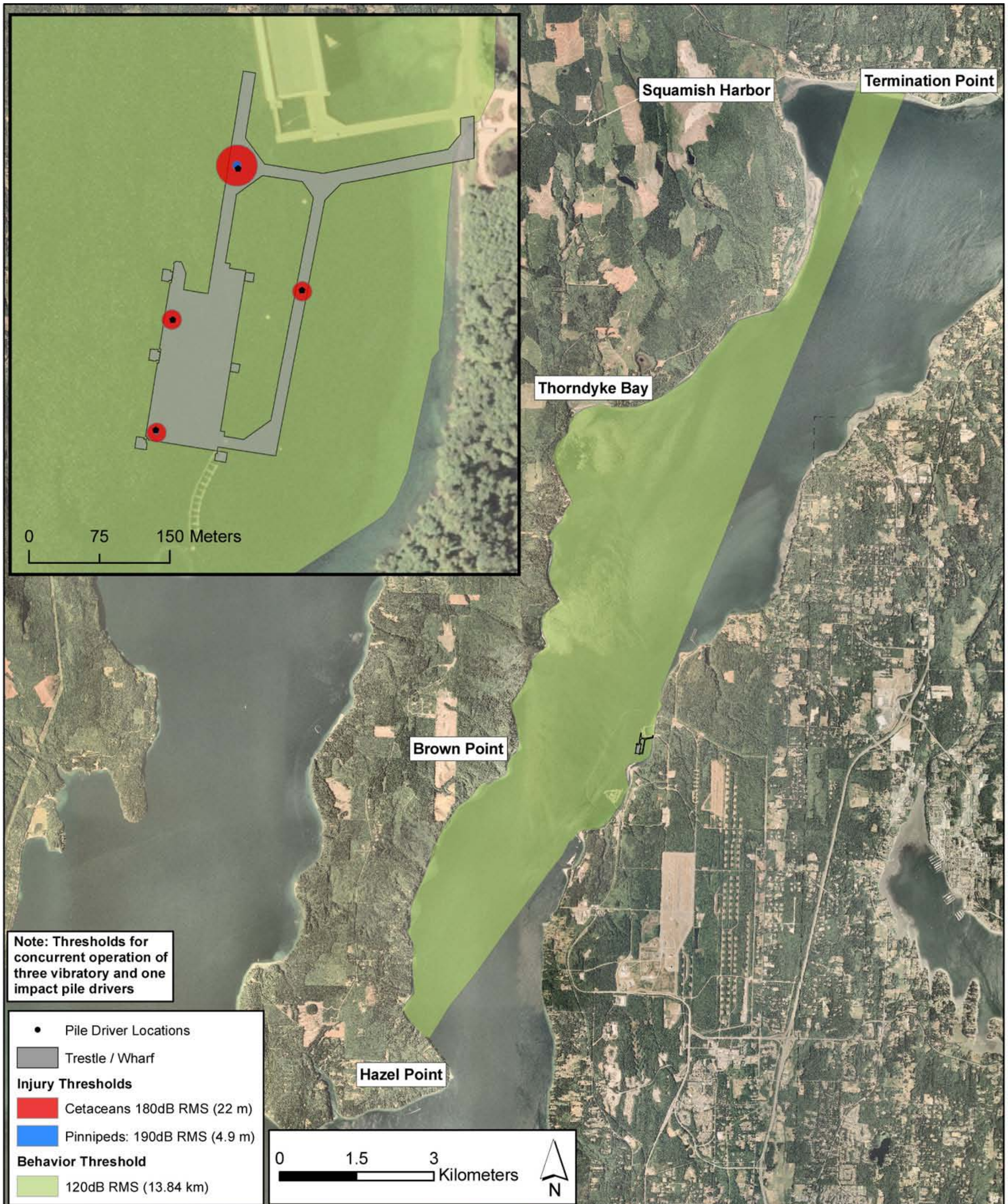


Figure 6-1. Representative View of Affected Areas for Marine Mammals Due to Underwater Pile Driving Noise

6.5.3 Airborne Sound Propagation Formula

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 near NBK at Bangor to be exposed to airborne sound pressure levels that could result in Level B behavioral harassment. The appropriate airborne noise thresholds for behavioral harassment for all pinnipeds except harbor seals is 100 dBRMS re 20 µPa (unweighted) and for harbor seals is 90 dBRMS re 20 µPa (unweighted) (see Table 6–3). Per WSDOT (2010) construction noise behaves as point-source, and thus propagates in a spherical manner, with a 6 dB decrease in sound pressure level over water ("hard-site" condition) per doubling of distance. A spherical spreading loss model, assuming average atmospheric conditions, was used to estimate the distance to the 100 dB and 90 dBRMS re 20 µPa (unweighted) airborne thresholds. The formula for calculating spherical spreading loss is:

$TL = 20 * \log_{10}(R1/R2)$,

Where: TL = Transmission loss
R1 = the distance of the modeled sound pressure level from the source, and
R2 = the distance from the source of the initial measurement.

6.5.4 Airborne Sound from Pile Driving

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. In order to determine reasonable airborne sound pressure levels and their associated effects on marine mammals that are likely to result from pile driving on NBK at Bangor, studies with similar properties to the proposed action were evaluated. Studies that met the following parameters were considered:

1. Pile materials: steel pipe piles (30–66-inch diameter);
2. Pile driver type: vibratory and impact; and
3. Physical environment: shallow depth (less than 100 feet).

Table 6–7 details representative pile driving activities that have occurred in recent years. Due to the similarity of these actions and the Navy's proposed action, they represent reasonable sound pressure levels that could be anticipated.

Table 6–7. Airborne Sound Pressure Levels from Similar In-situ Monitored Construction Activities

Project and Location	Pile Size and Type	Installation Method	Water Depth	Measured Sound Pressure Levels
Northstar Island, AK [1]	42-inch steel pipe pile	Impact	~12 m (40 feet)	97 dBRMS re 20 µPa at 160 meters (525 feet)
Keystone Ferry Terminal, WA [2]	30-inch steel pipe pile	Vibratory	~9 m (30 feet)	97 dBRMS re 20 µPa at 40 feet (13 meters)

Sources: Blackwell et al. 2004; Laughlin 2010b

Noise from multiple simultaneous sources produces an increase in the overall noise field. For the multiple-source analysis, a two-dimensional grid of closely spaced points was created, and noise levels were computed from individual sources at each grid point, then incoherently summed together to estimate the combined noise field. A-weighted and unweighted values were computed for each multiple-rig scenario analyzed. RMS calculations were made for both equivalent continuous sound and impulsive sound. In order to evaluate the contribution of the impact rig to the vibratory rigs, the impulsive wave form was converted to an equivalent continuous sound. Since the impulsive noise only exists for a short duration, a time-weighting factor was calculated to determine the effective continuous sound level to apply to the impulsive source level. This was done by taking the energy encompassed within an impulsive strike (assumed to be ~125 msec in duration in-air) and spreading it over the time for a continuous wave form (assumed to be 1 sec long).

Using the time-weighting factor computed as 10 log 10 [125 msec/ 1 sec], this results in a reduction in the intensity of the impulsive source level by 9 dB. This result was summed with continuous RMS noise levels from the vibratory drivers to establish the combined equivalent continuous noise level for both A-weighted and unweighted airborne noise sources.

In order to evaluate the contribution of the three vibratory rigs to the impulsive waveform produced by the impact rig, vibratory RMS levels were added directly to the impulsive RMS sound pressure levels of the impact driver. The maximum impulsive noise was computed as the sum of continuous vibratory energy and the impulsive RMS energy over the duration of the impact strike. Since this is only computed over the duration of each pile strike, the impulsive RMS sound pressure level for multiple rigs operating would always be higher than continuous equivalent RMS sound pressure levels.

For this analysis, it was assumed that all rigs were operating simultaneously, and the noise was incoherently summed to produce the expected noise field.

Based on in-situ recordings from similar construction activities, the maximum airborne noise levels that would result from impact and vibratory pile driving are estimated to be 97 dBRMS re 20 µPa at 525 feet (160 m) and 97 dBRMS re 20 µPa at 40 feet (13 m), respectively (Blackwell et al. 2004; Laughlin 2010b). The distances to the airborne harassment thresholds were calculated with the airborne transmission loss formula presented in Section 6.5.3. All calculated distances to marine mammal airborne noise thresholds as well as the areas encompassed by these threshold distances are shown in Table 6–8.

Table 6–8. Calculated[1] Maximum Distances in Air to Marine Mammal Noise Thresholds due to Pile Driving and Areas Encompassed by Noise Thresholds

	Harbor seal (90 dBRMS) [2]	Pinnipeds (seals, sea lions, except harbor seal) (100 dBRMS) [2]
Distance to Threshold[1]	361 meters	114 meters
Area Encompassed by Threshold	0.07 sq km	0.005 sq km

1. Distance to threshold calculation is based on concurrent operation of one impact hammer and three vibratory drivers.
2. Sound pressure levels used for calculations were: 97 dBRMS re 20 µPa at 160 meters (525 feet) (Blackwell et al. 2004) for impact hammer for 42-inch steel pile, and 98 dBRMS re 20 µPa for vibratory driver, for 36-inch steel pile (WSDOT 2010). All sound levels expressed in dBRMS re 20 µPa. All distances calculated over water.

For the analysis of behavioral harassment of pinnipeds due to construction of the EHW-2, combined sounds of the two pile driver types would be dominated by impulsive noise from the impact pile hammer. Treating the combined noise from both types of pile driver as impulsive noise, when multiple pile driving rigs are operating concurrently, construction of the EHW-2 would likely result in noise-related behavioral harassment to harbor seals at a distance of 361 meters, and to other pinnipeds (California sea lion and Steller sea lion) at a distance of 114 meters (Table 6–8). The areas encompassed by these threshold distances are shown in Table 6–8 and a representative scenario of areas affected by above-threshold noise levels for multiple pile driving rigs is shown in Figure 6–2. Other areas would be included in the above-threshold noise areas if the analysis was performed for pile driving rigs at other locations on the EHW-2.

6.5.5 Auditory Masking

Natural and artificial sounds can disrupt behavior by auditory masking, or interfering with a marine mammal’s ability to hear other relevant sounds, such as communication and echolocation signals (Wartzok et al. 2003/04). Masking occurs when both the signal and masking sound have similar frequencies and either overlap or occur very close to each other in time. Noise can only mask a signal if it is within a certain “critical band” around the signal’s frequency and its energy level is similar or higher (Holt 2008). Noise within the critical band of a marine mammal signal will show increased interference with detection of the signal as the level of the noise increases (Wartzok et al. 2003/04). In delphinid subjects, for example, relevant signals needed to be 17 to 20 dB louder than masking noise at frequencies below 1 kHz in order to be detected and 40 dB greater at approximately 100 kHz (Richardson et al. 1995).

If the masking sound is manmade, it could be potentially harassing (as defined by the MMPA) if it disrupts hearing-dependent behavior such as communications or echolocation. The most intense underwater sounds in the proposed action are those produced by impact pile driving. Given that the energy distribution of pile driving covers a broad frequency spectrum, with greatest amplitude typically from 50 to 1,000 Hz (WSDOT 2010), pile driving sound would be primarily within the lower audible range of the pinniped and cetacean species likely to occur in the project area. There may be some overlap of frequencies used for social signals by the marine mammal species with pile driving frequencies, especially the pinnipeds which use and are more sensitive to lower frequencies than the cetaceans that may occur in the project area (see Section 4.0, Status and Distribution of Marine Mammal Species).

Impact pile driving noise levels may exceed the levels of social signals within an unknown range of the driven pile, but impact pile driving activity will be relatively short-term. For each of the selected piles that will be proofed, actual pile driving is expected to last approximately 15 minutes per pile. Therefore, the likelihood that impact pile driving for this short duration would mask acoustic signals important to the behavior and survival of marine mammal species is negligible.

Vibratory pile driving produces frequencies from 1.25 to 2 kHz, which would be at the lower range of audible sound for most marine mammals that may occur in the project area. Given that the energy level of vibratory pile driving is less than half that of impact pile driving, the potential for masking noise would be limited to a very small radius around the given pile. The likelihood that vibratory pile driving would mask relevant acoustic signals for marine mammals is negligible. Any masking event that could possibly rise to Level B harassment under the MMPA would occur concurrently within the zones of behavioral harassment estimated for vibratory and impact pile driving (see Section 6.5.2, Underwater Noise from Pile Driving) and which are taken into account in the exposure analysis (see Section 6.7, Description of Take Calculation). Therefore, masking effects are not considered as separately contributing to exposure estimates in this IHA application.

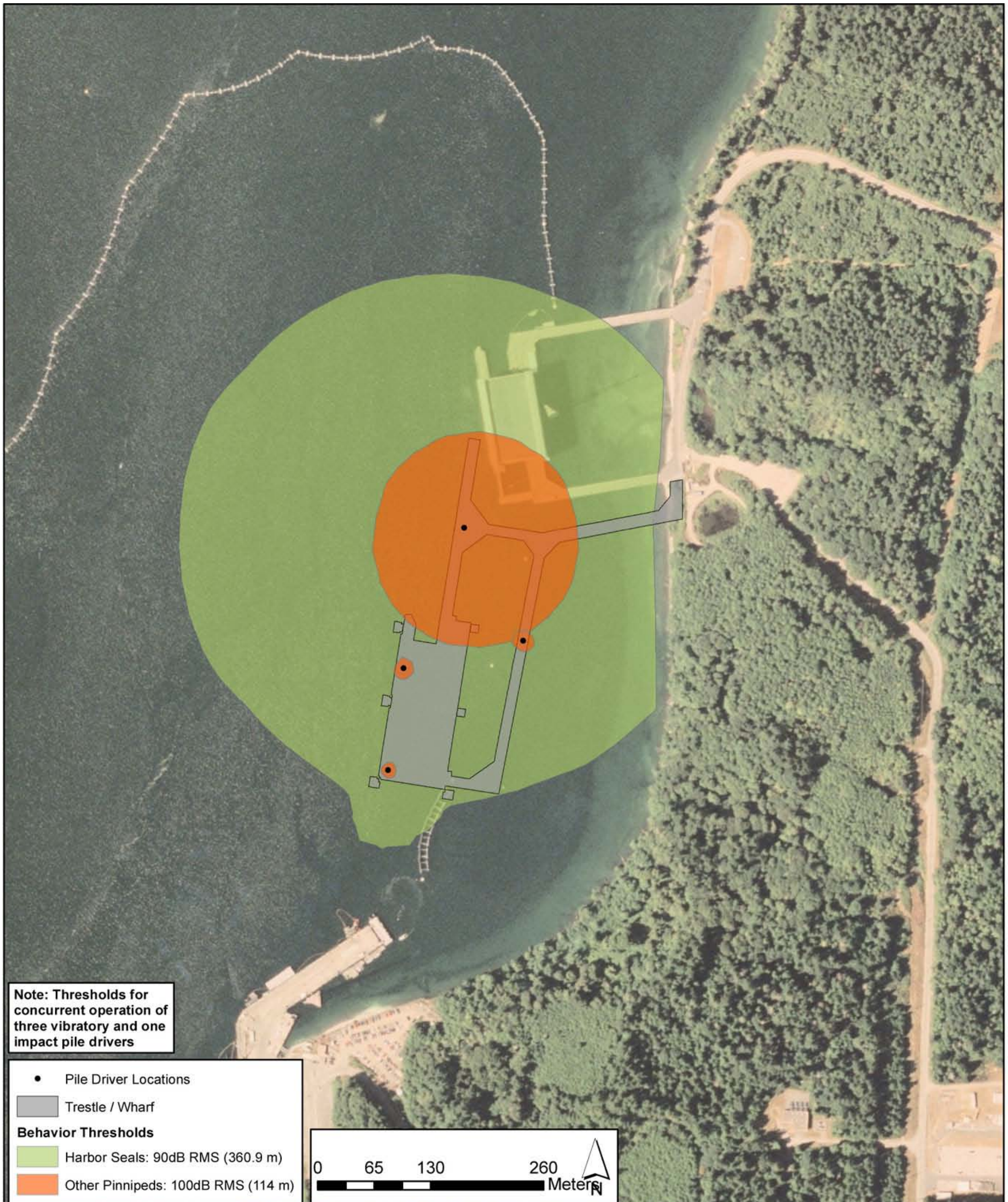


Figure 6−2. Representative View of Affected Areas for Marine Mammals Due to Airborne Pile Driving Noise

6.6 Basis for Estimating Harassment Exposures

The U.S. Navy is seeking authorization for the potential taking of Steller sea lions, California sea lions, harbor seals, transient killer whales, Dall's porpoises, and harbor porpoises in Hood Canal that may result from pile driving during construction of the EHW-2. The exposures requested are expected to have no more than a minor effect on individual animals and no effect on the populations of these species. Any effects experienced by individual marine mammals are anticipated to be limited to short-term disturbance of normal behavior or temporary displacement of animals near the source of the noise.

6.6.1 Steller Sea Lion

Steller sea lions were first documented in Hood Canal in 2008 while hauled out along the Bangor waterfront on NBK (Bhuthimethee 2008, personal communication; Navy 2010), and they are seasonally present. Beginning in April 2008, Navy personnel have recorded sightings of marine mammals at known haul-outs along the Bangor waterfront on NBK. Steller sea lions have been sighted on the submarines docked at Delta Pier North and Delta Pier South, and on the nearshore pontoons of the floating security fence (Navy 2010). These surveys have taken place frequently (average 14 per month) although without a formal protocol and only include known haul-outs. Steller sea lions were first observed on NBK at Bangor hauled out on a submarine at Delta Pier in November 2008. An independent observation reported four Steller sea lions at the same location on a different day in November 2008 (Bhuthimethee 2008, personal communication). On both occasions California sea lions were also present, allowing the informants to confirm their identifications based on discrepancies in size and other physical characteristics.

Boat-based opportunistic sightings along portions of the Bangor waterfront on NBK during the course of fish surveys during spring/summer of 2007 did not detect any Steller sea lions (Figure 7–24 in Agness and Tannenbaum 2009), nor did boat-based protocol marine wildlife surveys conducted during summer/fall 2008 and winter/spring 2009/2010 (Tannenbaum et al. 2009, 2011).

Data provided by Navy personnel since April 2008 have continued to document sightings of Steller sea lions at Delta Pier from November through April (Table 6–9). Steller sea lions have only been observed hauled out on submarines docked at Delta Pier. Delta Pier and other docks on NBK at Bangor are not accessible to pinnipeds, although the smaller California sea lions are able to haul out on pontoons that support the floating security barrier. One to two animals are typically seen hauled out with California sea lions; the maximum Steller sea lion group size seen at any given time was six individuals in November 2009. The time period from November through April coincides with the time when Steller sea lions are frequently observed in Puget Sound. Only adult and sub-adult males are likely to be present in the project area during this time; female Steller sea lions have not been observed in the project area. Since there are no known breeding rookeries in the vicinity of the project site, Steller sea lion pups are not expected to be present. By May, most Steller sea lions have left inland waters and returned to their rookeries to mate. Occasionally, sub-adult individuals (immature or pre-breeding animals) will remain in Puget Sound over the summer. However, on NBK at Bangor, Steller sea lions have only been observed from November through April and not during the summer months. Recent observational data from daily survey available from the Test Pile Program noted the presence of Steller sea lions along NBK at Bangor in October for the first time. Steller sea lions arrived on October 8th and were seen during surveys every day of the remaining 12 days of the project. Up to four individuals were sighted either hauled out at the submarines docked at Delta Pier or swimming in the waters just adjacent to the base. These sightings were incorporated into the data in Table 6-9 used to estimate the density of Steller sea lions for the month of October.

Table 6–9. Steller Sea Lions (SSL) Observed on NBK at Bangor, April 2008–June 2010

	Number of Surveys with SSL present	Number of Surveys	Frequency of SSL presence at survey sites[1]	Monthly Average of Maximum Number Observed	Density (animals/sq km)[2]
January	4	25	0.16	1.0	0.024
February	1	28	0.04	0.5	0.012
March	4	28	0.14	1.0	0.024
April	5	38	0.13	1.3	0.031
May	0	44	0.00	0.0	0
June	0	44	0.00	0.0	0
July	0	31	0.00	0.0	0
August	0	29	0.00	0.0	0
September	0	26	0.00	0.0	0
October	12	38	0.32	1.3	0.031
November	3	22	0.14	5.0	0.12
December	5	24	0.21	1.5	0.036
Totals	**31**	**377**	**Average: 0.095**	**Average Within In-Water Work Season: 1.16**	**Within In-Water Work Season: 0.028**

1. Frequency is the number of surveys with Steller sea lions present/number of surveys conducted.
2. Density was calculated as the monthly average of the maximum number of individuals present during Navy surveys at Delta Pier divided by the area defined by the 120 dB behavioral harassment isopleth (41.4 sq km).

