INCIDENTAL HARASSMENT AUTHORIZATION APPLICATION FOR THE NAVY'S TEST PILE PROGRAM CONDUCTED AT NAVAL BASE KITSAP BANGOR

Submitted to:

Office of Protected Resources,

National Marine Fisheries Service,

National Oceanographic and Atmospheric Administration

Prepared by:

Naval Facilities Engineering Command

For:

Naval Base Kitsap Bangor and

Naval Strategic Systems Program

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ACRONYMS AND ABBREVIATIONS

BSS	Beaufort Sea State
°C	Celsius
CA	California
CISS	Cast in Steel Shells
CV	Coefficient of Variation
dB	Decibel
dBA	Decibel with A-weighting filter
DoN	Department of the Navy
EEZ	Exclusive Economic Zone
EHW	Explosive Handling Wharf
EIS	Environmental Impact Statement
ESA	Endangered Species Act
°F	Fahrenheit
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
Ft.	Feet
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	Kilohertz
kg	Kilogram
km	Kilometer
lbs	Pounds
m	Meter
mi	Mile
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
NAVBASE	Naval Base
NBK	Naval Base Kitsap
NMFS	National Marine Fisheries Service
OR	Oregon
Pa	Pascal
PDA	Pile Dynamic Analyzer
PSU	Practical Salinity Units
PTS	Permanent Threshold Shift
RMS	Root Mean Square
SEL	Sound Exposure Level
SFOBB	San Francisco-Oakland Bay Bridge
SPL	Sound Pressure Level
TL	Transmission Loss
TS	Threshold Shift
TTS	Temporary Threshold Shift
TRIDENT	Trident Fleet Ballistic Missile
U.S.	United States
USACE	United States Army Corp of Engineers
° W	West
WA	Washington
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
ZOI	Zone of Influence

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EXECUTIVE SUMMARY

In accordance with the Marine Mammal Protection Act (MMPA) of 1972, as amended, the U.S. Navy (Navy) is applying for an Incidental Harassment Authorization (IHA) to initiate a Test Pile Program at Naval Base Kitsap (NBK) Bangor to collect geotechnical data to support the building of a new Explosive Handling Wharf (EHW-2). Six species of marine mammals are present within the waters surrounding NBK Bangor: the Steller sea lion (*Eumetopias jubatus*), the California sea lion (*Zalophus californianus*), the Harbor seal (*Phoca vitulina*), the Killer whale (*Orcinus orca*), the Dall's porpoise (*Phocoenoides dalli*), and the Harbor porpoise (*Phocoena phocoena*). These species may occur year-round in the Hood Canal, except the Steller sea lion which is only present from fall to late spring (Nov – June), outside of the project's timeline (16 July – 31 October). Additionally, while the Southern Resident killer whale (SRKW) is resident to the inland waters of Washington state and British Columbia it has not been observed in the Hood Canal in decades and was therefore excluded from further analysis. Only the five species which will be present during the project's timeline could be exposed to sound pressure levels associated with vibratory and impulsive pile driving.

The Navy proposes to install up to 29 test and reaction piles at NBK in Bangor, WA to gather geotechnical and noise data to validate the design concept for the EHW-2 and future projects at the Bangor waterfront. The test pile program will require a maximum of 40 work days for completion. The 40 work day duration of the program includes the time for the initial pile installations, time for performing loading tests, and time to remove all of the test piles. The pile lengths will range from 100 to 197 feet, and range in diameter from 30 to 60 inches. The test pile program will involve driving 18 steel pipe piles, at pre-determined locations within the proposed footprint of EHW-2. Some of the initial 18 piles will be removed and re-driven as part of lateral load and tension tests. A total of eleven piles will be installed to perform lateral load and tension load tests. All piles will be driven with a vibratory hammer for their initial embedment depths, and select piles will be impact driven for their final 10-15 feet for proofing[1]. Noise attenuation measures (i.e. bubble curtain/wall) will be used during all impact hammer operations and on 2 of the vibratory driven piles. Hydroacoustic monitoring will be accomplished to assess effectiveness of noise attenuation measures.

For pile driving activities, the Navy used NMFS promulgated thresholds for assessing pile driving impacts (NMFS 2005b, NMFS 2009), outlined in Section 6. The Navy used recommended spreading loss formulas (the practical spreading loss equation for underwater sounds and the spherical spreading loss equation for airborne sounds) and empirically measured source levels from other 30-inch to 72-inch steel pile driving events 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 1,180 Level B harassments may occur during the Test Pile Program from underwater sound. No incidents of harassment were predicted from airborne sounds associated with pile driving. Conservative

1 "Proofing" is driving the test 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.

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.

Pursuant to the Marine Mammal Protection Act (MMPA) Section 101(a)(5)(D)[2], the Navy submits this application to the National Marine Fisheries Service (NMFS) for an Incidental Harassment Authorization (IHA) for the incidental, but not intentional, taking of five marine mammal species during pile driving activities as part of the Test Pile Program between July 2011 and July 2012. The taking would be in the form of non-lethal, temporary harassment and is expected to have a negligible impact on these species. In addition, the taking would not have an unmitigable adverse impact on 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). 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.

2 16 U.S.C. § 1371(a)(5); 50 C.F.R. Part 216, Subpart I.