Based on observations in recent years on NBK at Bangor, Steller sea lions may occasionally be present in the project area during the in-water pile driving period (mid-July through mid-February). Steller sea lions hauled out on submarines at Delta Pier would be beyond the area encompassed by the airborne noise behavioral harassment threshold (Figure 6–2) and are unlikely to be affected by construction activities. When pile driving is under way, exposure to construction activity would likely involve sea lions that are moving through the area en route to Delta Pier or during the return trip to Puget Sound. Steller sea lions that are exposed to elevated noise levels could exhibit behavioral changes such as increased swimming speed, increased surfacing time, or decreased foraging. Pile driving would occur only during daylight hours, and therefore would not affect nocturnal movements of Steller sea lions in the water. Most likely, Steller sea lions affected by elevated underwater or airborne noise would move away from the sound source and be temporarily displaced from the affected areas. Given the absence of any rookeries, only one haul-out area near the project site (i.e., submarines docked at Delta Pier), and infrequent attendance by a small number of individuals at this site, potential disturbance exposures will have a negligible effect on individual Steller sea lions and would not result in population-level impacts.

6.6.2 California Sea Lion

California sea lions are present in Hood Canal during much of the year with the exception of mid-June through August (Table 6–10). California sea lions occur regularly in the vicinity of the project site from September through mid-June, as determined by Navy waterfront surveys conducted from April 2008 through June 2010 (Navy 2010).

Table 6–10. California Sea Lions (CSL) Observed on NBK at Bangor, April 2008–June 2010

	Number of Surveys with CSL present	Number of Surveys	Frequency of CSL presence at survey sites[1]	Monthly Average of Maximum Number Observed	Density (animals/sq km)[2]
January	15	25	0.60	24.0	0.58
February	24	28	0.86	31.0	0.75
March	26	28	0.93	38.5	0.93
April	27	38	0.71	36.3	0.88
May	32	44	0.73	25.0	0.6
June	7	44	0.16	5.3	0.13
July	0	31	0.00	0.0	0.0
August	1	29	0.03	0.5	0.0
September	9	26	0.35	22.0	0.53
October	22	26	0.85	45.5	1.1
November	22	22	1.00	54.0	1.3
December	14	24	0.58	32.5	0.79
Totals	**199**	**365**	**Average: 0.55**	**Average Within In-Water Work Season: 26.2**	**Within In-Water Work Season: 0.63**

1. Frequency is the number of surveys with California sea lions present/number of surveys conducted.
2. Density was calculated as the monthly average of the maximum number of individuals present during Navy surveys at Delta Pier divided by the area defined by the 120 dB behavioral harassment isopleths (41.4 sq km).

The largest number of California sea lions hauled out along the Bangor waterfront on NBK was 58 in a November survey. During the in-water construction period (mid-July to mid-February) the largest daily attendance averaged for each month ranged from 24 individuals to 54 individuals. The likelihood of California sea lions being present on NBK at Bangor is greatest from October through May, when the frequency of attendance in surveys was at least 0.58. Attendance along the Bangor waterfront on NBK in November surveys (2008/2009) was 100 percent. Additionally, five navigational buoys near the entrance to Hood Canal were documented as potential haul-outs, each capable of supporting three adult California sea lions (Jeffries et al. 2000).

Breeding rookeries are in California; therefore, pups are not expected to be present in Hood Canal (NMFS 2008b). Female California sea lions are rarely observed north of the California/ Oregon border; therefore, only adult and sub-adult males are expected to be exposed to project impacts.

California sea lions would typically be present in the project area during a portion (early September through mid-February) of the in-water pile driving period (mid-July through mid-February). When pile driving is under way, exposure to construction activity would likely involve sea lions that are moving through the area en route to a haul-out site at Delta Pier or during the return trip to Puget Sound. California sea lions that are exposed to elevated noise levels could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, California sea lions affected by elevated underwater or airborne noise would move away from the sound source and be temporarily displaced from the affected areas. Pile driving would occur only during daylight hours, and therefore would not affect nocturnal movements of California sea lions in the water. Given the absence of any breeding rookeries and only one haul-out area near the project site, potential disturbance exposures will have a minor effect on individual California sea lions and would not result in population-level impacts.

6.6.3 Harbor Seal

Harbor seals are the most abundant marine mammal in Hood Canal, where they can occur anywhere in Hood Canal waters year-round. Jeffries et al. (2003) assessed the harbor seal population in Hood Canal in 1999 and estimated 1,088 harbor seals. The Navy detected harbor seals during marine mammal boat surveys of the waterfront area from July to September 2008 (Tannenbaum et al. 2009) and November to May 2010 (Tannenbaum et al. 2011), as described in Section 3.3.1. Harbor seals were sighted during every survey and were found in all marine habitats including nearshore waters and deeper water, and hauled out on manmade objects such as piers and buoys. From 3 to 5 individuals were detected in most boat surveys, which encompassed the entire Bangor waterfront on NBK out to a distance of at least 1,800 feet from shore. Since there are no known pupping sites in the vicinity of the project site, harbor seal neonates are not expected to be present during pile driving. Otherwise, during most of the year, all age and sex classes could occur in the project area throughout the period of construction activity.

Potential exposures during pile driving would likely involve seals that are present in the area on foraging trips or in transit through the area. Harbor seals that are exposed could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, harbor seals affected by elevated underwater or airborne noise would move away from the sound source and be temporarily displaced from the affected areas. With the absence of any breeding rookeries and only a few small haul-out sites (primarily buoys and pontoons of the floating security barrier) near the project site, and the small number of individuals that frequent the project area, potential disturbance exposures will have a minor short-term effect on individual harbor seals and would not result in population-level impacts.

6.6.4 Transient Killer Whales

Transient killer whales are uncommon visitors to Hood Canal, but they may potentially be present anywhere in Hood Canal anytime during the year. Resident killer whales have not been documented in Hood Canal since 1995 (NMFS 2008c), but transient pods were observed in Hood Canal for lengthy periods of time in 2003 (January–March) and 2005 (February–June), feeding on harbor seals (London 2006). Transient killer whales are not considered regular or seasonal visitors to Hood Canal.

Potential exposures due to pile driving would likely involve transient killer whales that are moving through the area on foraging trips. Killer whales that are exposed to elevated noise levels could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, killer whales that are affected by elevated noise levels would move away from the sound source and be temporarily displaced from the affected areas. With the absence of any regular occurrence in Hood Canal, potential disturbance exposures will have a negligible short-term effect on individual killer whales and would not result in population-level impacts.

6.6.5 Dall's Porpoise

Dall's porpoises may be present anywhere in Hood Canal year-round, although their use of inland Washington waters centers on the Strait of Juan de Fuca. The Navy conducted marine mammal boat surveys of the waterfront area from July to September 2008 (Tannenbaum et al. 2009) and from November to May 2010 (Tannenbaum et al. 2011), as described in Section 3.3.1. During one of these surveys one Dall's porpoise was sighted in August in the deeper waters off Carlson Spit.

Potential exposures due to pile driving would likely involve Dall's porpoises that are moving through the area on foraging trips. Dall's porpoises that are exposed to elevated noise levels could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, Dall's porpoises that are affected by elevated noise levels would move away from the sound source and be temporarily displaced from the affected areas. With the absence of any regular occurrence adjacent to the project site, potential takes by disturbance will have a negligible short-term effect on individual Dall's porpoises and would not result in population-level impacts.

6.6.6 Harbor Porpoise

Harbor porpoises may be present anywhere in Hood Canal year-round. The Navy conducted nearshore marine mammal boat surveys of the Bangor waterfront area from July to September 2008 (Tannenbaum et al. 2009) and from November to May 2010 (Tannenbaum et al. 2011), as described in Section 3.3.1. During one of these surveys a harbor porpoise was sighted in May in the deeper waters within the WRA in the vicinity of the existing EHW. Overall, these nearshore surveys indicated a low occurrence of harbor porpoise within the waters adjacent to the base. However, recent marine mammal surveys conducted during the Test Pile Program indicate that the abundance of harbor porpoises within Hood Canal in the vicinity of NBK at Bangor is much more robust than anticipated from existing surveys and anecdotal evidence. During these surveys, while harbor porpoise presence in the immediate vicinity of the base (i.e., within 1 km) remained low, harbor porpoises were frequently sighted within several kilometers of the base, mostly to the north or south of the project area, but occasionally directly across from the proposed EHW-2 project site on the far side of Toandos Peninsula. Based on observations during trackline transect surveys conducted to date as part of the Test Pile Program, harbor porpoises have been seen commonly during surveys with the number of individuals sighted in the deeper water of Hood Canal ranging from 0 to 11 individuals, with an average of approximately 6 animals sighted per day (Navy, in prep.).

Potential exposures during pile driving would likely involve harbor porpoises that are present in the area on foraging trips or in transit through the area. Harbor porpoises that are exposed to elevated noise levels could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, harbor porpoises that are affected by elevated noise levels would move away from the sound source and be temporarily displaced from the affected areas. Since their occurrence immediately adjacent to the project site remains low, exposures would likely be at very low sound pressure levels. Therefore, potential takes by disturbance will have a negligible short-term effect on individual harbor porpoises. Given the abundance of these animals in Hood Canal and other inland waters and the proportion of harbor porpoises that may experience effects relative to the entire stock, the proposed action would not result in population-level impacts.

6.7 Description of Exposure Calculation

The exposure calculations presented here relied on the best data currently available for marine mammal populations in Hood Canal. Exposure calculations for California sea lions and Steller sea lions in the following sections are based on the Navy's marine mammal survey efforts described in detail in Section 3.3.1. Exposure calculations for the other marine mammals reported in this IHA are based in part on the Navy's boat surveys, described in Section 3.3.1, as well as the literature. A formula was developed for calculating exposures due to impact pile driving and applied to each group-specific noise impact threshold. The formula is founded on the following assumptions:

- Each species population is at least as large as any previously documented highest population estimate.
- Each species would be present in the project area during construction at the start of each day, based on observed patterns of occurrence in the absence of construction. The timeframe for takings would be 1 potential taking per individual per 24 hours.
- All pilings to be installed would have a noise disturbance distance equal to the piling that causes the greatest noise disturbance (i.e., the piling furthest from shore).
- Pile driving would occur every day of the in-water work window. For the first year of construction, assuming pile driving occurs 6.5 days per week over the 7 months (30 weeks) of pile driving, which amounts to 195 days of pile driving (Section 1.1.1).
- Sound attenuation modeling assumes three vibratory rigs may be in operation at the same time.
- Some type of mitigation (i.e., bubble curtain) will be utilized, as discussed previously.

The density calculation for marine mammals depends on the known or likely range of the species in Hood Canal, and is discussed in greater detail in the following species-specific sections. For harbor seals and the cetacean species, the range is known or assumed to encompass all of Hood Canal. For California sea lions and Steller sea lions, the range is assumed to encompass a smaller area around the project area (see Section 6.7.1, Steller Sea Lion, and Section 6.7.2, California Sea Lion, for details).

The calculation for all marine mammal exposures is estimated by:

Exposure estimate = (N * ZOI) * 195 days of pile driving activity, where:
N = density estimate used for each species
ZOI[7] = noise threshold zone of influence (ZOI) impact area[8]

[7] Zone of Influence (ZOI) is the area encompassed by all locations where the sound pressure levels equal or exceed the threshold being evaluated.

The ZOI impact area is the estimated range of impact to the noise criteria. The formula for determining the area of a circle (pi * radius^2) was used to calculate the ZOI around each pile, for each threshold. The distances specified in Tables 6–6 and 6–8 were used to calculate the overwater areas that would be encompassed within the threshold distances for injury or disturbance harassment. All impact pile driving exposure calculations were based on the estimated threshold ranges using a bubble curtain with 10 dB attenuation as a mitigation measure.

As described in Section 6.5.2 with regard to the distances, the ZOIs for each threshold are not spherical and would be truncated by land masses, such as points of land along the Bangor shoreline on NBK and the Toandos Peninsula on the opposite shoreline, which would dissipate sound pressure waves (WSDOT 2010). A representative scenario of areas affected by above-threshold noise levels for one impact and three vibratory pile driving rigs operating concurrently is shown in Figures 6–1 and 6–2. Other areas would be included in the above-threshold noise areas if the analysis was performed for pile driving rigs at other locations on the EHW-2.

The exposure assessment methodology is an estimate of the numbers of individuals exposed to the effects of pile driving activities exceeding NMFS established thresholds. Of significant note in these exposure estimates, additional mitigation methods (i.e., visual monitoring and the use of shutdown zones) were not quantified within the assessment and successful implementation of mitigation is not reflected in exposure estimates. Results from acoustic impact exposure assessments should be regarded as conservative overestimates that are strongly influenced by limited marine mammal population data.

6.7.1 Steller Sea Lion

Steller sea lions may be present in Washington inland waters but have only been detected in Hood Canal during the period from October to April, primarily during the course of the Navy's monitoring of California sea lions at haul-out sites along the Bangor waterfront on NBK, as described in detail in Section 3.3.1. Their occurrence on NBK at Bangor is infrequent, and has been less than 21 percent of surveys during any month since the survey effort began in April 2008 (Navy 2010).

The Navy determined a reasonable area that Steller sea lions could be expected to utilize in the project area while swimming and foraging, based on available literature, in order to calculate in-water density for sound exposure modeling. Foraging trips of satellite-tracked adult western stock Steller sea lions in Alaska averaged 17 $\pm$ 5 km during summer, and 133 $\pm$ 60 km in winter (Merrick and Loughlin 1997). Eastern stock Steller sea lions were concentrated within 1 to 13 km (mean 7.0 km) of rookeries off the coast of California during summer and were observed 7 to 59 km offshore (mean 28.2 km) in autumn (Bonnell et al. 1983). Foraging ranges of young-of-the-year animals in Alaska averaged 30 km (Merrick and Laughlin 1997). Winter foraging ranges for adult male eastern stock Steller sea lions in Washington inland waters have not been reported, but can reasonably be expected to be as great as distances reported for females and immatures. Given these distances, the Navy concluded that it was reasonable to expect that Steller sea lions could travel 30 to 130 km when foraging in inland waters. The project action

[8] The product of N*ZOI was rounded to the nearest whole number before multiplying by the number of pile driving days. If the product of N*ZOI rounds to zero, the number of exposures calculated was zero regardless of the number of pile driving days.

area was defined as the calculated distance from EHW-2 pile driving locations to the behavioral harassment threshold (120 dB sound pressure level) or the greatest line-of-sight distance (13.8 km) that underwater sound waves could travel from pile driving locations unimpeded by land masses (Figure 6–1). The affected area was determined to be 41.4 sq km (Table 6–6). The Navy believes that it is reasonable to expect that Steller sea lions would forage within this area, given their reported foraging distances. Moreover, it is assumed that any sea lions swimming within this area would be potentially subject to exposure to elevated pile driving noise from the EHW-2 construction site. Because they are infrequently present in the project area, the density calculation for Steller sea lions uses the average of the monthly maximum number of individuals present during surveys at Delta Pier rather than the maximum number (6) ever observed (Navy 2010) (Table 6–9). The average of the monthly maximum number present during the in-water work window is 1.16 animals. Therefore, the density used in the sound exposure analysis was calculated as the monthly average of the maximum number of Steller sea lions on NBK at Bangor (1.16 individuals) (Table 6–9) divided by the area encompassed by the maximum fetch of the project area (41.4 sq km). The calculated density of Steller sea lions is 0.028 animal per sq km. Exposures were calculated using this density in the formula described in Section 6.7.

With regard to the range of this species in Hood Canal and the project area, it is assumed that the opportunity to haul out on submarines docked at Delta Pier is a primary attractant for Steller sea lions in Hood Canal, as they have not been reported either hauled out or swimming, to the south of NBK at Bangor. Their haul-out site, submarines docked at Delta Pier (approximately 1 km from the EHW-2 construction area), is within the underwater distance threshold for behavioral harassment due to concurrent impact and vibratory pile driving (13.8 km), but not within the airborne disturbance thresholds for concurrent impact and vibratory pile driving (114 meters for sea lions). It is assumed that animals swimming to and from the submarines may be exposed to disturbing noise levels primarily resulting from vibratory pile driving, as this zone (approximately 41.4 sq km) is significantly larger than the affected areas for impact pile driving. Therefore, their range in Hood Canal is conservatively assumed to be the area encompassed by the underwater disturbance threshold for vibratory pile driving.

Exposures to underwater and airborne pile driving noise were calculated using the formula in Section 6.7. Table 6–11 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater and in-air.

Table 6–11. Number of Potential Exposures of Steller Sea Lions within Various Acoustic Threshold Zones

Season	Density of Steller Sea Lions [1] (sq km)	Underwater		Airborne
		Injury Threshold (190 dBRMS)	Behavioral Harassment Threshold (160 dB and 120 dBRMS) [2]	Behavioral Harassment Threshold (100 dBRMS)
Mid-July – Mid-February	0.028	0	390 [3]	0

1. Density was calculated as the average of the maximum number of individuals present during surveys at Delta Pier during the in-water construction season (July 16 – February 15) divided by the area encompassed by the underwater disturbance threshold for vibratory pile driving. The airborne exposure calculations assumed that 100 percent of the in-water densities were available at the surface to be exposed to airborne sound.
2. Distance to the 160 dBRMS behavioral harassment zone for impulsive noise is combined with distance to the 120 dBRMS behavioral harassment zone for continuous noise.

3. Using the noise exposure calculation (Density [0.024 sea lion/sq km]*ZOI for behavioral harassment [41.4 sq km]) this results in a daily abundance of 1 Steller sea lion in the ZOI. Multiplied by 195 potential days of pile driving, the model estimates 195 behavioral harassment exposures. The density calculation assumes an even distribution of Steller sea lions. However, in reality their distribution is patchy with their occurrence concentrated near Delta Pier in groups of 1-4 individuals. As a result, it is more likely that more than one exposure would occur in a day. To ensure the Navy has adequate coverage, the Navy increased the number of takes requested to 2 exposures per day of pile driving, for a total of 390 exposures in the first in-water work window.

Based on the density analysis and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), an average of 1 individual Steller sea lion may experience elevated noise levels that would qualify as harassment on a given day while present during the in-water work period. The density analysis assumes an even distribution of animals. However, in reality Steller sea lion distribution within the project area is patchy with their occurrence concentrated near Delta Pier in groups of 1-4 individuals. As a result, it is more likely that more than one exposure would occur in a day. To ensure the Navy has adequate coverage, the Navy increased the number of takes requested to 2 exposures per day of pile driving, for a total of 390 exposures in the first in-water work window. The product of n*ZOI for the injury threshold rounded to zero, so the calculated number of injury-level exposures was zero, as was the calculated level of exposures due to elevated airborne noise. Therefore, the total number of exposures over the first year of pile driving activity (to be covered by the requested IHA) is estimated to be 390~~195~~ due to behavioral harassment resulting from concurrent underwater impact and vibratory pile driving, as described in Table 6–11.

Steller sea lions that are exposed to acoustic harassment could exhibit behavioral reactions but are unlikely to be injured by pile driving noise. Disturbance from underwater noise impacts is not expected to be significant at the population level because it is estimated that only a small number of Steller sea lions may be affected by acoustic harassment. Additionally, marine mammal observers will be monitoring the shutdown zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any sea lions enter or approach the shutdown zone. This will ensure that no sea lions are subject to noise levels that would constitute Level A exposure.

6.7.2 California Sea Lion

No regular haul-outs were documented during aerial survey population counts of California sea lions within Hood Canal (Jeffries et al. 2000). However, the Navy's observations of animals hauled out on vessels and manmade structures on NBK at Bangor indicate that California sea lions are present in Hood Canal during much of the year with the exception of mid-June through August (Table 6–10). The Navy has conducted waterfront surveys beginning in April 2008, and results were compiled through June 2010 for the analysis in this IHA (Navy 2010), as described in Section 3.3.1. These surveys, which are summarized in Table 6–10, represent the best available data for California sea lion abundance within Hood Canal.

Table 6–10 reports the frequency of California sea lion presence at survey sites and the monthly average of the maximum number of California sea lions observed during the Navy's surveys. During the in-water construction period (mid-July to mid-February), the largest daily attendance averaged for each month ranged from 24 individuals to 54 individuals. The largest monthly average (54 animals) was recorded in November, as was the largest daily count (58). The likelihood of California sea lions being present on NBK at Bangor was greatest from October through May, when the frequency of attendance in surveys was at least 0.58. Attendance along the Bangor waterfront on NBK in November surveys (2008 and 2009) was 100 percent.

The Navy determined a reasonable area that this population could be expected to utilize while swimming and foraging, based on available literature on California sea lions, in order to calculate in-water density for sound exposure modeling. Costa et al. (2007) found that foraging adult females (n = 32) in California traveled an average of 66.3 + 11 km from their rookery. Wintering males from the Columbia River (n = 14) traveled a maximum of 70 km from shore (Wright et al. 2010). Additional data from 12 adult males from mixed stocks in Washington had a maximum travel speed of 99 km (62 miles) per day (Wright et al. 2010). Given these distances, the Navy concluded that it was reasonable to expect that California sea lions could travel between 55 and 100 km when foraging. Since these were straight-line distances, the area encompassed would be smaller. The project action area was defined as the calculated distance from EHW-2 pile driving locations to the behavioral harassment threshold (120 dB sound pressure level) or the greatest line-of-sight distance (13.8 km) that underwater sound waves could travel from pile driving locations unimpeded by land masses (Figure 6–1). The affected area was determined to be 41.4 sq km (Table 6–6). The Navy believes that it is reasonable to expect that California sea lions would forage within this area, given their reported foraging distances. Moreover, it is assumed that any sea lions swimming within this area would be potentially subject to exposure to elevated pile driving noise from the EHW-2 construction site. Therefore, the density used in the sound exposure analysis was calculated as the monthly average of the maximum number of California sea lions on NBK at Bangor (26 individuals) (Table 6–10) divided by the area encompassed by the maximum fetch of the project area (41.4 sq km). The calculated density of California sea lions is 0.63 animal per sq km. Exposures were calculated using this density in the formula described in Section 6.7.

With regard to the range of this species in Hood Canal and the project area, it is assumed that the opportunity to haul out on submarines docked at Delta Pier is a primary attractant for California sea lions in Hood Canal, as they have rarely been reported, either hauled out or swimming, to the south of NBK at Bangor (Jeffries 2007, personal communication). Their haul-out sites, submarines docked at Delta Pier and nearby pontoons of the security fence in this area (approximately 1 mile from the proposed EHW-2 location), are within the underwater distance threshold for behavioral harassment due to concurrent impact and vibratory pile driving (13.8 km), but not within the airborne noise disturbance thresholds for concurrent impact and vibratory pile driving (114 meters). It is assumed that animals swimming to and from the submarines may be exposed to disturbing noise levels primarily resulting from vibratory pile driving, as this zone (approximately 41.4 sq km) is significantly larger than the affected areas for impact pile driving. Therefore, their range in Hood Canal is conservatively assumed to be the area encompassed by the underwater disturbance threshold for vibratory pile driving.

Exposures to underwater and airborne pile driving noise were calculated using the formula in Section 6.7. Table 6–12 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater and in-air.

Table 6–12. Number of Potential Exposures of California Sea Lions within Various Acoustic Threshold Zones

Season	Density of California Sea Lions [1] (sq km)	Underwater		Airborne
		Injury Threshold (190 dBRMS)	Behavioral Harassment Threshold (160 dB and 120 dBRMS) [2]	Behavioral Harassment Threshold (100 dBRMS)

Mid-July – Mid-February	0.63	0	5,070	0

1. Density was calculated as the average of the maximum number of individuals present during surveys at Delta Pier during the in-water construction season (July 16 – February 15) divided by the area encompassed by the underwater disturbance threshold for vibratory pile driving. Airborne exposure calculations assume that 100 percent of the in-water densities were available at the surface to be exposed to airborne sound.
2. Distance to the 160 dBRMS behavioral harassment zone for impulsive noise is combined with distance to the 120 dBRMS behavioral harassment zone for continuous noise.

Based on the density analysis (Section 6.6.2) and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), an average of 26 individual California sea lions may experience sound pressure levels on a given day while present during the in-water work period that would qualify as harassment. The product of n*ZOI for the injury threshold rounded to zero, so the calculated number of injury-level exposures was zero, as was the calculated level of exposures due to elevated airborne noise. The total number of exposures over the first year of pile driving activity (to be covered by the requested IHA) is estimated to be 5,070 due to behavioral harassment caused by concurrent impact and vibratory pile (Table 6–12).

California sea lions that are exposed to acoustic harassment could exhibit behavioral reactions but are unlikely to be injured by pile driving noise. Marine mammal observers will be monitoring the shutdown zones during pile driving activities (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any sea lions enter or approach the shutdown zone. This will ensure that no sea lions are subject to noise levels that would constitute Level A exposure.

6.7.3 Harbor Seal

Harbor seals are the most abundant marine mammal in Hood Canal, where they can occur anywhere in Hood Canal waters year-round. Jeffries et al. (2003) conducted aerial surveys of the harbor seal population in Hood Canal in 1999 for the Washington Department of Fish and Wildlife and reported 711 harbor seals hauled out. The authors adjusted this abundance with a correction factor of 1.53 to account for seals in the water, which were not counted, and estimated that there were 1,088 harbor seals in Hood Canal. The correction factor (1.53) was based on the proportion of time seals spend on land versus in the water over the course of a day, and was derived by dividing one by the percentage of time harbor seals spent on land. These data came from tags (VHF transmitters) applied to harbor seals at six areas (Grays Harbor, Tillamook Bay, Umpqua River, Gertrude Island, Protection/Smith Islands, and boundary Bay, BC) within two different harbor seal stocks (the coastal stock and the inland waters of WA stock) over four survey years. The Hood Canal population is part of the inland waters stock, and while not specifically sampled, Jeffries et al. (2003) found the VHF data to be broadly applicable to the entire stock. The tagging research in 1991 and 1992 conducted by Huber et al. (2001) and Jeffries et al. (2003) used the same methods for the 1999 and 2000 survey years. These surveys indicated that approximately 35 percent of harbor seals are in the water versus hauled out on a daily basis (Huber et al. 2001; Jeffries et al. 2003).

In order to estimate the underwater exposures from pile driving operations, the Navy determined the proportion of the Hood Canal population that could be in the water and susceptible to exposure on a daily basis. Jeffries et al. (2003) applied the correction factor on an annual basis, thereby assuming that the proportion of harbor seals on land versus in-water was consistent on a daily basis for the entire year. Similarly, the Navy assumed that the proportion of the population susceptible to exposure to underwater sound on a daily basis was 35 percent of the total population (35 percent of 1,088 animals, or approximately 381 individuals). The Navy recognizes that over the course of the day, while the proportion of animals in the water may not vary significantly, different individuals may enter and exit the water. However, fine-scale data on harbor seal movements within the project area on time durations of less than a day are not available.

Exposures to underwater and airborne pile driving noise were calculated using a density derived from the number of harbor seals that are present in the water at any one time (35 percent of 1,088 animals, or approximately 381 individuals), divided by the area of Hood Canal (291 sq km, or 112 square miles) (Huber et al. 2001; Jeffries et al. 2003). The density of harbor seals calculated in this manner (1.3 animals/sq km) is corroborated by results of the Navy's marine mammal boat surveys on NBK at Bangor in 2008 and 2009/10, in which an average of 5 individual harbor seals was observed in the 3.9 sq km survey area (density = 1.3 animals/sq km) (Tannenbaum et al. 2009, 2011). Exposures to underwater noise were calculated with the formula in Section 6.7.

In order to analyze the potential for harbor seals to be disturbed by airborne noise associated with pile driving for EHW-2, the Navy looked at the likelihood for harbor seals in the project area to be hauled out and/or swimming with their heads out of the water. While Huber et al (2001) indicated that harbor seals typically spend 65 percent of their time hauled out, the Navy's waterfront surveys and boat surveys (Agness and Tannenbaum 2009; Tannenbaum et al. 2009, 2011; Navy 2010) found that it is rare for harbor seals to haul out along the Bangor waterfront on NBK. Harbor seals occasionally haul out on pontoons of the floating security fence, buoys, and barges within the Waterfront Restricted Area but have not been observed on submarines. Documented use of these structures has been outside of the zone of influence for airborne noise resulting from EHW-2 construction. An observation of harbor seals hauled out on a log on the shoreline approximately 1,460 feet due south of EHW-1 represents the closest documented haul-out site to the proposed EHW-2 construction site. This observation was in the vicinity of the southern end of the EHW-2 construction zone, but the log in question is no longer present. Harbor seals' ideal haul-out locations include intertidal or sub-tidal rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and floats (Wilson 1978; Prescott 1982; Schneider and Payne 1983; Gilbert and Guldager 1998; Jeffries et al. 2000). Although in-water sightings of harbor seals are common in the project area, available haul-out locations that would fall within the calculated airborne acoustic noise zone of influence (361 meters) are limited. The only structures within the airborne zone of influence (Figure 6–2) are the EHW-1 wharf and Marginal Wharf, both of which are elevated more than 16 feet above MHHW and thus inaccessible to pinnipeds. The shoreline zone between these structures is a narrow area that is backed by a steep cliff face. Portions of the intertidal zone that are exposed at low tide are vegetated with eelgrass and macroalgae, which are not favored haul-out locations for harbor seals.

Therefore, on NBK at Bangor, harbor seals would primarily be exposed to airborne noise effects as they swim or rest in the water with their heads above the surface. Based on the diving cycle of tagged harbor seals near the San Juan Islands, we estimate that seals are on the surface approximately 16.4 percent of their total in-water duration (Suryan and Harvey 1998). Therefore, by multiplying the percentage of time spent at the surface (16.4%) by the total in-water population of harbor seals at any one time (~381 individuals), the number of harbor seals with the potential to experience airborne impacts (~63 individuals) can be obtained. Airborne exposures were calculated (see Section 6.7 for formula) using a density derived from the number of harbor seals available at the surface (~63 individuals), divided by the area of Hood Canal (291 sq km)(density in air = 0.2 animals/sq km).

Table 6–13 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater and in-air for each season.

Table 6–13. Number of Potential Exposures of Harbor Seals within Various Acoustic Threshold Zones

Season	Density of Harbor Seals [1] (sq km)	Underwater		Airborne
		Injury Threshold (190 dB$_{RMS}$)	Behavioral Harassment Threshold (160 and 120 dB$_{RMS}$)[2]	Behavioral Harassment Threshold (90 dB$_{RMS}$)
Mid-July – Mid-February	1.3	0	10,530	0[3]

1. Density was calculated as the number of individuals present in the water (not hauled out) in Hood Canal at any given time (Huber et al. 2001).
2. Distance to the 160 dB$_{RMS}$ behavioral harassment zone for impulsive noise is combined with distance to the 120 dB$_{RMS}$ behavioral harassment zone for continuous noise.
3. Harbor seal densities (0.2/sq km) exposed to airborne noise were calculated using the percentage (16.4%) of animals in the water but on the surface (Suryan and Harvey 1998).

Based on the density analysis above and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), up to 54 individual harbor seals may experience sound pressure levels on a given day that would qualify as harassment. The product of n*ZOI for the injury threshold rounded to zero, so the calculated number of injury-level exposures was zero, as was the calculated level of exposures due to elevated airborne noise. The total number of exposures over the first year of pile driving activity (to be covered by the requested IHA) is calculated to be 10,530 exclusively due to behavioral harassment (Table 6–13). Harbor seals that are exposed to acoustic harassment could exhibit behavioral reactions but are unlikely to be injured by pile driving noise. Marine mammal observers will be monitoring the shutdown zones during pile driving activities (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any seals enter or approach the shutdown zone. This will ensure that no seals are subject to noise levels that would constitute Level A exposure.

6.7.4 Killer Whale

Transients are uncommon visitors to Hood Canal. In 2003 and 2005, small groups of transient killer whales (6 to 11 individuals per event) visited Hood Canal to feed on harbor seals and remained in the area for significant periods of time (59 to 172 days) between the months of January and July (London 2006). These whales used the entire expanse of Hood Canal for feeding. No other confirmed sightings of transient killer whales in Hood Canal were found. Based on these data, the density for transient killer whales in Hood Canal for January to June was calculated to be 0.04/sq km (a maximum of 11 individuals observed at one time divided by the area of the Hood Canal [291 sq km]). Given the rarity of transient killer whale visits in Hood Canal in the past decade, this density is a very conservative overestimate. It is assumed for the exposure analysis (see Section 6.7 for the formula) that transient killer whales could occur in Hood Canal, including the project area, at any time during the in-water work season.

Table 6–14 depicts the number of acoustic harassments that are estimated from underwater vibratory and impact pile driving.

Table 6–14. Number of Potential Exposures of Transient Killer Whales within Various Acoustic Threshold Zones

Season	Density of Transient Killer Whales [1] (sq km)	Underwater	
		Injury Threshold (180 dB_{RMS})	Behavioral Harassment Threshold (160 dB and 120 dB_{RMS})[2]
Mid-July – Mid-February	0.04	0	390

1. Density was calculated as the maximum number of individuals present at a given time during two visits in 2003 and 2005 (London 2006) divided by the area of Hood Canal.
2. Distance to the 160 dB_{RMS} behavioral disturbance zone for impulsive noise is combined with distance to the 120 dB_{RMS} behavioral disturbance zone for continuous noise.

Based on the density analysis above and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), up to 2 individual killer whales may experience sound pressure levels on a given day that would qualify as harassment. The product of n*ZOI for the injury threshold rounded to zero, so the calculated number of injury-level exposures was zero. The total number of exposures over the first year of pile driving activity (the period covered by this IHA application) is estimated to be 390 due to behavioral harassment caused by concurrent impact and vibratory pile driving as described in Table 6–14. Killer whales that are exposed to acoustic harassment could exhibit behavioral changes but are unlikely to be injured by pile driving noise. Disturbance from underwater noise impacts is not expected to be significant at the population level because it is estimated that only a small number of killer whales may be affected by acoustic harassment. Additionally, marine mammal observers will be monitoring the shutdown zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any killer whales enter or approach the shutdown zone. This will ensure that no killer whales are subject to noise levels that would constitute Level A exposure.

6.7.5 Dall's Porpoise

Dall's porpoise may be present in Hood Canal year-round and are assumed to use the entire area. The Navy conducted boat surveys of the waterfront area from July to September 2008 (Tannenbaum et al. 2009) and November 2009 to May 2010 (Tannenbaum et al. 2011). During one of the surveys a single Dall's porpoise was sighted in August 2009 in the deeper waters off Carlson Spit. In the absence of an abundance estimate for the entire Hood Canal, density was derived from the waterfront surveys using the number of individuals seen divided by total area of survey effort (18 surveys with approximately 3.9 km^2 [1.5 sq mi] of effort per survey, using strip transect surveys). Exposures were calculated using the formula in Section 6.7. Table 6–15 depicts the number of acoustic harassments that are estimated from underwater vibratory and impact pile driving.

Table 6–15. Number of Potential Exposures of Dall's Porpoise within Various Acoustic Threshold Zones

Season	Density of Dall's Porpoise [1] (sq km)	Underwater	
		Injury Threshold (180 dBRMS)	Behavioral Disturbance Threshold (160 and 120 dBRMS)[2]
Mid-July – Mid-February	0.01	0	195[3]

1. Density was calculated as the number of individuals observed in 18 surveys of the 3.9 sq km Bangor waterfront area on NBK (Tannenbaum et al. 2009, 2011).
2. Distance to the 160 dBRMS behavioral disturbance zone for impulsive noise is combined with distance to the 120 dBRMS behavioral disturbance zone for continuous noise.
3. The number of exposures calculated for Dall's porpoise was zero for disturbance from both impact and vibratory pile driving. Dall's porpoise are rarely present in Hood Canal and only one was observed in 18 full surveys of the waters off NBK at Bangor. Since this individual was observed in deeper offshore waters encompassed by the vibratory pile driving behavioral harassment zone (120 dB threshold), it is possible that an animal may be exposed to behavioral harassment due to pile driving with one impact hammer and three vibratory drivers operating concurrently. Therefore, the Navy believes that additional disturbance exposures may occur due to multiple-rig pile driving based on possible exposure of 1 Dall's porpoise per day during pile driving, for a total of 195 behavioral harassment exposures due to pile driving over the course of the project.

Based on the density analysis above and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), zero exposures were calculated for Dall's porpoise for underwater pile driving noise. However, the Navy requests behavioral harassment (Level B) takes due to pile driving noise based on possible exposure of 1 Dall's porpoise per day during the 195 days of pile driving covered by this IHA application (as described in Table 6–15). Dall's porpoises that are exposed to acoustic harassment could exhibit behavioral changes but are unlikely to be injured by pile driving noise. Disturbance from underwater noise impacts is not expected to be significant at the population level because it is estimated that only a small number of Dall's porpoises may be affected by acoustic harassment. Additionally, marine mammal observers will be monitoring the shutdown zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any porpoises enter or approach the shutdown zone. This will ensure that no Dall's porpoises are subject to noise levels that would constitute Level A exposure.

6.7.6 Harbor Porpoise

Harbor porpoises may be present in Hood Canal year-round and are assumed to use the entire area. The Navy conducted vessel-based line transect surveys conducted in Hood Canal during the Test Pile Program (Navy, in prep.). Over the course of the surveys, the total trackline length was 259.01 kilometers. Sightings of harbor porpoises during these surveys were used to generate a density for Hood Canal. Based on guidance from other line transect surveys conducted for harbor porpoises using similar monitoring parameters (i.e., boat speed, number of observers, etc.) (Barlow 1988; Calambokidis et al. 1993; Caretta et al. 2001), the Navy determined the effective strip width for the surveys to be one kilometer, or a perpendicular distance of 500 meters from the transect to the left or right of the vessel. The effective strip width was set at the distance at which the detection probability for harbor porpoises was equivalent to one, which assumes that all individuals on a transect are detected. Only sightings occurring within the effective strip width were used in the density calculation. By multiplying the trackline length of the surveys by the effective strip width, the total area surveyed during the surveys was 259.01 sq. km. Thirty five individual harbor porpoises were sighted within this area, resulting in a density of 0.135 animals per sq.km. To account for availability bias [g(0)] or the animals which are unavailable to be detected because they are submerged, the Navy utilized a g(0) value of 0.54, derived from other similar line transect surveys (Barlow 1988; Calambokidis et al. 1993; Carretta et al. 2001). This resulted in a density of 0.250 harbor porpoises per sq. km. Exposures were calculated using the formula in Section 6.7. Table 6–16 depicts the number of acoustic harassments that are estimated from underwater vibratory and impact pile driving.

Table 6–16. Number of Potential Exposures of Harbor Porpoise within Various Acoustic Threshold Zones

Season	Density of Harbor Porpoise [1] (sq km)	Underwater	
		Injury Threshold (180 dBRMS)	Behavioral Disturbance Threshold (160 and 120 dBRMS)[2]
Mid-July – Mid-February	0.250	0	1,950

1. Density was calculated as the number of individuals observed in Test Pile Program surveys covering 259.01 sq km, corrected for detectability g(0) (Navy, in prep.).
2. Distance to the 160 dBRMS behavioral disturbance zone for impulsive noise is combined with distance to the 120 dBRMS behavioral disturbance zone for continuous noise.

Based on the density analysis above and using the most conservative criterion for disturbance (the 120 dB vibratory disturbance threshold), up to 10 individual harbor porpoises may experience sound pressure levels on a given day that would qualify as harassment. The product of n*ZOI for the injury threshold rounded to zero, so the calculated number of injury-level exposures was zero, as was the calculated level of exposures due to elevated airborne noise. The total number of exposures over the first year of pile driving activity (to be covered by the requested IHA) is calculated to be 1,950 exclusively due to behavioral harassment (Table 6–16). Harbor porpoises that are exposed to acoustic harassment could exhibit behavioral changes but are unlikely to be injured by pile driving noise. Disturbance from underwater noise impacts is not expected to be significant at the population level because it is estimated that only a small number of harbor porpoises may be affected by acoustic harassment relative to the size of the entire stock. Additionally, marine mammal observers will be monitoring the shutdown zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews to stop work if any porpoises enter or approach the shutdown zone. This will ensure that no harbor porpoises are subject to noise levels that would constitute Level A exposure.

6.8 Summary

Based on the modeling results presented above, the total number of exposures that the Navy is requesting for the six marine mammal species that may occur within the project area are presented below in Table 6–17.

No species of pinnipeds would be exposed to airborne sound pressure levels that would cause harassment.

Table 6–17. Summary of Potential Exposures for All Species during the First In-Water Pile Driving Season (July 16 to February 15)

Species	Underwater			Airborne		Total
	Injury Threshold (190 dB)	Injury Threshold (180 dB)	Behavioral Harassment Threshold (160 dB and 120 dB)[1]	Behavioral Harassment Threshold (100 dB)*	Behavioral Harassment Threshold (90 dB)*	
Steller sea lion	0	N/A	390[2]	0	N/A	**390**[2]
California sea lion	0	N/A	5,070	0	N/A	**5,070**
Harbor seal	0	N/A	10,530	N/A	0	**10,530**
Transient killer whale	N/A	0	390	N/A	N/A	**390**
Dall's porpoise	N/A	0	195[3]	N/A	N/A	**195**[2]
Harbor porpoise	N/A	0	1,950	N/A	N/A	**1,950**
Total	**0**	**0**	**18,525**	**0**	**0**	**18,525**
* Airborne harassment thresholds do not specify pile driver type.						

1. Distance to the 160 dBRMS behavioral disturbance zone for impulsive noise is combined with distance to the 120 dBRMS behavioral disturbance zone for continuous noise.
2. The number of behavioral harassment exposures calculated for Steller sea lions based on the modeling was 195. The density analysis assumes an even distribution of animals. However, in reality Steller sea lion distribution within the project area is patchy with their occurrence concentrated near Delta Pier in groups of 1-4 individuals. As a result, it is more likely that more than one exposure would occur in a day. To ensure the Navy has adequate coverage, the Navy increased the number of takes requested to 2 exposures per day of pile driving, for a total of 390 exposures in the first in-water work window.
3. The number of behavioral harassment exposures calculated for Dall's porpoise was zero. Dall's porpoises are rarely present in Hood Canal and only one was observed in 24 surveys of the waters off NBK at Bangor. Since this individual was observed in deeper offshore waters encompassed by the continuous noise behavioral harassment zone (120 dB threshold), it is possible that an animal may be exposed to behavioral harassment due to pile driving with one impact hammer and three vibratory drivers operating concurrently. Therefore, the Navy believes that harassment exposures may occur due to multiple-rig pile driving based on possible exposure of 1 Dall's porpoise per day during pile driving, for a total of 195 behavioral harassment exposures due to vibratory pile driving over the course of the first year of construction.

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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 Underwater Noise Effects

The effects of pile driving on marine mammals are dependent on several factors, including the species, size, and depth of the animal; 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. The farther away from the source, the less intense the exposure should be. 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 would also likely require less time to drive the pile, and possibly less forceful equipment, which would ultimately decrease the intensity of the acoustic source.

Impacts to marine species are expected to be the result of physiological responses to both the type and strength of the acoustic signature (Viada et al. 2008). Behavioral impacts are also expected, 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 brief acoustic effects such as behavioral disturbance, tactile perception, physical discomfort, slight injury of the internal organs and the auditory system, to death of the animal (Yelverton et al. 1973; O'Keefe and Young 1984; Ketten 1995; Navy 2001).

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, damage the cochlea, cause hemorrhage, and leakage of cerebrospinal fluid into the middle ear (Ketten 2004). Sub-lethal impacts also include hearing loss, which is caused by exposure to perceptible sounds. Moderate injury implies partial hearing loss. Permanent hearing loss (also called permanent threshold shift or PTS) can occur when the hair cells of the ear are damaged by a very loud event, as well as prolonged exposure to noise. Instances of temporary threshold shifts (TTS) 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 (TTS) 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). While injuries to other sensitive organs are possible, they are less likely since pile driving impacts are almost entirely acoustically mediated, versus explosive sounds which also include a shock wave that can result in damage.

No physiological responses are expected from pile driving operations occurring during construction of the EHW-2, for several reasons. First, vibratory pile driving, which is being utilized as the primary installation method, does not generate high enough peak sound pressure levels that are commonly associated with physiological damage. Additionally, the Navy will employ noise attenuating devices (see Section 11) that will greatly reduce the chance that a marine mammal may be exposed to sound pressure levels that could cause physical harm. Furthermore, the Navy will have trained biologists monitoring a shutdown zone equivalent to the Level A harassment zone (inclusive of the 180 dB re 1µPa (cetaceans) and 190 dB re 1µPa (pinnipeds) isopleths) to reduce the potential for injury of marine mammals.

Behavioral Responses

Behavioral responses to sound are highly variable and context specific. 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. 2003/04). 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; NRC 2003; Wartzok et al. 2003/04). 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 haul-out 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 also 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. 2003/04; 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 dBRMS 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 (CALTRANS 2001, 2006, 2010). Harbor seals were observed in the water at distances of approximately 400 to 500 meters from the pile driving activity and exhibited no alarm responses, although several showed alert reactions, and none of the seals appeared to remain in the area. 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 to 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.

Studies of marine mammal responses to continuous noise, such as vibratory pile installation, are limited. 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 & Research Corporation 2009). Most marine mammals observed during the two lengthy construction seasons were beluga whales; 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 the three project construction seasons 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 the project area during pile driving without apparent discomfort, but others may be displaced with undetermined long-term effects. Avoidance of the affected area during pile driving operations would reduce the likelihood of injury impacts but would reduce access to foraging areas in nearshore and deeper waters of Hood Canal. Noise-related disturbance across the 1.4-mile width of Hood Canal may inhibit some marine mammals from transiting the area. Given the long duration of the project (200 to 400 days of pile driving over 2 to 3 construction seasons), there is a potential for displacement of marine mammals from the affected area due to these behavioral disturbances during the in-water construction season. However, habituation over time may occur, along with a decrease in the severity of responses. Also, since pile driving would only occur during daylight hours, marine mammals transiting the project area or foraging or resting in the project area at night would not be affected. Effects of pile driving activities would be experienced by individual marine mammals, but would not cause population level impacts or affect the continued survival of the species.

7.1.2 Airborne Noise Effects

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 noise would have less impact to cetaceans than pinnipeds because noise from atmospheric sources does not transmit well through the air-water interface (Richardson et al. 1995); thus, airborne noise would primarily be an issue for pinnipeds that are swimming or hauled out in the project area. In general, pinnipeds are less sensitive to airborne sound than are most terrestrial carnivores and less sensitive to underwater sound than strictly aquatic mammals (e.g., cetaceans), within the range of best sensitivity (Kastak and Schusterman 1998). Pinnipeds' hearing represents a compromise between aerial and aquatic adaptations, but the extent of adaptation for underwater hearing varies among pinniped families. California sea lions (members of the Otariidae, or eared seal family) appear to be better adapted to in-air hearing than underwater hearing in comparison to harbor seals (members of the Phocidae, or hair seal family), which are better adapted to hearing underwater (Richardson et al. 1995; Kastak and Schusterman 1998). Within the range 100 Hz to 1.6 kHz, harbor seals hear nearly as well in air as underwater and had lower thresholds (i.e., greater sensitivity) than California sea lions (Kastak and Schusterman 1998). In air, harbor seals are most sensitive to frequencies between 6 and 16 kHz (Richardson et al. 1995; Wolski et al. 2003) but have functional hearing between 100 Hz and 30 kHz (Richardson et al. 1995; Kastak and Schusterman 1998). Thus, construction noise such as pile driving is well within the low-frequency range for this species. California sea lions are most sensitive at frequencies between 2 and 16 kHz (Schusterman 1974) and thus have functional hearing that includes lower-frequency construction noise (Kastak and Schusterman 1998).

Most likely, airborne sound would 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 in the vicinity of pile driving may avoid or withdraw from the area, or show increased alertness or alarm (e.g., head 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.

Based on these observations, marine mammals on NBK at Bangor may exhibit temporary behavioral reactions to airborne pile driving noise, but the effect would be largely limited to the unlikely situation where animals are swimming in the areas encompassed by the airborne noise thresholds (90 dB for harbor seals, 361 meters from the driven pile; and 100 dB for other pinnipeds, 114 meters from the driven pile). Pinnipeds have habituated to existing airborne noise levels at Delta Pier on NBK at Bangor, where they regularly haul out on submarines and the floating security fences. The distance between the EHW-2 project site and haul-out sites is 1 km or greater, which is beyond the airborne behavioral harassment threshold for pinnipeds that frequent the Bangor waterfront on NBK. The exposure modeling results (Section 6.7) indicate that no hauled-out pinnipeds would be exposed to airborne noise levels at sound levels that would constitute Level B behavioral harassment during either impact or vibratory pile driving (see Section 6 for modeling results). In conclusion, airborne noise may have a temporary minor effect on a few individuals, but this level of exposure is not likely to result in population level impacts.

7.1.3 Non-Pile Driving Noise Effects

Under existing conditions, the Bangor waterfront on NBK produces an environment of complex and highly variable noise that could affect marine mammals. Existing underwater noise levels primarily due to industrial activity and small vessel traffic measured along the Bangor waterfront on NBK were measured at 114 dB re 1µPa between 100 Hz and 20 kHz (Slater 2009). As discussed in Section 2.1.8, Ambient Underwater Soundscape, peak spectral noise from industrial activity was noted below the 300 Hz frequency, with maximum levels of 110 dB re 1µPa noted in the 125 Hz band. In the 300 Hz to 5 kHz range, average levels ranged between 83 and 99 dB re 1µPa. These frequencies are in the lowest portion of the functional hearing ranges of marine mammals that occur on NBK at Bangor.

During construction of the EHW-2, noise would be generated by barge-mounted equipment such as cranes and generators, but this noise would typically not exceed existing underwater noise levels resulting from existing routine waterfront operations on NBK at Bangor, including Delta Pier, Marginal Wharf, and the existing EHW facility.

During the first construction season, it is possible that pile driving for the EHW-2 would at times take place concurrently with pile driving for replacement of piles at the nearby EHW-1. At these times, underwater and airborne noise levels would increase by approximately 3 dB at locations roughly equidistant between the EHW-1 and EHW-2 pile drivers, resulting in a moderate increase in the exposure distance for marine mammals. At locations substantially closer to one driver than another, noise from the closer driver would predominate. Pile replacement at the EHW-1 is covered by a separate IHA.

Existing airborne noise levels at developed wharfs and piers on NBK at Bangor result from vehicle traffic and operation of equipment such as forklifts, generators, pumps, and cranes. Noise is estimated to range from 70 to 90 dBA and may peak at 99 dBA for short durations (Slater 2009; WSDOT 2010). Construction of the EHW-2 will increase vehicle traffic and use of construction equipment at the EHW-2 project site, with similar noise levels expected. With the exception of occasional noise peaks, most airborne construction equipment noise would be lower than MMPA threshold criteria for Level B disturbance harassment (Table 6–3), and the effects on marine mammals would be negligible.

7.2 Other Effects on Marine Mammals

Construction period effects on marine mammals may result from water quality changes, increased vessel activity and human presence in the project area, collisions with vessels, and changes in prey availability (see Section 9).

7.2.1 Water Quality

Water quality would be impacted as a result of spud use and barge anchoring and installation of piles because bottom sediments would be temporarily re-suspended. Turbidity plumes would be generated periodically in relation to the level of in-water construction activities. The quantity and settling speed of resuspended sediments reflect the composition of sediments; in general, sediments at the EHW-2 project site are coarse-grained and are more resistant to resuspension and have a higher settling speed than fine-grained sediments. Calculations of sediment dispersion distance, using worst-case current velocity and residence time of sediment particles, indicate a likely spread up to approximately 130 feet (Morris et al 2008).

Re-suspended sediments could potentially re-suspend metals and organic contaminants that may be present in marine sediments. Sediment quality sampling was conducted at the EHW-2 project site during 2007 pursuant to guidelines established by the Washington State Sediment Management Standards (SMS) (WAC 173-204) (Hammermeister and Hafner 2009). Sediments sampled included a large number of contaminants that are ubiquitous in Puget Sound, including heavy metals, polycyclic aromatic hydrocarbons, chlorinated aromatics, pesticides, PCBs, and other compounds listed under the SMS. However, their concentrations were below levels of concern as defined by the Washington State Sediment Management Standards (SMS). The marine Sediment Quality Standards (SQS) established by the SMS include numeric criteria using bulk contaminant concentrations and biological impacts criteria based on sediment bioassays that define the lower limit of sediment quality expected to cause no adverse impacts to biological resources in Puget Sound. Sediment sampling at the EHW-2 project site indicated that sediment quality at the project site is generally good; that is, levels of contaminants meet applicable state standards (Hammermeister and Hafner 2009). Thus, marine mammals exposed to resuspended sediments resulting from EHW-2 in-water construction are not likely to be impacted by contaminants.

The activities that generate suspended sediments would be short-term and localized and suspended sediments would disperse and/or settle rapidly. Moreover, marine mammals are expected to avoid the immediate construction area due to increased vessel traffic, noise and human activity, and possibly reduced prey abundance. Therefore, no direct impacts to marine mammals are expected due to water quality effects during construction.

7.2.2 Vessel Traffic

Marine mammals on NBK at Bangor encounter vessel traffic associated with daily operations, maintenance, and security monitoring along the waterfront. Vessel movements have the potential to affect marine mammals by directly striking or disturbing individuals, as evidenced by behavioral changes. For example, several studies have linked vessels with behavioral changes in killer whales in Pacific Northwest inland waters (Kruse 1991; Kriete 2002; Williams et al. 2002; Bain et al. 2006), although it is not well understood whether the presence and activity of the vessel, the vessel noise, or a combination of these factors produces the changes. The probability and significance of vessel and marine mammal interactions is dependent upon 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 haul outs 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 and Verboom 1999; Ng and 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 a vessel (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 and Kramer 2005).

During construction of the EHW-2, several additional vessels would operate in the project area, including one derrick barge and one pile barge for pile driving, and one derrick barge and two material barges for deck construction, tug boats that would move barges into position, and small supporting boats. At any given time, there would be no more than two tugs and six smaller boats, plus barges, present in the construction area. Harbor seals Steller sea lions, and California sea lions are expected to alter foraging activities along the Bangor waterfront on NBK to avoid boats but may remain in the area, as these marine mammals have become habituated to an industrial waterfront with substantial boat activity. These vessels would operate at low speeds within the relatively limited construction zone and access routes during the in-water construction period. Low speeds are expected to reduce the impact of boat movements in the construction zone during this period. Marine vessel traffic would potentially pass near marine mammals on an incidental basis, but short-term behavioral reactions to vessels are not expected to result in long-term impacts to individuals, or to marine mammal populations in Hood Canal.

7.2.3 Collisions with Vessels

Collisions of vessels and marine mammals, primarily cetaceans, are not expected during construction because vessel speeds would be low. All of the cetaceans likely to be present in the project area are fast-moving odontocete species that tend to surface at relatively short, regular intervals allowing for increased detectability and avoidance. Vessel impacts are more frequently documented in slower-moving cetaceans or those that spend extended periods of time at the surface, but these species do not occur in Hood Canal. Although boat traffic in the localized EHW-2 area will increase, once construction is completed, overall vessel traffic along the Bangor waterfront on NBK is not expected to increase above current vessel traffic.

7.3 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to sound pressure levels during pile driving operations on NBK at Bangor, which may result in Level B Behavioral harassment. Any marine mammals that are exposed (harassed) may change their normal behavior patterns (i.e., swimming speed, foraging habits, etc.) or be temporarily displaced from the area of construction. Any exposures would likely have only a minor effect on individuals and no effect on the population. The sound generated from vibratory pile driving is non-pulsed (e.g., continuous), which is not known to cause injury to marine mammals. Mitigation is likely to avoid most potential adverse underwater impacts to marine mammals from impact pile driving. Nevertheless, some level of impact is unavoidable. The expected level of unavoidable impact (defined as an acoustic or harassment exposure) is described in Sections 6 and 7. This level of effect is not anticipated to have any detectable adverse impact to population recruitment, survival, or recovery (i.e., no more than a negligible adverse effect).

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8 IMPACT 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

Historically, Pacific Northwest treaty Indian tribes were known to utilize several species of marine mammals including, but not limited to: harbor seals, Steller sea lions, northern fur seals, gray whales, and humpback whales (Norberg 2007a, personal communication). Recently, several Pacific Northwest treaty Indian tribes have promulgated[9] tribal regulations allowing tribal members to exercise treaty rights for subsistence harvest of California sea lions and harbor seals (Carretta et al. 2007b).[10] The Makah Indian Tribe (Makah) has specifically passed hunting regulations for gray whales (Norberg 2007b, personal communication). However, the directed take of marine mammals (not just gray whales) for ceremonial and/or subsistence purposes was enjoined by the Ninth Circuit Court of Appeals in a ruling against the Makah in 2002, 2003, and 2004 (Norberg 2007b, personal communication; NMFS 2008d). The issues surrounding the Makah gray whale hunt (in addition to the hunt for marine mammals in general) is currently in litigation or not yet clarified in recent court decisions (Wright 2007, personal communication). These issues also require National Environmental Policy Act and MMPA compliance, which has not yet been completed. Presently, there are no known active ceremonial and/or subsistence hunts for marine mammals in Puget Sound or the San Juan Islands.

8.2 Summary

Potential impacts resulting from the proposed action will be limited to individuals of marine mammal species located in the marine waters near NBK at Bangor and will be limited to Level B harassment. Therefore, no impacts to the availability of species or stocks for subsistence use were found.

[9] To make known by open declaration; publish; proclaim formally or put into operation (a law, decree of a court, etc.).

[10] Some coastal tribes also have regulations that allow their fishermen to protect their life, gear, and catch from seals and California sea lions by lethal means. These rare takes, which are not for subsistence or ceremonial needs, are reported annually to NMFS by each tribe (Wright 2007, personal communication).

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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.

The construction of the EHW-2 will not result in permanent impacts to habitats used directly by marine mammals, such as haul-out sites, but will affect the prey base such as forage fish and salmonids. There are no rookeries or major haul-out sites within 10 km, foraging hotspots, or other ocean bottom structure of significant biological importance to marine mammals that may be present in the marine waters in the vicinity of the project area. The main impact issue associated with the EHW-2 will be elevated noise levels and the associated direct effects on marine mammals, as discussed in Sections 6 and 7. The most likely impact to marine mammal habitat would result from pile driving effects on likely marine mammal prey (i.e., fish).

9.1 Effects on Potential Prey (Fish)

Construction would impact marine habitats used by fish. Marine habitats used by fish species that occur along the Bangor waterfront on NBK include offshore (deeper) habitat, nearshore habitats (intertidal zone and shallow subtidal zone), and other habitats, including piles used for structure and cover. The greatest impacts to prey species during construction would result from benthic habitat displacement, resuspension of sediments, and behavioral disturbance due to pile driving noise. The prey base for the most common marine mammal species (harbor seal and California sea lion) in the project area includes a wide variety of small fish such as Pacific hake, Pacific herring, and juvenile salmonids, as well as adult salmonids, when available. Steller sea lions in the project area probably consume pelagic and bottom fish. Dall’s porpoise and harbor porpoise are also occasionally seen in Hood Canal, where they probably feed on schooling forage fishes, such as Pacific herring, smelts, and squid. Transient killer whales consume marine mammals; in Hood Canal they prey on harbor seals. Southern resident killer whales do not occur in Hood Canal, but consume salmonids (with a strong preference for Chinook salmon) that originate in Hood Canal tributaries.

9.1.1 Underwater Noise Effects on Fish

The greatest impact to marine fish during construction would occur during impact pile driving because pile driving would exceed the established underwater noise thresholds for fish, for both behavior and injury. The applicable criterion for injury to fish would be 187 dBSEL for a fish greater than 2 grams in weight and 183 dBSEL for a fish less than 2 grams in weight (Fisheries Hydroacoustic Working Group 2008) (Table 9–1). No injury threshold for fish has been identified for vibratory pile driving. In addition to injury thresholds, the Fisheries Hydroacoustic Working Group (2008) established underwater noise threshold criteria for behavioral impacts to fish, including startle response, at a level of 150 dBRMS. This behavioral threshold applies to both impact and vibratory pile driving.

Table 9–1. Estimated Distances to Underwater Noise Thresholds, One Impact and Three Vibratory Pile Drivers, Peak, RMS, and SEL

Functional Hearing Group	Underwater Threshold	With Noise Attenuator Distance to Threshold (meters)
Fish ≥ 2 grams (based on 6,400 impact pile strikes)		
Injury	187 dBSEL	464 [1]
Fish < 2 grams (based on 6,400 impact pile strikes)		
Injury	183 dBSEL	464 [2]
Fish all sizes		
Injury	206 dBPEAK	4
Behavior	150 dBRMS	2,224 (continuous) 3,361 (impulsive)

1. Distances shown are limited by effective quiet; calculated distance is 546 meters.
2. Distances shown are limited by effective quiet; calculated distance is 1,009 meters.

During pile driving, the associated underwater noise levels would have the potential to cause injury and would result in behavioral response, including project area avoidance. Average underwater baseline noise levels acquired along the waterfront were measured at a level of 114 dB re 1µPa (Slater 2009). Sound during impact pile driving would be detected above the average background noise levels at any nearby location in Hood Canal with a direct acoustic path (e.g., line-of-sight from the driven pile to the receiver location). To reduce the underwater noise levels and associated impacts to underwater organisms during active impact pile driving, a bubble curtain or other noise attenuating device would be deployed that should reduce sound levels by 10 dB. To further minimize the underwater noise impacts during pile driving, vibratory pile drivers would be used to the maximum extent practicable for structural integrity to drive piles; an impact hammer would be primarily used to proof load the piles to verify load bearing capacity, and not as the primary means to drive piles.

For the concurrent operation of one impact and three vibratory pile drivers averaging 6,400 daily strikes, a fish less than 2 grams could be injured by noise levels from pile driving if it occurred within 464 meters (1,522 feet) (Table 9–1). Any fish greater than 2 grams could also be injured by noise levels from pile driving if it occurred within 464 meters (1,522 feet) under a 6,400 daily strike scenario (Table 9–1). The reason for identical distances for different sound exposure level (SEL) thresholds is that the NMFS SEL model methodology includes a factor that adjusts the maximum affected area to exclude single strike values less than 150 dBSEL re 1 µPa^2-sec, which are assumed to not accumulate to cause injury (WSDOT 2009). This factor (“effective quiet”) has the effect of fixing the maximum distance at which injury is expected to occur, regardless of the number of hammer strikes used in the model calculation. For these assumed conditions, both 187 and 183 dBSEL re 1 µPa^2-sec threshold values will be limited to 464 meters (1,522 feet) for 6,400 pile strikes.

Behavioral disturbance of fish of all sizes was evaluated at the 150 dBRMS re 1µPa threshold for multiple pile driver scenarios where all sound sources were treated as continuous in nature, and where all sound sources were treated as impulsive in nature. The distance out to the behavioral disturbance threshold was greatest when all sound sources were treated as impulsive sounds. Under this scenario, the threshold would be exceeded within a circle centered at the location of the driven pile out to a distance of approximately 3,361 meters (11,024 feet) (in a direct line-of-sight) (Table 9–1).

Fish in the 150 dB range may display a startle response during initial stages of pile driving, and would likely avoid the immediate project vicinity during construction activities, including pile driving. However, field observation investigations of Puget Sound salmonid behavior, when occurring near pile driving projects (Feist 1991; Feist et al. 1992), found little evidence that normally nearshore migrating salmonids move farther offshore to avoid the general project area. In fact, some studies indicate that construction site behavioral responses, including site avoidance, may be as strongly tied to visual stimuli as to underwater sound (Feist 1991; Feist et al. 1992; Ruggerone et al. 2008). Therefore, it could be assumed that salmonids, and likely other species, may alter their normal behavior, including startle response and avoidance of the immediate project site, but occurrence within most of the 2,224-meter (7,297-foot, continuous noise source) to 3,361-meter (11,024-foot, impulsive noise source) disturbance areas would not change.

Thus, prey availability for wildlife predators within an undetermined portion of the construction impact zone for fish would be reduced. These impacts would occur over each of 7 months of in-water construction during the 3-year construction period. The duration of fish avoidance of this area after pile driving stops is unknown, but a rapid return to normal recruitment, distribution, and behavior is anticipated. Any behavioral avoidance by fish of the disturbed area would still leave significantly large areas of fish and marine mammal foraging habitat in Hood Canal and the nearby vicinity. Some adverse effects on individual marine mammals are possible with construction of the EHW-2, but this does not rise to the level of MMPA take.

9.1.2 Effects on Fish Habitats/Abundance

Construction of the EHW-2 would adversely affect some of the habitat conditions (NMFS 1999) for salmonids and forage fish in the project area. Positioning and anchoring the construction barges and driving piles would locally increase turbidity, disturb benthic habitats, disturb forage fish, and shade marine vegetation in the immediate project vicinity. Construction would bury benthic organisms with limited mobility under sediment. Increased turbidity would make it difficult for predators to locate prey. All of these actions would indirectly affect marine mammals by degrading foraging and refuge habitat quality for prey species and reducing their invertebrate and forage fish prey base. In addition to impacts to the biological productivity of benthic organisms, construction would reduce the extent and degrade the quality of marine vegetation, adversely affecting availability of marine fish prey populations for marine mammals. Construction impacts to benthic habitats reflect the size of the construction zone. Construction of the EHW-2 is expected to displace or disturb 25.7 acres of benthic habitat, including 0.92 acre of marine vegetation (primarily eelgrass beds and algae, but also a small portion of kelp beds). Some of these effects described above, such as barge placement and increased turbidity, would occur only during the in-water construction period and thus would be temporary.

Construction impacts to salmonid populations, which includes ESA-listed species, would be minimized by adhering to the in-water work period designated for northern Hood Canal waters, when less than 5 percent of all salmonids that occur in NBK at Bangor nearshore waters are expected to be present (SAIC 2006; Bhuthimethee et al. 2009). Some habitat degradation is expected during construction, but the impacts to salmonids and forage fish would be temporary and localized.

Long-term operation of the EHW-2 would adversely affect a number of habitat conditions for forage fish primarily in nearshore waters. Decreased habitat value for forage fish, salmonids, other finfish, and, to a lesser extent, shellfish, would result in localized minor long-term impacts to marine mammal prey availability. The increased surface area of overwater structures (6.3 acres) would reduce biological productivity overall through shading and reduction in the size of eelgrass beds and other marine vegetation (approximately 0.13 acre), and impact the prey base (benthic organisms, ground fish, and pelagic fish) in the intertidal, subtidal, and nearshore deeper water zones. In addition, the EHW-2 will inhibit movement of shoreline-dependent fishes such as juvenile salmonids and forage fishes. Increased lighting at the EHW-2 may affect prey availability, depending on the species, for marine mammals. Some fish may be attracted by artificial lighting, which may in turn attract predators, including marine mammals, and facilitate their feeding. Overall, a localized change to the prey base in terms of abundance and species composition for some marine mammals is expected. Section 11.2 describes the marine habitat mitigation action that the Navy would undertake as part of the proposed action. This habitat mitigation action, including mitigation for eelgrass, would compensate for the impacts of the proposed action to marine habitat and species.

Adverse impacts of the EHW-2 would be limited to the small area including and adjacent to the trestle and wharf (approximately 6.3 acres). In the context of the Hood Canal marine mammal populations overall, the affected area is too small to constitute an adverse impact. Thus, no additional MMPA take is expected with operation of the EHW-2. Moreover, the numbers of marine mammals affected by impacts to prey populations would be small; therefore, the impact would be insignificant in the context of marine mammal populations.

The project has the potential to affect the southern resident killer whale population, which does not occur in the project area, by indirectly affecting its prey base. The diet of southern resident killer whales includes a disproportionate number of adult Chinook (Ford et al. 1998; Ford et al. 2010; Hanson et al. 2010). Available information on the proportion of Hood Canal Chinook salmon in the diet of southern resident killer whales indicates that it is about 20.4 percent in May (however, this is based on a sample size of 9), but less than 5 percent in other months (June to September) for which data are available. Adult Hood Canal Chinook salmon returns are subject to many variables, among which the effects of the EHW-2 are likely to be minor. Mitigation efforts, including scheduling in-water construction for the period when juvenile Chinook salmon are least abundant, and using a bubble curtain or other noise attenuating device for impact pile driving, would minimize this potential adverse effect. Therefore, the project's effect on the southern resident killer whale prey base would be insignificant, and not likely to adversely affect the population.

9.2 Effect on Haul-out Sites

No effects are expected on existing haul-out sites. California sea lions, Steller sea lions, and harbor seals use various manmade structures on NBK at Bangor for hauling out, but cannot use the existing EHW, nor would they be able to use the new wharf and trestles as haul-out sites, as the decks of these structures would be approximately 13 feet above MHHW. The shoreline abutment would be a vertical structure 10 feet high and would not be accessible for hauling out. Armor rock placed at the base of the abutment could potentially be accessible to marine mammals. However, since the shoreline in the project area is not used for hauling out by any pinniped species under existing conditions, it is unlikely that pinnipeds would haul out in the vicinity of the EHW-2 in the future.

9.3 Likelihood of Habitat Restoration

Compensatory mitigation measures would be implemented to restore marine fish habitats, and by extension to restore marine mammal prey base. These measures are described in Section 11.2

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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 populations involved.

Construction and operation of the EHW-2 will affect marine mammal habitats indirectly through impacts to prey abundance and availability. The most important impacts to marine mammal fish species consumed by marine mammals will result from injury and behavioral disturbance to fish species during pile driving. Fish may avoid an undetermined portion of the affected area, defined by the injury and behavioral disturbance thresholds in Table 9–1, during the in-water work season. Post-construction, the EHW-2 will adversely affect prey availability and abundance by creating a barrier to nearshore migration, shading the benthic habitat, and eliminating eelgrass beds. These adverse effects will be compensated by mitigation actions described in Section 11. The numbers of marine mammals affected by impacts to prey populations would be small; therefore, the impact would be minor in the context of marine mammal populations.

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11 MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

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 exposures outlined in Section 6 represent the maximum expected number of marine mammals that could be exposed to acoustic sources reaching Level B harassment levels. The Navy proposes to employ a number of mitigation measures, discussed below, in an effort to minimize the number of marine mammals potentially affected.

11.1 Mitigation for Pile Driving Activities

The modeling results for ZOIs discussed in Section 6 were used to develop mitigation measures for pile driving activities on NBK at Bangor. The ZOIs effectively represent the monitoring zone that would be established around each pile to prevent Level A harassment to marine mammals. While the ZOIs vary between the different diameter piles and types of installation methods, the Navy is proposing to establish mitigation zones for the maximum zone of influence for all pile driving conducted during construction of the EHW-2.

1. *Shutdown and Buffer Zone (Impact and Vibratory pile driving/removal):*
   - During impact pile driving/removal the shutdown zone shall include all areas where the underwater SPLs are anticipated to equal the Level A (injury) harassment criteria for marine mammals (180 dB isopleths for cetaceans; 190 dB isopleths for pinnipeds). For pinnipeds the shutdown distance will be 10 meters[11] from the pile and for cetaceans the shutdown distance will be 25 meters[12] from the pile.
   - During vibratory pile driving/removal involving multiple pile driving rigs, the shutdown zone shall include all areas where the underwater SPLs are anticipated to equal the Level A (injury) harassment criteria for marine mammals (180 dB isopleths for cetaceans; 190 dB isopleths for pinnipeds). For pinnipeds the shutdown distance will be 10 meters[13] from the pile and for cetaceans the shutdown distance will also be 10 meters[14] from the pile.
   - All shutdown zones will initially be based on the distances from the source which were predicted for each threshold level. However, in-situ acoustic monitoring will be utilized to determine the actual distances to these threshold zones, and the size of the shutdown

[11] The modeled injury threshold distance for pinnipeds for one impact pile driver is approximately 5 meters, but the Navy has rounded this distance up to 10 meters to be consistent with the shutdown zone for in-water non-pile driving activities.
[12] The modeled injury threshold distance for cetaceans for one impact pile driver is approximately 22 meters, but the Navy has rounded this distance up to 25 meters.
[13] The actual modeled injury threshold distance for pinnipeds for three vibratory pile drivers is approximately 2.3 meters, but the Navy has rounded this distance up to 10 meters to be consistent with the shutdown zone for in-water non-pile driving activities.
[14] The modeled injury threshold distance for cetaceans for three vibratory pile drivers is 10 meters.

zones will be adjusted accordingly (increased or decreased) based on received sound pressure levels.

- During impact pile driving/removal the buffer zone shall include all areas where the underwater or airborne SPLs are anticipated to equal or exceed the Level B (disturbance) harassment criteria for marine mammals during impact pile driving (160 dB isopleth). For pinnipeds and cetaceans the buffer zone would be approximately 464 meters and would be encompassed by the area inside the WRA fence line in the immediate vicinity of the EHW-2 footprint.
- During vibratory pile driving, the Level B (disturbance) harassment criterion (120 dB isopleth) predicts an affected area of 41.4 sq km (16 sq mi). The size of this area would make effective monitoring impractical. As a result, a buffer zone of 464 meters, equivalent to the size of the predicted 160 dB isopleth, will be monitored for pinnipeds and cetaceans during all vibratory pile driving/removal activities
- The shutdown and buffer zones will be monitored throughout the time required to drive a pile. If a marine mammal enters the buffer zone, an exposure would be recorded and behaviors documented. However, the pile segment would be completed without cessation, unless the animal approaches or enters the shutdown zone, at which point, all pile driving activities will immediately be halted.
- Under certain construction circumstances where initiating the shutdown and clearance procedures (which could include a delay of 15 min or more) would result in an imminent concern for human safety the shutdown provision may be waived. The Navy is working with NMFS HQ to clarify situations or criteria in which such as scenario may occur.

2. *Shutdown Zone (In-water construction activities not involving a pile driving hammer)*

- During in-water construction activities not involving a pile driver, but having the potential to affect marine mammals, in order to prevent injury to these species from their physical interaction with construction equipment, a shutdown zone of 10 meters (33 feet) will be monitored to ensure that marine mammals are not present in this zone.
- These activities could include, but are not limited to: (1) the movement of the barge to the pile location, (2) the positioning of the pile on the substrate via a crane (i.e., “stabbing” the pile), (3) the removal of the pile from the water column/substrate via a crane (i.e. “deadpull”), or (4) the placement of sound attenuation devices around the piles.

3. *Visual Monitoring:*

A marine mammal monitoring plan will be finalized prior to commencement of pile driving activities; however, at a minimum it will include the following:

- Monitoring will be conducted by qualified, trained marine mammal observers (hereafter, “observer”). An observer is a biologist with prior training and experience in conducting at-sea 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, 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.

- Prior to the start of pile driving/removal activity, the shutdown zones will be monitored for 15 minutes to ensure that they are clear of marine mammals. Pile driving will only commence once observers have declared the shutdown zone clear of marine mammals. The behavior of animals that remain in the buffer zone will be monitored and documented to the extent practicable.
- During impact and vibratory pile driving/removal, monitoring will be conducted before, during, and after pile driving activities. Monitoring will take place from 15 minutes prior to initiation through 30 minutes post-completion of pile driving activities. Pile driving activities include the time to install or remove a single pile, or series of piles, as long as the time elapsed between uses of the pile driver is no more than 30 minutes.
- During in-water construction activities that do not involve a pile driving hammer, as defined above in Section 11.1.2, monitoring will be conducted within the shutdown zone to preclude injury from their physical interactions with construction equipment. Monitoring will take place from 15 minutes prior to initiation until the action is complete.
- If a marine mammal approaches/enters the shutdown zone during the course of pile driving/removal operations, or other in-water construction activities not involving a pile hammer, the action will be halted and delayed until either the animal has voluntarily left and been visually confirmed beyond the shutdown zone or 15 minutes have passed without detection of the animal.

3. *Noise Attenuating Devices:* Noise attenuating devices (e.g., bubble curtain) will be utilized during all impact pile driving operations.
4. *Acoustic Measurements:* Acoustic measurements will be used to empirically verify the proposed shutdown zones and the soft-start procedures. For further detail regarding the acoustic monitoring plan see Section 13.
5. *Timing Restrictions:* To minimize the number of fish exposed to underwater noise and other disturbance, in-water work would only be conducted during the in-water work window (from July 16 through February 15) for Puget Sound Marine Area 13 as outlined in WAC-220-110-271 and USACE (2010), when juvenile ESA-listed salmonids are least likely to be present. The initial months (July to September) of the timing window overlap with times when Steller sea lions are not expected to be present within the study area.
6. *Soft Start:* The use of a soft-start procedure is believed to provide additional protection to marine mammals by providing a warning and/or giving marine mammals a chance to leave the area prior to the hammer operating at full capacity. Soft-start techniques for impact and vibratory pile driving will be used, as follows[15]:

[15] The sequence of the soft-start procedures includes a minor deviation from those typically requested by the NMFS which utilize a longer waiting period (one minute vs. 30 seconds). The Navy requested to change the waiting period because observational data during the Test Pile Program and EHW-1 repairs indicated a one minute wait period may be too long. Longer breaks between the sounds may be interpreted by the animals as a transient sound, and may not serve the intended purpose to provide an indication that louder sounds are about to begin. The Navy consulted with NMFS regarding using a shorter waiting period (i.e. 30 seconds) and the Service found the Navy's reasoning to be valid and accepted the requested modification.

"The soft-start requires contractors to initiate noise from vibratory hammers for 15 seconds at reduced energy followed by a 30-second waiting period. This procedure should be repeated two additional times. If an impact hammer is used, contractors are required to provide an initial set of three strikes form the impact hammer at 40 percent energy, followed by a 30-second waiting period, then two subsequent 3-strike sets."

7. *Daylight Construction:* Impact pile driving during the first half of the in-water work window (July 16 to September 15) would only occur between 2 hours after sunrise and 2 hours before sunset to protect breeding marbled murrelets. Vibratory pile driving and other construction activities occurring in the water between July 16 and September 15 could occur during daylight hours (sunrise to sunset). Between September 16 and February 15, construction activities occurring in the water would occur during daylight hours (sunrise to sunset[16]). Other construction would occur between 7:00 AM and 10:00 PM 6 days per week, but could occur 7 days per week.

11.2 Habitat Mitigation

In addition to mitigation measures described in Section 11.1, the following compensatory mitigation measures would be implemented to restore marine fish habitats, and by extension to indirectly benefit marine mammals in the project area:

11.2.1 Compensatory Mitigation

Compensatory Mitigation is the term given to projects or plans undertaken to offset "unavoidable adverse environmental impacts which remain after all appropriate and practicable avoidance and minimization has been achieved." Compensatory Mitigation involves actions taken to offset unavoidable adverse impacts to wetlands, streams, and other aquatic resources. For impacts authorized under a Section 404 permit, Compensatory Mitigation is not considered until after all appropriate and practicable steps have been taken to first avoid and then minimize adverse impacts to the aquatic ecosystem pursuant to 40 CFR part 230 (i.e., the Clean Water Act Section 404(b)(1) Guidelines). Compensatory Mitigation is required for permits authorized by the Clean Water Act Section 404 and other Department of the Army permits.

The Compensatory Mitigation Rule establishes a hierarchy for Compensatory Mitigation:

- Mitigation Banks
- In-Lieu Fee (ILF) Programs
- Permittee-Responsible Mitigation

A preference for mitigation banks is established at present. However, there are no established mitigation banks or ILF programs for Kitsap County or the Hood Canal. Therefore, the Navy's preference for providing mitigation and complying with the Compensatory Mitigation Rule is through the development of an ILF Program. The goal of the ILF Program is to ensure no net loss of nearshore aquatic resource functions by in-kind mitigation within Kitsap County and/or

[16] Sunrise and sunset are to be determined based on the National Oceanic and Atmospheric Administration data which can be found at http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html.

Hood Canal. The Navy would partner with a qualified ILF sponsor that would be responsible for preparing all documentation associated with establishment of the program, including a prospectus, a credit/debit calculation tool or instrument, mitigation plans, and other appropriate documents. The ILF sponsor would be responsible for performing all of the required functions of the program including fiscal management; agreement(s) with entities that will purchase and hold mitigation sites in conservation status in perpetuity; reporting; and contracting for the design, construction, and monitoring for specific mitigation projects.

The Navy anticipates that the Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework could provide an assessment tool to identify and prioritize mitigation sites. As the ILF program is developed for Kitsap County and/or Hood Canal, a more detailed credit/debit calculation tool or instrument would be developed. This information would be developed and reviewed in conjunction with the development of the ILF program. Mitigation can include protection, restoration, enhancement, and/or creation. The mitigation strategy selected will be based on an assessment of type and degree of disturbance at the landscape, drift cell, and nearshore assessment unit (NAU) scales.

Priority will be given to mitigation strategies that augment regional and local watershed plans and goals. Such strategies include, but are not limited to, protection and restoration of critical resource areas through acquisition or conservation easements, reconnecting pocket estuaries to tidal fluxes, shoreline rehabilitation, removal of fish migration barriers, stream restoration, and reforestation of watersheds and marine/freshwater riparian zones.

11.2.2 Alternative Mitigation Strategies

In the event that an ILF program is not established in Kitsap County in time for use as mitigation for the proposed action, other mitigation options will be considered. As an alternative to pursuing the development of an ILF program for Kitsap County/and or Hood Canal, the Navy is currently assessing nearshore permittee responsible mitigation opportunities within the Hood Canal and Puget Sound with state and local agencies and tribes. The Navy would identify appropriate in-kind mitigation sufficient in size to ensure no net-loss of aquatic resource functions. Strategies to effect no net loss could include a combination of restoration, enhancement, creation, and preservation of nearshore habitats. Potential nearshore mitigation sites will take into consideration state and local watershed management plans, property ownership, tribal usual and accustomed areas, likelihood of success, ability to address multiple functions and services both among and within aquatic habitat types, and the ability to affect or improve regional aquatic resource conservation initiatives. As with the proposed development of an ILF program, these potential permittee-responsible mitigation projects would also be reviewed in accordance with the Compensatory Mitigation Rule and would be submitted for review and approval as part of the application process. In the event that the Navy selects a permittee-responsible mitigation as the Compensatory Mitigation strategy, a mitigation plan would be submitted to the U.S. Army Corps of Engineers.

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12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

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 an/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(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.

Subsistence use is the traditional exploitation of marine mammals by native peoples for their own consumption. Based on the discussions in Section 8, there are no adverse effects on the availability of species or stocks for subsistence use.

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13 MONITORING AND REPORTING MEASURES

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 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 would 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 Monitoring Plan

The following monitoring measures would be implemented along with the mitigation measures (Section 11) in order to reduce impacts to marine mammals to the lowest extent practicable. The marine mammal monitoring plan would be developed further and submitted to NMFS for approval prior to the start of construction. The monitoring plan includes the following components: acoustic measurements and visual observations.

13.1.1 Acoustic Measurements

The Navy will conduct acoustic measurements within the first 30 days of pile driving or until, a representative acoustic sample of the major pile driving scenarios under the modeled conditions (1. impact hammer and vibratory driving [operating concurrently in various combinations]; 2. smaller [24-inch to 36-inch] and larger [48-inch] piles; 3. plumb and batter piles; 4. Pile driving occurring in different depth regimes) is captured. The Navy is working with NMFS HQ to determine an appropriate number of piles to record for each scenario. Some pile removal is expected to occur to remove temporary falsework piles; this has been accounted for in the analysis. All measurements will be made with the noise attenuation measures discussed previously in place. As with the Test Pile Program, these noise measurements will determine the actual distances to the following isopleths: 190 dB re 1μPa RMS, 180 dB re 1μPa RMS, and 160 dB re 1μPa RMS. The Navy will also conduct underwater acoustic monitoring for vibratory pile driving to determine the actual distance to the 120 dB re 1μPa RMS isopleth for marine mammal behavioral harassment relative to background levels. Maximum sound pressure levels will also be documented. Airborne noise monitoring will be conducted during impact and vibratory pile driving to identify the actual distance to the 90 dB re 20μPa RMS, and 100 dB re 20μPa RMS airborne isopleths.

At a minimum, the methodology will include:

- For underwater recordings, a stationary hydrophone system with the ability to measure sound pressure levels at mid-water depth and approximately 1 meter from the bottom, (taking tidal changes into account) will be placed at a distance of 10 meters from the source. The hydrophone will be deployed so as to maintain a constant distance of 10 meters from the pile.
- For airborne recordings, reference recordings will be attempted at approximately 50 feet (15.2 meters) from the source via a stationary hydrophone. However, other distances may be utilized to obtain better data if the pile driving signal cannot be isolated clearly due to other sound sources (i.e., barges or generators).

- Each hydrophone (underwater) and microphone (airborne) will be calibrated prior to the start of the action and will be checked at the beginning of each day of monitoring activity. Other hydrophones and microphones will be placed at other distances and/or depths and moved as necessary to determine the distance to the thresholds for marine mammals (these include peak, RMS, and SEL for underwater noise, and unweighted for airborne noise).
- Unweighted ambient conditions, both airborne and underwater, will be measured and recorded for 30 to 60 seconds each hour, every day for one week during the first 30 days of the construction period to determine background noise levels. These measurements are intended to capture ambient background noise during the timeframe of construction, but in the absence of pile driving noise. Ambient noise recordings will be edited for anomalous data to provide the best possible baseline condition for background noise. Recording will be made in the 10 Hz to 20 kHz range.
- Airborne levels would be recorded as an unweighted time series. The distance to marine mammal airborne noise disturbance thresholds (90 dB re 20 μPa RMS for harbor seals, 100 dB re μPa RMS for other pinnipeds) will be determined.
- Sound levels associated with the soft-start techniques (on a representative subset of piles) will also be measured.
- Environmental data will be collected, such as wind speed and direction, wave height, precipitation, presence and location of other vessels, and types and locations of in-water construction activities, as well as other factors that could contribute to influencing the airborne and underwater sound levels (e.g., aircraft, boats, etc.).
- The construction contractor will supply the Navy and other relevant monitoring personnel the substrate composition, hammer model and size, hammer energy settings and any changes to those settings during hammering of the piles being monitored, depth of the pile being driven, and blows per foot for the piles monitored.
- For acoustically monitored piles, post-analysis of underwater sound level signals will include the average RMS value across all pile strikes per pile, the rise time, average duration of each pile strike, and number of strikes per pile, as well as a frequency spectrum with mitigation, between 10 and 20,000 Hz, for up to eight successive strikes with similar sound levels. RMS analyses will be completed for vibratory driving, including presentation of representative frequency spectra.
- For acoustically monitored piles, post–analysis of airborne noise will be presented in an unweighted format, and will include presentation of the average RMS value across all pile strikes per pile, and the average RMS value for vibratory driving. Frequency spectra will be provided from 10 to 20,000 Hz for up to eight successive strikes with similar sound levels, and will also be provided for representative vibratory driving.

13.1.2 Visual Marine Mammal Observations

The Navy will collect sighting data and behavioral responses to construction for marine mammal species observed in the region of activity during the period of construction. All observers will be experienced biologists trained in marine mammal identification and behaviors, as described in

Section 11.1.3, *Visual Monitoring*. NMFS requires that the observers have no other construction-related tasks while conducting monitoring.

13.1.3 Methods of Monitoring

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

- MMOs would be located at the best vantage point(s) in order to properly see the entire shutdown zone. This may require the use of a small boat to monitor certain areas while also monitoring from one or more land based vantage points. At least one MMO would be assigned to monitor the shutdown zone around each pile driving rig while it is in active use for pile installation or removal.
- During all observation periods, observers would use binoculars and the naked eye to search continuously for marine mammals.
- If a shutdown zone is obscured by fog or poor lighting conditions, pile driving at that location would not be initiated until that shutdown zone is visible.
- The shutdown and buffer zone around the pile will be monitored for the presence of marine mammals before, during, and after any pile driving activity.
- Pre-Activity Monitoring: The shutdown zone will be monitored for 15 minutes prior to initiating the soft start for pile driving or other in-water construction activities not involving pile driving (i.e. pile “stabbing, “dead pull”). If marine mammal(s) are present within the shutdown zone prior to the soft-start or in-water construction activities, the start of the action would be delayed until the animal(s) leave the shutdown zone. Pile driving or other in-water construction activities would resume only after the MMO has determined, through visual observation or by waiting approximately 15 minutes that the animal has moved outside the shutdown zone.
- During Activity Monitoring: The shutdown zone will also be monitored throughout the time required to drive/remove a pile or complete other in-water construction activities. If a marine mammal is observed outside of this zone, an exposure would be recorded and behaviors documented, to the extent practicable. However, that pile segment or other in-water construction activity would be completed without cessation, unless the animal approaches/enters the shutdown zone, at which point all pile driving or other in-water construction activities will be halted. However, the shutdown provision may be waived in situations where shutdown would create an imminent concern for human safety (see Section 11.1). Pile driving or other in-water construction activities may only resume once the animal has left the shutdown zone of its own volition or has not been re-sighted for a period of 15 minutes.
- Post-Activity Monitoring: Monitoring of the shutdown zone would continue for 30 minutes following the completion of pile driving.
- The individuals that implement the monitoring protocol will assess its effectiveness using an adaptive approach. Monitoring biologists will use their best professional judgment throughout implementation and will seek improvements to these methods when deemed

appropriate. Any modifications to protocol will be coordinated between the U.S. Navy and NMFS.

13.1.4 Data Collection

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

- Date and time that pile driving begins or ends;
- Construction activities occurring during each observation period;
- Weather parameters identified in the acoustic monitoring (e.g., percent 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 driving activities to marine mammals and distance from the marine mammal to the observation point;
- Locations of all marine mammal observations; and
- Other human activity in the area.

13.2 Reporting

A draft report would be submitted to NMFS within 60 days of the completion of the first 30 days of pile driving monitoring for the EHW-2. Results will include acoustic measurements and marine mammal monitoring summarized in graphical form and include summary statistics and time histories of impact sound values for each pile. The report will also provide descriptions of any problems encountered in deploying noise attenuating devices, any adverse responses to construction activities by marine mammals, and actions taken to solve these problems. A final report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS.

Within 60 days of the end of the in-water work period, a draft comprehensive report on all marine mammal monitoring conducted under the incidental harassment authorization would be submitted to NMFS. The report will include marine mammal observations pre-activity, during-activity, and post-activity during pile driving days. A final report will be prepared and submitted to NMFS within 30 days following receipt of comments on the draft report from NMFS.

At a minimum, the monitoring reports will include:

- General data:
  - Date and time of activity
  - Water conditions (e.g., sea-state, tidal state)
  - Weather conditions (e.g., percent cover, visibility)
  - Physical characteristics of the bottom substrate into which the piles are driven
- Specific pile driving data:

- Description of the pile driving activity being conducted (size and type)
- Detailed description of the noise attenuating device, including design specifications
- Impact or vibratory hammer force used to drive/extract the piles
- Description of the monitoring equipment
- Distance between hydrophone(s) and pile
- Depth of the hydrophone(s)
- Depth of water in which the pile was driven for acoustically monitored piles.
- Depth into the substrate that the pile was driven for acoustically monitored piles.
- Ranges and means for peak, RMS, and SELs for acoustically monitored piles
- Results of the acoustic measurements, including the frequency spectrum, peak and RMS SPLs, and single-strike and cumulative SEL with and without the attenuation system for acoustically monitored piles.
- Results of the airborne noise measurements (unweighted levels) for acoustically monitored piles.

➢ Pre-activity observational survey-specific data:

- Dates and time survey is initiated and terminated
- Description of any observable marine mammal or fish behavior in the immediate area during monitoring
- If possible, the correlation to underwater sound levels occurring at the time of this observable behavior
- Actions performed to minimize impacts to marbled murrelets or marine mammals

➢ During-activity observational survey-specific data:

- Description of any observable marine mammal or fish behavior within monitoring zones or in the immediate area surrounding monitoring zones
- If possible, the correlation to underwater or airborne sound levels occurring at the time of this observable behavior
- Actions performed to minimize impacts to marine mammals or marbled murrelets
- Times when pile driving is stopped due to presence of marine mammals or marbled murrelets within 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 distances, behavioral reactions within and outside of shutdown zones, to the extent possible.
- A refined exposure estimate based on the number of marine mammals observed during the course of construction.

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14 RESEARCH

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

To minimize the likelihood that impacts will occur to the species, stocks, and subsistence use of marine mammals, all construction activities will be conducted in accordance with all federal, state, and local regulations and minimization measures proposed by the Navy will be implemented to protect marine mammals. The Navy will coordinate all activities with the relevant federal and state agencies. These include but are not limited to: the NMFS, USFWS, U.S. Coast Guard, Federal Energy Regulatory Commission, U.S. Army Corps of Engineers, and WDFW. The Navy will share field data and behavioral observations on all marine mammals that occur in the project area. Draft results of each monitoring effort will be provided to NMFS in summary reports within 60 days of the conclusion of monitoring. This information could be made available to regional, state, and federal resource agencies, scientists, professors, and other interested private parties upon written request to NMFS.

Additionally, the Navy provides a significant amount of funding and support for marine research. The Navy provided $26 million in Fiscal Year 2008 and $22 million in Fiscal Year 2009 to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. Over the past 5 years the Navy has funded over $100 million in marine mammal research, with several projects ongoing in Washington.

The Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Gaining a better understanding of marine species distribution and important habitat areas,
- Developing methods to detect and monitor marine species before and during training,
- Understanding the effects of sound on marine mammals, and
- Developing tools to model and estimate potential effects of sound.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods in Navy activities. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential monitoring tool. 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 future research as described previously.

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APPENDIX

NOISE ANALYSIS APPROACH

NOISE ANALYSIS APPROACH

This appendix describes the methods for estimating underwater and airborne noise levels generated by pile driving. Subsequent sections describe the effects of these noise levels on the species of interest.

ESTIMATED UNDERWATER NOISE LEVELS

Underwater noise will be generated by pile driving, vessel and boat traffic, and construction equipment. The greatest sound levels will be produced by impact driving large (48 inches in diameter or smaller) hollow steel piles, which could generate peak sound levels of approximately 200 dBPEAK re 1µPa and average RMS levels of approximately 185 dBRMS re 1µPa at a distance of 10 meters while using a bubble curtain or other noise attenuating device that will reduce noise levels by 10 dB. RMS calculations used for acoustic analyses are computed as 20 times $\log_{10}$ of the square-root of the sum of squared pressures over the noise event in question, referred to the standard reference pressure of 1µPa. Vibratory pile driving, which will be used predominantly, will produce lower noise levels, approximately 180 dBRMS re 1µPa at 10 meters. Underwater noise levels from pile driving will exceed the threshold limits for effects on marine mammals, fish, and diving birds such as marbled murrelets. There will be no increase in underwater noise from operation of the EHW-2.

Construction of the EHW-2 will result in increased underwater noise levels in Hood Canal, due primarily to the installation of piles. Some noise will be generated by construction support vessels, small boat traffic, and barge-mounted equipment such as cranes and generators, but this noise will typically not exceed existing underwater noise levels resulting from routine waterfront operations in the vicinity of the construction site, encompassing Delta Pier, Marginal Wharf, and the existing EHW facility. Several non-pile driving construction activities will also occur at the project area. Among them are the installation of cast-in-place concrete pile caps, concrete wharf deck, operations support building, cranes, power utility booms, lightning protection towers, and camels. While no empirical data exist for these construction activities, they will occur on the tops of the piles or attached to the wharf's deck, and are expected to produce noise levels significantly lower than those estimated for pile installation using an impact/vibratory pile driver. It is possible that sound could be transmitted from these activities along the piles' length and enter the water. However, underwater acoustic impacts from these construction operations are expected to be minimal.

During the first construction season, it is possible that pile driving for the EHW-2 would at times take place concurrently with pile driving for the replacement of piles at the nearby EHW-1. At these times, underwater and airborne noise levels would increase by approximately 3 dB at locations roughly equidistant between the EHW-1 and EHW-2 pile drivers, resulting in a moderate increase in the exposure distance for marine mammals. At locations substantially closer to one driver than another, noise from the closer driver would predominate. Pile replacement activities at the EHW-1 are covered by a separate IHA.

The greatest underwater noise will be created while driving piles using an impact hammer. An impact hammer will be used to "proof" every fourth to fifth driven pile to ensure it provides adequate load bearing capacity. The majority of the pile driving, however, will use vibratory methods. In some cases where difficult geological conditions are encountered, it may be necessary to use an impact hammer to drive certain piles for part or all of their required depth. It is assumed that on most days, a single impact hammer would be used to proof up to five piles, with each pile requiring a maximum of 200 strikes. This likely scenario would require up to 1,000 impact strikes per day (1,000 daily strike scenario). A less likely but possible scenario assumes driving three piles full length (2,000 strikes per pile) and proofing an additional two piles at 200 strikes each with an impact hammer. This scenario would result in up to 6,400 impact strikes per day (6,400 daily strike scenario). Construction will typically occur 6 days per week, but could occur 7 days per week. Impact pile driving during the first half of the in-water work window (July 16 to September 15) will only occur between 2 hours after sunrise to 2 hours before sunset to protect breeding murrelets. Between September 16 and February 15, pile driving can occur during daylight hours. The number of in-water pile driving days will be between 200 and 400 for the preferred alternative.

Up to three vibratory driving rigs could be used concurrently, but only one impact hammer rig will operate at a time or in conjunction with multiple vibratory rigs.

Several measures will be used to minimize the noise generated by pile driving. A soft-start approach (noise attenuator), in which hammer energy levels are increased from low to high, will be used for both pile driving methods to allow time for fish, birds, and mammals to move away from the pile driving site before the highest noise levels are produced. Soft starts for vibratory drivers require initial starts of 15 seconds at reduced energy followed by a 30-second waiting period. This measure shall be repeated two additional times. Soft starts for impact hammers shall be one dry fire followed by a 30-second waiting period. This procedure shall be repeated two additional times. A bubble curtain or other noise attenuating device will be used to minimize underwater noise levels when the impact hammer is used.

All of the piles will be constructed of hollow steel. From the perspective of underwater noise generation, in general driving larger piles requires more energy, and thus pile driving larger piles is expected to produce higher underwater noise levels than smaller piles. The available data, however, indicate that the difference between 30-inch and 48-inch piles in terms of noise levels generated during pile driving is minimal (WSDOT 2010a). Therefore, estimating source levels for impact pile driving for the EHW-2 considered information for 36-inch to 66-inch piles, and a conservative approach was used to select source levels to use in the analysis. Available information from studies of impact hammer pile driving was reviewed, and those most relevant to the EHW-2 pile driving project in terms of pile type and size, pile driver type, and water depth were identified (Table A–1). Based on this review, the best conservative estimate of source level for impact hammer driving for the EHW-2 project is approximately 195 dBRMS re 1μPa at 10 meters, in the absence of noise attenuation measures. The corresponding peak source level is approximately 210 dB re 1μPa (WSDOT 2010a).

Note that Table A–1 includes recent impact pile driving of 42-inch steel pipe piles for the Carderock pier project on NBK at Bangor. This project is similar to the proposed EHW-2 in terms of pile size, type, and location (substrate). The fact that the source level for the Carderock pier project was estimated at 195 dBRMS supports using this source level for the EHW-2 pile driving.

Available data for vibratory pile driving projects were reviewed (Table A–2). Considering the paucity of data for vibratory driving, the most conservative source level was used for the EHW-2 analysis: 180 dBRMS re 1μPa.

Table A–2. Sound Pressure Levels from Pile Driving Studies Using Impact Hammers

Project	Location	Pile Type	Hammer Type	Water Depth	Distance	Measured Sound Levels (RMS)
Eagle Harbor Maintenance Facility[1]	Bainbridge Island, WA	Steel Pipe/ 30-inch	Diesel Hammer	10 m	10 m	192 dB re 1 µPa
Friday Harbor Ferry Terminal[2]	Friday Harbor, WA	Steel Pipe/ 30-inch	Diesel Hammer	10 m	10 m	196 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Impact Hammer	~10 m	10 m	193 dB re 1 µPa
Mukilteo Test Piles	WA	Steel Pipe/ 36-inch	Impact	7.3 m	10 m	195 dB re 1 µPa
Anacortes Ferry	WA	Steel Pipe/ 36-inch	Impact	12.8 m	10 m	199 dB re 1 µPa
Carderock Pier, NBK at Bangor[4]	WA	Steel Pipe/ 42-inch	Impact	14.6–21.3 m	10 m	195 dB re 1 µPa
Russian River	Russian River, CA	Steel Pipe/ 48-inch	Diesel Impact	2 m	10 m 20 m 45 m 65 m	195 dB re 1 µPa 190 dB re 1 µPa 185 dB re 1 µPa 175 dB re 1 µPa
Unknown	CA	Steel CISS/ 60-inch	Impact	~10 m	10 m	195 dB re 1 µPa
Richmond-San Rafael Bridge	San Francisco Bay, CA	Steel Pipe/ 66-inch	Diesel Impact	4 m	4 m 10 m 20 m 30 m 40 m 60 m 80 m	202 dB re 1 µPa 195 dB re 1 µPa 189 dB re 1 µPa 185 dB re 1 µPa 180 dB re 1 µPa 169 dB re 1 µPa 170 dB re 1 µPa

1. JASCO Research Ltd. (2005). 2. Laughlin (2005b). 3. Adapted from Compendium of Pile Driving Data report to the California Department of Transportation - Illingworth & Rodkin, Inc. (2007). 4. Navy (2009). Source level at 10 meters (m) estimated based on measurements at distances of 48 to 387 m.

Table A–3. Sound Pressure Levels from Pile Driving Studies Using Vibratory Hammers

Project	Location	Pile Type	Hammer Type	Water Depth	Distance	Measured Sound Levels (RMS)
Vashon Terminal[1]	WA	Steel Pipe/ 30-inch	Vibratory	~6 m	11 m	165 dB re 1 µPa
Keystone Terminal[2]	WA	Steel Pipe/ 30-inch	Vibratory	~5 m	10 m	164 dB re 1 µPa
Keystone Terminal[2]	WA	Steel Pipe/ 30-inch	Vibratory	~8 m	10 m	165 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Vibratory Driver*	~5 m	10 m	170 dB re 1 µPa
Unknown[3]	CA	Steel Pipe/ 36-inch	Vibratory Driver*	~5 m	10 m	175 dB re 1 µPa
Unknown	CA	Steel Pipe/ 72-inch	Vibratory Driver	~5 m	10 m	170 dB re 1 µPa
Unknown	CA	Steel Pipe/ 72-inch	Vibratory Driver	~5 m	10 m	180 dB re 1 µPa

1. Source: Laughlin 2010a; RMS noise levels reported in terms of the 30-second average continuous sound level and computed from the Fourier transform of pressure waveforms in 30-second time intervals. Average of measured values at 11 meters.
2. Source: Laughlin 2010b; RMS noise levels reported in terms of the 30-second average continuous sound level and computed from the Fourier transform of pressure waveforms in 30-second time intervals.
3. Adapted from *Compendium of Pile Driving Data* report to the California Department of Transportation - Illingworth & Rodkin, Inc. (2007); *RMS impulse level used duration of (35 msec).

Use of a bubble curtain or other noise attenuating device to mitigate noise levels will be employed to minimize the noise levels during impact pile driving operations. Unconfined bubble curtain attenuators (Type I) emit a series of bubbles around a pile to introduce a high-impedance boundary through which pile driving noise is attenuated. Noise reduction results using an unconfined bubble curtain from several projects performed (Illingworth and Rodkin 2001; WSDOT 2010b) indicate a wide variance results, with very little measurable attenuation in some cases (less than 6 dB), and high attenuation (greater than 15 dB) in other cases.

Reductions of 85 percent (approximately 17 dB, computed as $20 \cdot \log_{10}$ the ratio of peak pressure reduced by 85 percent with the use of a bubble curtain) or more have been reported with the proper use of a Type II (confined) bubble curtain (Longmuir and Lively 2001), although reductions of 5 to 15 dB are more typical (Laughlin 2005a). A confined bubble curtain places a shroud around the pile to hold air bubbles near the pile, ensuring they are not washed away by currents or tidal action. For impact analysis, an average SPL reduction of 10 dB was assumed. Estimated SPLs for impact pile driving noise without a noise attenuator are presented for reference only.

Due to the sharp, impulsive nature of impact pile driving, the frequency range over which detectable noise can be heard is broad; measurements have reported detectable noise up to 25.6 kHz (David 2006). However, the bulk of acoustic energy generated underwater due to pile driving ranges between 50 and 1,000 Hz (WSDOT 2010a). This range was confirmed by recent pile driving acoustic reports in Puget Sound, which show the majority of observed energy to be below 1,000 Hz (Carlson et al. 2005; Laughlin 2005b).

Noise Modeling Technique

A practical sound propagation modeling technique was used to estimate the range from the pile driving activity to various expected SPLs in the water. 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 transmission loss of the energy as it dissipates with distance. The transmission loss equation is given by:

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

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. This model follows recommended best practices by WSDOT (2010a).

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 in-water structures and sediments. In a perfectly unobstructed (free-field) environment not limited by depth or water surface, noise follows the spherical spreading law, resulting in a 6 dB reduction in noise level for each doubling of distance from the source [20*log(range)]. Cylindrical spreading occurs in an environment wherein noise propagation is bounded by the water surface and sea bottom. In this case, a 3 dB reduction in noise level is observed for each doubling of distance from the source [10*log(range)]. The propagation environment along the Bangor waterfront on NBK is neither free-field nor cylindrical; as the receiver moves away from the shoreline, the water increases in depth, resulting in an expected propagation environment that would lie between spherical and cylindrical spreading loss conditions. Since no empirical propagation loss studies have been conducted along the Bangor waterfront on NBK to measure the propagation environment, a practical spreading loss model was adopted to approximate the environment for noise propagation between the cylindrical and spherical methods. The practical spreading loss method uses a 4.5 dB reduction in noise level for each doubling of distance from the source [15*log(range)], and has been accepted by NMFS and USFWS.

Underwater noise is frequently characterized by three specific descriptors: (1) instantaneous peak SPL (dBPEAK), which describes the instantaneous maximum overpressure or underpressure observed during an event; (2) RMS (dBRMS) SPL, which is computed as the square root of the sum of the pressure squared normalized over the event duration, and is thus representative of an "average" SPL during an event; and (3) sound exposure level, or SEL (dBSEL), which indicates the amount, e.g., "dose" of acoustic energy normalized to a one-second time interval, and is computed as the cumulative sum of sound pressure squared normalized to a one-second duration. When characterizing impulsive noise, such as with impact pile driving, all three descriptors are used to assess different biological effects to a number of marine species. For quasi steady-state noise, such as operation of a boat or during vibratory pile driving, RMS levels are typically compared, although peak and SEL levels can also be computed. Due to the continuous nature of the noise, SEL values are often numerically equal to RMS levels in this case.

Specific noise thresholds are described within each biological section and use peak, RMS, and SEL representations to describe specific impacts to marine species.

Impact Pile Driving

Peak Levels

Peak attenuation levels for 48-inch hollow steel piles driven with a bubble curtain are provided in Table A–3 and shown in Figure A–1. Peak levels without a noise attenuator are also shown in the table for reference; all biological impact analyses assume the 10 dB reduction. Peak levels of 206 dBPEAK will be exceeded within a radius of 4 meters from each driven pile, and levels exceeding 180 dBPEAK will be exceeded within a radius of 215 meters when a properly operating confined bubble curtain or other noise attenuating device is used.

Table A–4. Attenuation Levels vs. Distance Underwater for Pile Driving Peak Impact Noise

Distance (meters) From Driven Pile	With Noise Attenuator Practical Spreading Loss Model [1,2] (dBPEAK re1μPa)	Without Noise Attenuator Practical Spreading Loss Model [1] (dBPEAK re1μPa)
2.1	210	220
3.9	206	216
7.3	202	212
10	200	210
20	195	205
30	193	203
61	188	198
91	186	196
122	184	194
152	182	192
183	181	191
216	180	190
305	178	188
488	175	185
975	170	180
1,951	166	176
4,877	160	170
11,659	154	164

1. Source level of 210 dBPEAK at 10 meters is assumed for 48-inch-diameter hollow steel pile.
2. 10 dB reduction for confined bubble curtain or other noise attenuating device.

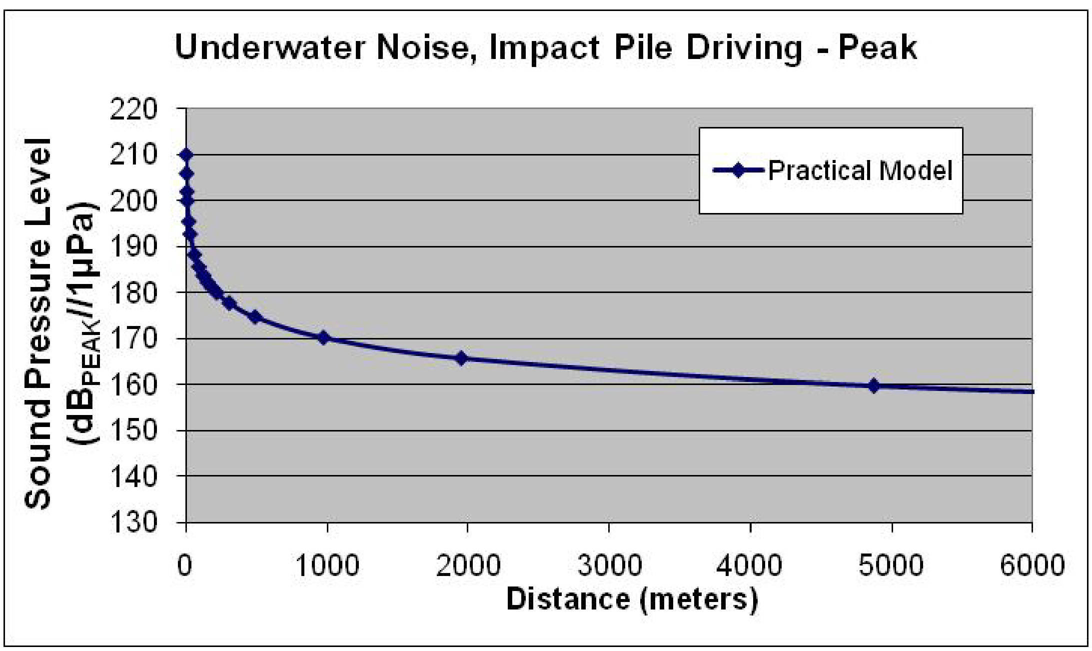

Figure A–1. Peak Underwater Noise Assessment for Impact Pile Driving With Noise Attenuator

RMS Levels

RMS attenuation levels for impact driven 48-inch hollow steel piles using a confined bubble curtain or noise attenuator are provided in Table A–4 and shown in Figure A–2. Using the practical propagation model, SPLs above 190 dBRMS re 1µPa will be exceeded within a circle centered at the location of the driven pile out to a distance of 5 meters while driving 48-inch hollow steel piles. Values for 180 dBRMS and 160 dBRMS are also provided in the table. RMS levels without a noise attenuator are provided for reference; all biological impact analyses assume the 10 dB reduction.

Average underwater baseline noise levels acquired near the NBK at Bangor Marginal Wharf facility, which is near the location of the EHW-2, were measured at a level of 114 dBRMS re 1µPa (Slater 2009). Sound during impact pile driving will be detected above the average background noise levels at any location in Hood Canal with a direct acoustic path (i.e., "line of sight" from the driven pile to the receiver location). To the west of the EHW-2, Toandos Peninsula bounds the extent of sound travel within the construction area; thus, geography will not allow direct sound path propagation south of Brown Point, nor north of Termination Peninsula at the western terminus of the Hood Canal Bridge adjacent to Squamish Harbor. Locations beyond these points will receive substantially lower noise levels since there is no direct sound path, and thus no impacts will be observed.

Table A–5. Attenuation Levels vs. Distance for Pile Driving RMS Impact Noise

Distance (meters) From Driven Pile	With Noise Attenuator Practical Spreading Loss Model [1,2] (dBRMS re1µPa)	Without Noise Attenuator Practical Spreading Loss Model [1] (dBRMS re1µPa)
2.1	195	205
4.6	190	200
10	185	195
11	184	194
21	180	190
54	174	184
91	171	181
122	169	179
152	167	177
183	166	176
244	164	174
305	163	173
464	160	170
1,219	154	164
1,585	152	162
1,829	151	161
2,154	150	151

1. Source level of 195 dBRMS at 10 meters is assumed for 48-inch-diameter hollow steel pile.
2. 10 dB reduction for confined bubble curtain or other noise attenuator.

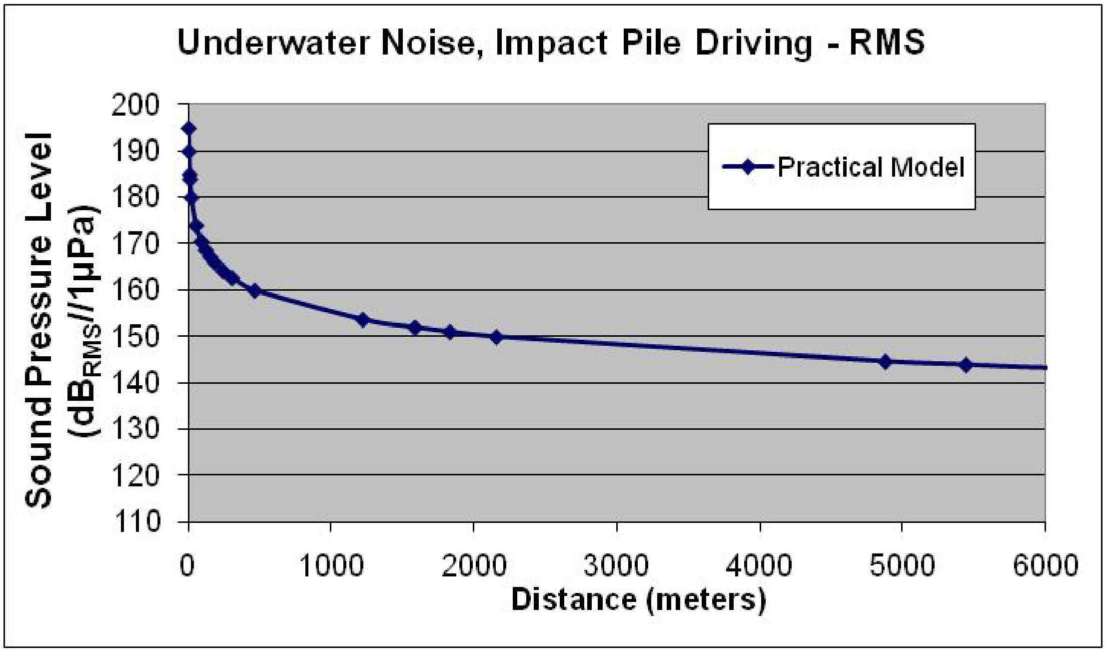

Figure A–2. RMS Underwater Noise Assessment for Impact Pile Driving With Noise Attenuator

Sound Exposure Levels

Impact SEL attenuation levels for 48-inch hollow steel piles driven with an impact hammer and with a confined bubble curtain or other noise attenuating device are provided in Table A–5 and shown in Figure A–3. Two pile driving scenarios were modeled, as described in Chapter 2. Analysis included both the 1,000 and 6,400 daily strike scenarios. For this analysis, stationary, non-moving fish conditions were assumed, that is, fish that will not move away from the site during pile driving operations. Model results followed the technique used by NMFS (WSDOT 2009). Using the practical spreading model, a level of 187 dBSEL re 1μPa^2-sec will be exceeded within a circle centered at the location of the driven pile out to a distance of approximately 158 meters while driving 48-inch hollow steel piles (1,000 daily strike scenario) using a bubble curtain attenuator, and up to 546 meters for the 6,400 daily strike scenario. Levels of 183 dBSEL re 1μPa^2-sec will be exceeded within a circle centered at the location of the driven pile out to a distance of approximately 293 meters in the 1,000 daily strike scenario, and 1,009 meters in the 6,400 daily strike scenario. It should be noted that the NMFS SEL model methodology includes a factor that adjusts the maximum affected area to exclude single strike values less than 150 dBSEL re 1 μPa^2-sec, which are assumed to not accumulate to cause injury (WSDOT 2009). This factor has the effect of fixing the maximum distance at which injury is expected to occur, regardless of the number of hammer strikes used in the model calculation. For these assumed conditions, both 187 and 183 dBSEL re 1 μPa^2-sec threshold values will be limited to 464 meters for 6,400 pile strikes.

Table A–6. Attenuation Levels vs. Distance for Pile Driving SEL Impact Noise with Noise Attenuator, 1,000 and 6,400 strikes per day

Distance (meters) From Driven Pile	Practical Spreading Loss Model [1,2] 1,000 Strikes (dB_{SEL} re $1\mu Pa^2$-sec)		Practical Spreading Loss Model [1,3] 6,400 Strikes (dB_{SEL} re $1\mu Pa^2$-sec)	
	With Attenuator	Without Attenuator	With Attenuator	Without Attenuator
2.2	215	225	223	233
4.6	210	220	218	228
10	205	215	213	223
16	202	212	210	220
20	200	210	209	219
34	197	207	205	215
55	194	204	202	212
74	192	202	200	210
91	191	201	199	209
158	187	197	195	205
255	184	194	192	202
293	183	193	191	201
546	179 [3]	189	187 [3]	197
1,009	177 [3]	187	185 [3]	195
1,951	175 [3]	185	183 [3]	193
3,901	173 [3]	183	181 [3]	191
4,877	169 [3]	179 [4]	177 [3]	187 [4]
9,754	165 [3]	175 [4]	173 [3]	183 [4]

1. Single strike source level of 185 dB_{SEL} at 10 meters is assumed for 48-inch-diameter hollow steel pile.
2. 10 dB reduction for confined bubble curtain or noise attenuator.
3. Effective quiet range for SEL impact with noise attenuator is 464 meters.
4. Effective quiet range for SEL impact with noise attenuator is 2,154 meters.

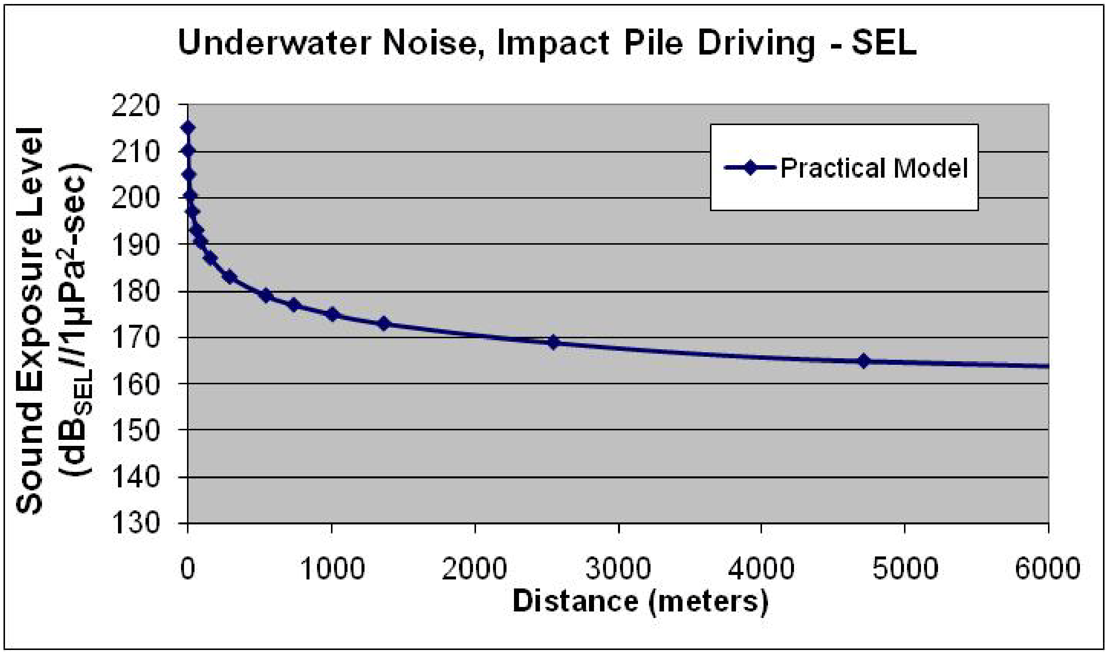

Figure A–3. SEL Underwater Noise Assessment for Impact Pile Driving With Noise Attenuator, Likely Scenario, 1,000 Strikes

Pile Driving, Multiple-Rig Operation

Underwater noise levels during multiple-rig pile driving will produce noise levels higher than those observed with a single rig operating due to the additive effects of multiple noise sources. Noise from multiple simultaneous sources produces an increase in the overall noise field. A doubling in sound power results in an increase of 3 dB, which is the result of two sources incoherently adding acoustic pressures in the combined noise environment. The resultant SPL from *n*-number of multiple sources is computed with the following relationship using principles of decibel addition:

$$CombinedSPL = 10 \cdot \log_{10}\left(10^{\frac{SPL1}{10}} + 10^{\frac{SPL2}{10}} + ... + 10^{\frac{SPLn}{10}}\right)$$

For each multiple-source analysis, a two-dimensional grid of closely spaced points was created, and noise levels were computed from individual sources at each grid point, then incoherently summed together to estimate the combined noise field. This analyses provides a robust means to estimate the additive effects of noise levels with multiple pile drivers simultaneously operating. Peak and RMS values were computed for each multiple-rig scenario analyzed. Impact SEL calculations for multiple-rig scenarios were not repeated, since only one impact pile driver will be operated at any time. Continuous vibratory energy contributions were not included in SEL calculations for comparison to SEL thresholds for impact driving. This is because the SEL metric is intended to characterize total energy in transient noise events and is not intended for long-term continuous noise types; the existing SEL thresholds are intended for transient noise events. Peak levels were determined by summing peak levels from impact pile driving with peak levels from vibratory driving. Peak vibratory levels were assumed to be 3 dB higher than continuous RMS levels following the assumption that the typical vibratory waveform is sinusoidal (WSDOT 2010a); thus, peak pressures will be higher than RMS values by $\sqrt{2}$ (approximately 1.41 times higher pressure), which matches typical values of 183 dB_{PEAK} reported in the literature (Illingworth and Rodkin 2007). Infrequent transient peaks of higher SPLs during vibratory driving could be possible if a pile contacts a hard object such as a rock in the substrate during vibratory driving, but this case was not modeled due to the transient, occasional nature of this occurrence.

For the case of continuous underwater noise, the effects of impulsive impact noise from an impact driver were added to continuous vibratory pile driving noise to provide the most conservative combined estimate of the equivalent continuous root-mean-square (RMS) sound field. This process involved converting the time-varying impact noise to an equivalent continuous RMS noise level, and then adding it to the continuous RMS noise level created by the vibratory driver. A time-weighting factor was computed to account for the ratio of the time duration the noise persisted compared to the time it was silent. Using this methodology, the equivalent continuous noise level from the impact driving is computed as the sound pressure level of a steady sound source containing the same energy as the impact driver. Calculations for this assumed that the impact noise persisted for 100 milliseconds, which is representative of the longest duration impact waveforms reported for impact driving (ICF Jones and Stokes and Illingworth and Rodkin 2009). Furthermore, it was assumed that the pile driving rate was one hammer impact per second. The equivalent continuous noise factor was then computed as the ratio of “on” time vs. “total” time, or 10*log10(on/total), or 10*log10(100msec/1sec), resulting in a 10 dB factor which was subtracted from the RMS impact levels to form the equivalent continuous contribution by the impact hammer.

Two multiple-rig scenarios were analyzed: (1) three vibratory rigs operating concurrently, and (2) three vibratory rigs and one impact rig operating concurrently. Up to three vibratory rigs could be operating simultaneously, with each rig producing noise levels of up to 180 dB_{RMS} re 1µPa at 10 meters (Illingworth and Rodkin 2007). An impact pile driver will produce peak levels of 200 dB_{PEAK} and 185 dB_{RMS} re 1µPa at 10 meters with a noise attenuator assumed to reduce radiated levels by 10 dB. Highest levels will be produced immediately adjacent to each pile being driven, and will taper off as the receiver moves away from the work area.

Three Vibratory Pile Driving Rigs

A majority of the pile driving will be done using vibratory methods. A vibratory pile driver operates by continuously shaking the pile at a fixed frequency, basically vibrating it into the ground. The vibrating action of the pile loosens or “liquefies” the bottom substrate in the vicinity of the pile, and, as a result, the pile moves downward due to the weight of the pile and the vibratory driver (WSDOT 2010a). Due to the nature of the project, up to three vibratory pile driving rigs could be used simultaneously, which will create more underwater noise than a single vibratory driver.

With three vibrating pile rigs operating, SPLs of 150 dB_{RMS} will occur at a distance of 2,082 meters (1.3 miles) from the work area, and levels of 120 dB_{RMS} will occur at distances of up to 206,959 meters (128 miles). Practically, the maximum affected range above 120 dB_{RMS} will be approximately 13,800 meters (8.6 miles) from the driven pile, which is bounded by the furthest line-of-sight distance from the EHW-2 location to the northern shore of Squamish Harbor. Further propagation is limited by land masses.

Within 10 meters of each pile being driven, the noise from other piles being driven hundreds of feet away will not noticeably contribute to the noise in the vicinity of the initial pile. Thus, within 10 meters from a pile, maximum noise levels for a multiple-rig operating scenario will be approximately the same as that for a single rig operating. However, further away from each pile, the noise contributions from adjacent pile drivers will become more significant, resulting in a more complex attenuation environment and higher observed noise levels than with a single rig operating. The noise field in the vicinity of the pile driving area (nominally within 300 meters of the work area) will not attenuate in a simple circular pattern due to the interaction and addition of the multiple rigs contributing to the overall noise field. At substantial distances, the field will behave in a more circular manner, however, as the relative distance from the rigs becomes large compared to the distance between the rigs. Table A–6 summarizes estimated distances to specific functional hearing group thresholds from the EHW-2 project site during three-rig vibratory driving.

Table A–7. Estimated Distances to Underwater Noise Thresholds, Three Vibratory Drivers, Continuous RMS Noise

Functional Hearing Group	Underwater Threshold	Distance to Threshold (meters)
Marbled murrelets		
Behavior	150 dBRMS	2,082
Cetaceans (whales, dolphins, porpoises)		
Injury	180 dBRMS	10
Behavior	120 dBRMS	13,800 [1]
Pinnipeds (seals, sea lions, walrus)		
Injury	190 dBRMS	2.1
Behavior	120 dBRMS	13,800 [1]
Fish all sizes		
Behavior	150 dBRMS	2,082

1. Limited by propagation due to land mass.

One Impact and Three Vibratory Pile Driving Rigs

With one impact rig and three vibrating pile rigs operating, SPLs exceeding 150 dBRMS will occur at distances within 3,361 meters from the EHW-2 location (Table A–7). Peak levels exceeding 180 dBPEAK will occur within 224 meters of the pile driving activity. Use of a noise attenuator, such as a bubble curtain, was assumed to provide a 10 dB reduction in peak and impulsive RMS noise. Levels of 120 dBRMS will practically occur at distances of up to 13,800 meters (8.6 miles) from the driven pile, which is bounded by the furthest line-of-sight distance from the EHW-2 location to the northern shore of Squamish Harbor. Further propagation is limited by land mass.

There will be no increase in overall underwater noise along the Bangor waterfront on NBK from operation of the EHW-2 because there will be no expected increase in vessel traffic or other operational activities. However, operational noise will be introduced at the site of the EHW-2, which is adjacent to the existing EHW. Routine maintenance of the EHW-2 will include inspection and repair of piles, which will infrequently increase underwater noise levels due to occasional repair activity.

Table A–8. Estimated Distances to Underwater Noise Thresholds, One Impact and Three Vibratory Pile Drivers, Peak, RMS, and SEL

Functional Hearing Group	Underwater Threshold	With Noise Attenuator Distance to Threshold (meters)	Without Noise Attenuator Distance to Threshold (meters)
Marbled murrelets			
Injury	202 dBSEL (6,400 strikes)	55	255
Behavior	150 dBRMS	2,224 (continuous) 3,361 (impulsive)	3,360 (continuous) 10,690 (impulsive)
Cetaceans (whales, dolphins, porpoises)			
Injury	180 dBRMS	10 (continuous) 22 (impulsive)	22 (continuous) 105 (impulsive)
Behavior	160 dBRMS (impulsive)	724	2,295
Behavior	120 dBRMS (continuous)	13,800 [1]	13,800 [1]
Pinnipeds (seals, sea lions, walrus)			
Injury	190 dBRMS	2.1 (continuous) 4.9 (impulsive)	4.8 (continuous) 22 (impulsive)
Behavior	160 dBRMS (impulsive)	724	2,295
Behavior	120 dBRMS (continuous)	13,800 [1]	13,800 [1]
Fish ≥ 2 grams (based on 6,400 impact pile strikes)			
Injury	187 dBSEL	464 [2]	2,154 [3]
Fish < 2 grams (based on 6,400 impact pile strikes)			
Injury	183 dBSEL	464 [4]	2,154 [5]
Fish all sizes			
Injury	206 dBPEAK	4	19
Behavior	150 dBRMS	2,224 (continuous) 3,361 (impulsive)	3,361 (continuous) 10,690 (impulsive)

1. Limited by propagation due to land mass.
2. Distances shown are limited by effective quiet; calculated distance is 546 meters.
3. Distances shown are limited by effective quiet; calculated distance is 2,551 meters.
4. Distances shown are limited by effective quiet; calculated distance is 1,009 meters.
5. Distances shown are limited by effective quiet; calculated distance is 4,713 meters.

ESTIMATED AIRBORNE NOISE LEVELS

Construction of the EHW-2 will result in increased airborne noise in the vicinity of the construction site. Maximum peak levels will be created during impact pile driving using a single acting diesel impact hammer, estimated to be 105 dBA re 20µPa at a distance of 50 feet (15 meters) from the pile, and 97 dBRMS re 20 µPa at 160 meters (unweighted, Blackwell et al. 2004); vibratory driving will create noise levels of 95 dBA re 20µPa at 50 feet (15 meters), and unweighted noise levels of 97 dBRMS re 20 µPa at 12 meters (WSDOT 2010c). Other construction activities or equipment, such as cranes, heavy trucks, excavators, and jackhammers used for land clearing, delivery of materials, and debris removal, will also cause noise; however, this noise level will be much lower compared to noise produced by the impact hammer (Table A–8). In the absence of pile driving noise, maximum construction noise will be 94 dBA re 20µPa at a distance of 50 feet (15 meters) from the activity, computed as the summation of noise of all equipment operating simultaneously (WSDOT 2010a).

Table A–9. Maximum Noise Levels at 15 meters for Common Construction Equipment

Equipment Type	Maximum Noise Level
Scraper	90
Backhoe	90
Jackhammer	89
Crane	81
Pumps	81
Generator	81
Front loader	79
Air Compressor	78

Source: WSDOT 2010a.
Note: Maximum SPLs in dBA re 20µPa (A-weighted).

Sensitive receptors along Hood Canal adjacent to the project site will be affected by construction noise. Airborne noise due to impact pile driving will be the most noticeable to such sensitive receptors. Noise impacts due to other construction activities will be minimal. Construction will typically occur 6 days per week, but could occur 7 days per week. Pile driving during the first half of the in-water work window (July 16 to September 15) will only occur between 2 hours after sunrise to 2 hours before sunset to protect breeding murrelets. Between September 16 and February 15, pile driving can occur during daylight hours. Non-pile driving construction activities could last until 10:00 PM in accordance with the WAC noise guidelines. The number of pile driving days will be between 211 and 411, including the time to drive the abutment piles.

Airborne noise is commonly reported using A-weighted levels (dBA), which indicates the type of filtering used in the measurement. The purpose for using A-weighting is to assess impacts to human receptors, and thus is filtered or "shaped" to correspond to how humans hear. Construction noise behaves as a point-source, and thus propagates in a spherical manner, with a 6 dB decrease in SPL per doubling of distance (WSDOT 2010a). Two specific noise conditions exist at the EHW-2 project site, namely propagation over water to the west side of Hood Canal, and over heavily vegetated terrain on the east side of Hood Canal. In the first condition, WSDOT (2010a) considers propagation over water as a "hard-site" condition; thus, no additional noise reduction factors apply. However, in the second condition two noise reduction factors apply for the topography of the EHW-2 project site. The first of these is a 7.5 dB loss factor per doubling of distance in "soft-site" conditions, wherein normal, unpacked earth is the predominant soil condition. The second factor is a reduction of 10 dB for interposing dense vegetation, e.g., trees and brush, between the noise source and potential receptors.

Impact Pile Driving

Table A–9 tabulates expected A-weighted received noise levels from the 6,400 daily strike scenario for three conditions:

- Noise over soft-site terrain conditions, using a 7.5 dB loss factor per doubling of distance;
- Noise over soft-site terrain conditions, using a 7.5 dB loss factor as described above, with a 10 dB reduction in maximum noise level due to the presence of dense vegetation; and
- Noise over water, using a 6 dB loss factor per doubling of distance.

Figure A–4 shows the same information in a graphical format.

Table A–10. Attenuation Levels vs. Distance for Impact Pile Driving Peak Airborne Noise, A-weighted

Distance (meters) From Driven Pile	Over Water [1]	Soft Site, No Vegetation [2]	Soft Site, With Vegetation [3]
15.2	105	105	95
20	103	102	92
41	96	94	84
51	95	92	82
68	92	89	79
171	84	79	69
383	77	70	60
457	75	68	58
607	73	65	55
671	72	64	54
2,713	69	49	39
6,553	52	39	29

Note: Maximum SPLs in dBA re 20µPa (A-weighted).

1. 6 dB loss per doubling of distance due to hard-site conditions.
2. 7.5 dB loss per doubling of distance due to soft-site conditions.
3. 7.5 dB loss per doubling of distance due to soft-site conditions, plus 10 dB fixed loss due to the presence of vegetation.

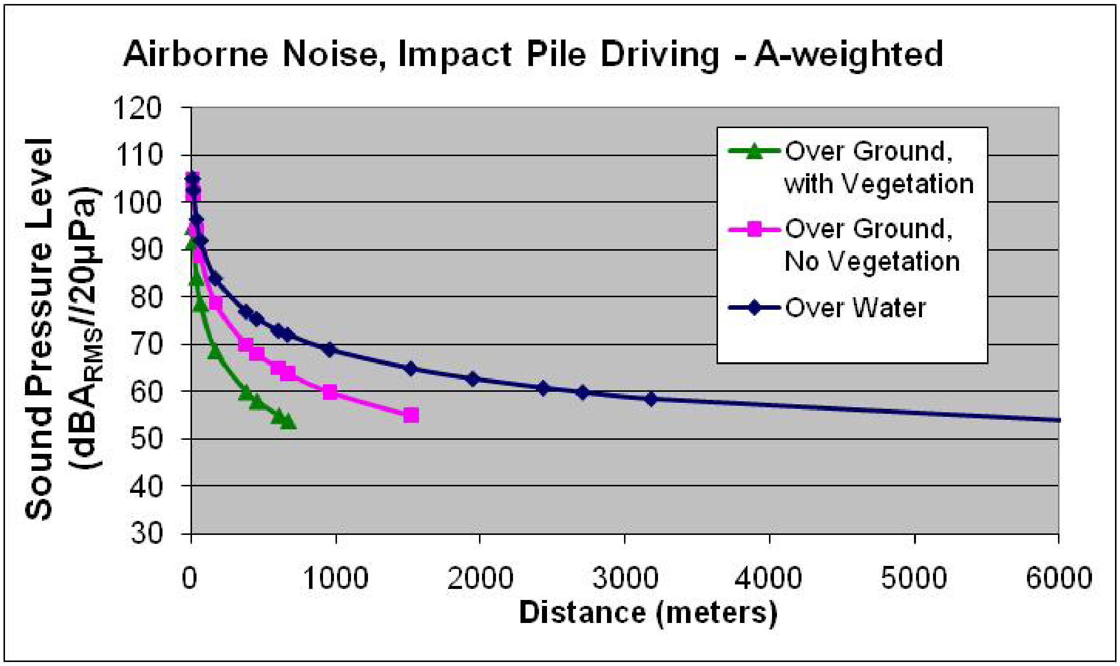

Figure A–4. Airborne Noise Assessment for Impact Pile Driving Showing Expected Noise Levels Over Terrain and Water, A-weighted Sound Pressure Levels

Not all receptors have the same hearing sensitivity as humans, and thus A-weighted analysis is inappropriate for certain species, particularly pinnipeds. An unweighted airborne noise analysis is therefore presented to address pinnipeds. Table A–10 and Figure A–5 show results of the unweighted airborne noise analysis for impact pile driving.

Table A–11. Attenuation Levels vs. Distance for Pile Driving Impact Airborne Noise, Unweighted RMS

Distance (meters) From Driven Pile	Over Water [1]	Soft Site, No Vegetation [2]	Soft Site, With Vegetation [3]
8.5	122	124	114
9.8	121	122	112
15.2	117	117	107
30.2	111	110	100
76	103	100	90
113	100	96	86
190	95	90	80
358	90	83	73

Note: Maximum SPLs in dB$_{RMS}$ re 20µPa (unweighted).

1. 6 dB loss per doubling of distance due to hard-site conditions.
2. 7.5 dB loss per doubling of distance due to soft-site conditions.
3. 7.5 dB loss per doubling of distance due to soft-site conditions, plus 10 dB fixed loss due to the presence of vegetation.

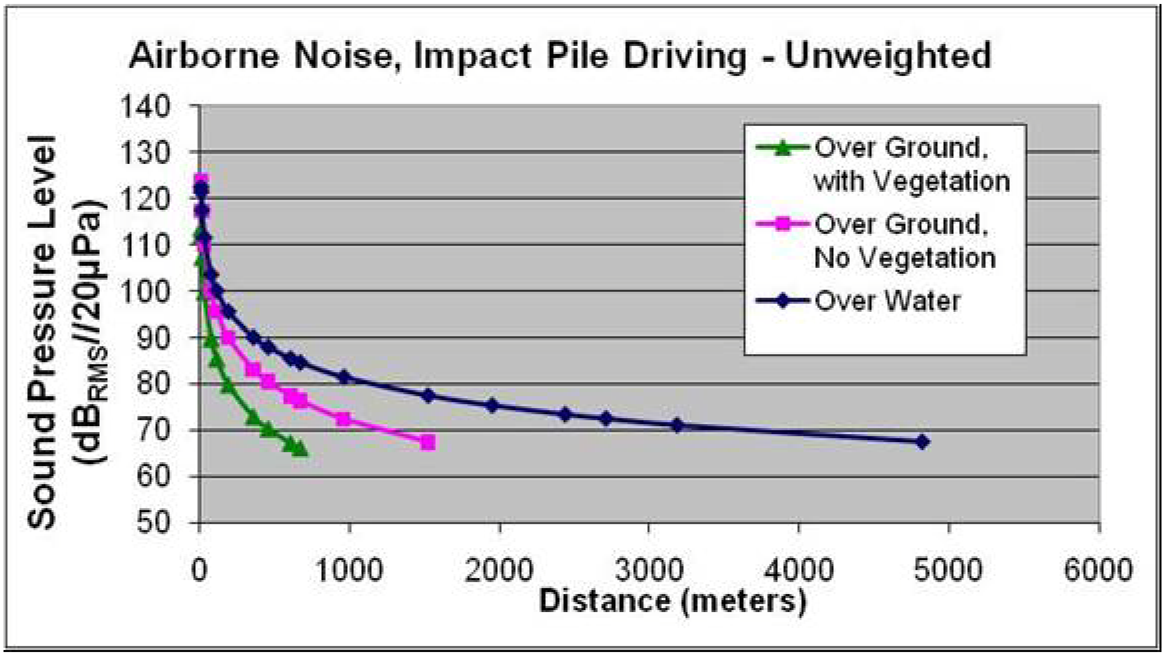

Figure A–5. Airborne Noise Assessment for Impact Pile Driving Showing Expected Noise Levels Over Terrain and Water, Unweighted Sound Pressure Levels

Vibratory Pile Driving

A vibratory pile driver will be the preferred method to drive pilings. An impact hammer will be used if a vibratory pile driver was unable to install pilings to the required depth. No more than one impact pile driver will operate at one time. Up to three vibratory pile driving rigs could be used simultaneously, which will create more airborne noise than a single vibratory driver. Estimated noise conditions are presented for both single-rig and multiple-rig construction. Multiple-rig construction estimates are presented for concurrent operation of three vibratory drivers, and one impact hammer with three vibratory pile drivers.

Several measures will be used to minimize the noise generated by pile driving. A soft-start approach, in which hammer energy levels are increased from low to high, will be used for both pile driving methods to allow time for birds and mammals to move away from the pile driving site before the highest noise levels are produced. Soft starts for vibratory drivers require initial starts of 15 seconds at reduced energy followed by a 1-minute waiting period. This measure shall be repeated two additional times. Soft starts for impact hammers shall be one dry fire followed by a 1-minute waiting period. This procedure shall be repeated two additional times.

Pile Driving, Multiple-Rig Operation

Noise from multiple simultaneous sources produces an increase in the overall noise field. A doubling in sound power results in an increase of 3 dB in the environment, which is the result of two sources incoherently adding acoustic pressures in the combined noise environment. The resultant SPL from *n*-number of multiple sources is computed with the following relationship using principles of decibel addition:

$$CombinedSPL = 10 \cdot \log_{10}\left(10^{\frac{SPL1}{10}} + 10^{\frac{SPL2}{10}} + ... + 10^{\frac{SPLn}{10}}\right)$$

For each multiple-source analysis, a two-dimensional grid of closely spaced points was created, and noise levels were computed from individual sources at each grid point, then incoherently summed together to estimate the combined noise field. A-weighted and unweighted values were computed for each multiple-rig scenario analyzed. RMS calculations were made for both equivalent continuous sound and impulsive sound. An equivalent continuous SPL was computed for the impact driver by spreading the impulsive RMS energy over the same time duration as a vibratory driver. With an assumed impact rate of one pile strike per second, and an impulsive duration of 125 msec (one-eighth of a second, equivalent to a sound meter “fast” averaging time for peak measurements), an equivalent continuous SPL was computed. This result was summed with continuous RMS noise levels from the vibratory drivers to establish the combined equivalent continuous noise level. For the impulsive RMS metric of concurrently operating pile drivers, vibratory RMS levels were added directly to the impulsive RMS sound levels of the impact driver. The maximum impulsive noise was computed as the sum of continuous vibratory energy and the impulsive RMS energy over the duration of the impact strike. Since this is only computed over the duration of each pile strike, the impulsive RMS SPL for multiple rigs operating will always be higher than continuous equivalent RMS SPLs.

For this analysis, it was assumed that all rigs were operating simultaneously, and the noise was incoherently summed to produce the expected noise field. Highest levels will be produced immediately adjacent to each pile being driven, and will taper off as the receiver moved away from the work area. Within close proximity of the EHW-2 construction area, the resultant noise field is complex and non-circular due to the geometry of the pile driver rigs. As the receiver moves away from the construction area, the resultant noise field will become somewhat circular. Two multiple-rig scenarios were analyzed: (1) three vibratory rigs operating concurrently and (2) three vibratory rigs and one impact rig operating concurrently. Highest levels will be produced immediately adjacent to each pile being driven and will taper off as the receiver moves away from the work area.

Three Vibratory Pile Driving Rigs

Airborne noise levels during multiple-rig impact and vibratory pile driving will produce noise levels higher than those observed with a single rig operating. Three vibratory rigs will each produce noise levels of up to 95 dBA re 20µPa at 15 meters, and unweighted noise levels of 97 dBRMS re 20 µPa at 12 meters (WSDOT 2010c). Within 15 meters of each pile being driven, the noise from other piles being driven hundreds of feet away will not noticeably contribute to the noise in the vicinity of the initial pile. Thus, within 15 meters from a pile, maximum noise levels for a multiple-rig operating scenario will be approximately the same as that for a single rig operating. Farther away from each pile, the noise contributions from adjacent pile drivers will become more significant, resulting in a more complex attenuation environment, and higher observed noise levels than with a single rig operating. With three vibratory rigs operating, SPLs of 92 dBA RMS will occur at a distance of 21 meters from any of the three driven piles over water. Unweighted levels of 100 dBRMS will occur at a distance of 8.5 meters or less from each driven pile, and a level of 90 dBRMS will occur within 27.7 meters of each rig. Table A–11 summarizes estimated distances to specific functional hearing group thresholds from the EHW-2 project site during three-rig vibratory driving.

Table A–12. Estimated Distances to Airborne Noise Thresholds, Three Vibratory Drivers, Continuous RMS Noise

Functional Hearing Group	Airborne Threshold	Distance to Threshold (meters)[1]
Marbled murrelets		
Injury	92 dBA	21
Pinnipeds (seals, sea lions, walrus)		
Behavior, harbor seals	90 dBRMS, unweighted	27.7
Behavior, other species	100 dBRMS, unweighted	8.5

1. Distance thresholds show worst-case condition, over water.
2. Time weighted average > 8 hours exposure.

One Impact and Three Vibratory Pile Driving Rigs

Maximum noise levels will occur during use of an impact hammer in combination with multiple vibratory rigs. With one impact rig and three vibratory rigs operating, SPLs exceeding 92 dBA RMS will occur at a distance of approximately 78 meters from the impact pile being driven, 21 meters from any of the vibratory driven piles. Unweighted levels of 100 dBRMS will occur at a distance of 114 meters or less from the impact driven pile, and within 12 meters of each vibratory driven pile. Unweighted levels exceeding 90 dBRMS will occur within 361 meters of the impact driven pile, and levels greater than 100 dBRMS will occur within 114 meters of the impact pile. Table A–12 summarizes estimated distances to specific functional hearing group thresholds from the EHW-2 project site during concurrent impact and three-rig vibratory driving.

Table A–13. Estimated Distances to Airborne Noise Thresholds, One Impact and Three Vibratory Drivers

Functional Hearing Group	Airborne Threshold	Distance to Threshold (meters)[1]
Marbled murrelets		
Injury	92 dBA	21 (continuous) 78 (impulse)
Pinnipeds (seals, sea lions, walrus)		
Behavior, harbor seals	90 dBRMS, unweighted	127 (continuous) 361 (impulse)
Behavior, other species	100 dBRMS, unweighted	40 (continuous) 114 (impulse)

1. Distance thresholds show worst-case condition, over water.
2. Time weighted average > 8 hours exposure.

Operations will result in increased localized noise at the EHW-2 project site. However, overall noise along the Bangor waterfront on NBK is anticipated to remain similar to existing conditions, since vessel traffic will remain the same. Once construction of the EHW-2 is completed, noise occurring at the existing EHW and other waterfront facilities will occur at the existing EHW facility and the EHW-2. Maintenance of the EHW-2 will include routine inspections, repair, and replacement of facility components (not piles) as required. These activities will not generate noise appreciably different from normal operational noise along the Bangor industrial waterfront on NBK.

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