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 Introduction

Naval Base Kitsap (NBK) Bangor, Washington is located on the Hood Canal approximately 20 miles west of Seattle, WA (Figure 1-1 and 1-2). NBK Bangor provides berthing and support services to United States (U.S.) Navy submarines and other fleet assets. The entirety of NBK Bangor, including the land areas and adjacent water areas in the Hood Canal are restricted from general public access. The Navy proposes to install 29 test and reaction piles at NBK Bangor as part of a Test Pile Program to support the design of the future construction of a new Explosive Handling Wharf (EHW-2). Sections 1.2 and 1.3 describe the proposed activities to be conducted in detail. The proposed actions with the potential to affect marine mammals within the waterways adjacent to NBK Bangor that could result in harassment under the Marine Mammal Protection Act (MMPA) of 1972, as amended in 1994, are vibratory and impulsive pile driving operations associated with the Test Pile Program.

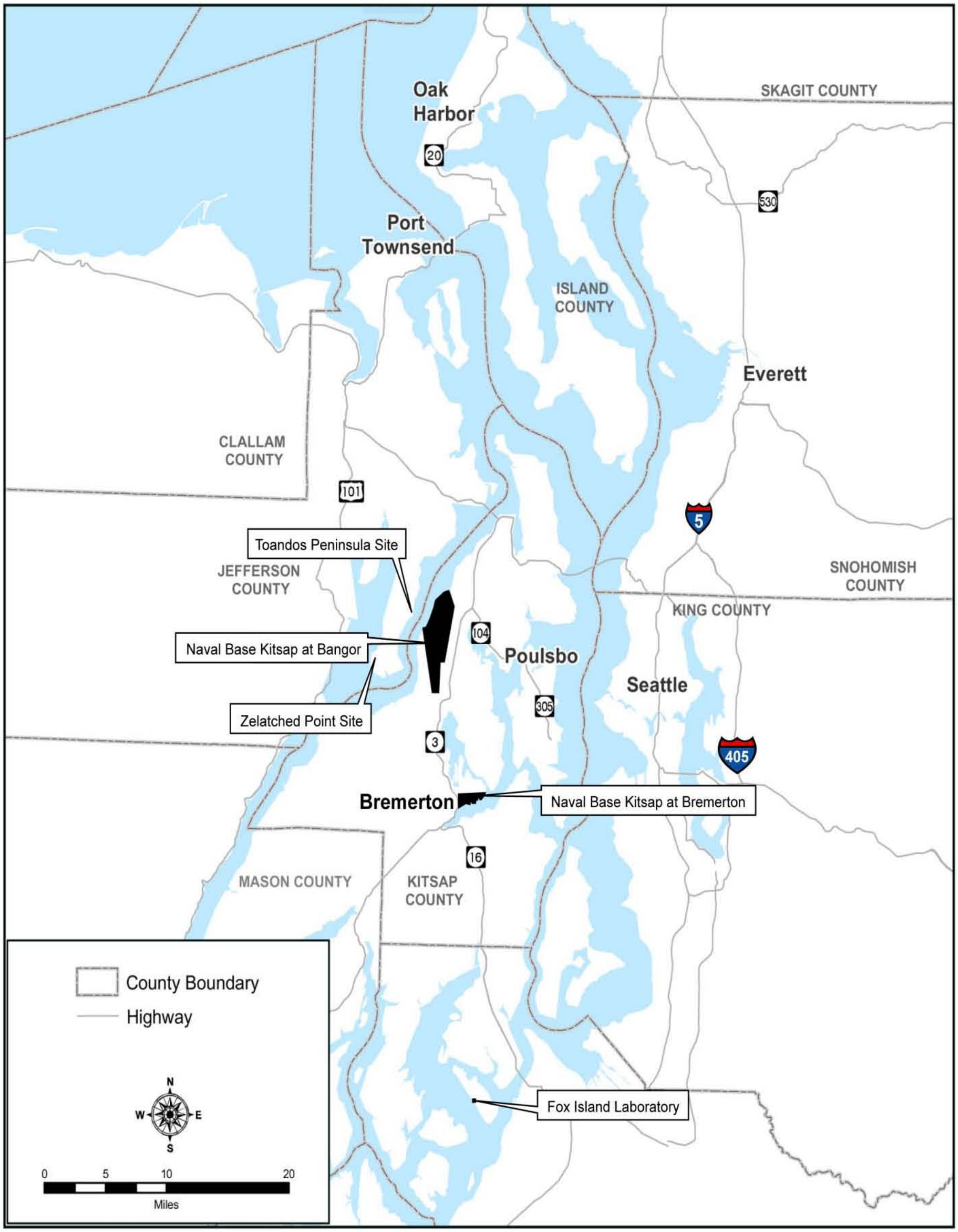
1.2 Proposed Action

As part of the U.S. Navy's sea-based strategic deterrence mission, the Navy Strategic Systems Programs (SSP) directs research, development, manufacturing, test, evaluation, and operational support of the TRIDENT Fleet Ballistic Missile (TRIDENT) program. The proposed action (also called the Test Pile Program) for this harassment authorization request is to install and remove up to 29 test and reaction piles, conduct loading tests on select piles, and measure in-water sound propagation parameters (*e.g.* transmission loss, water depth, etc.) during pile installation and removal. Geotechnical and sound propagation data collected during pile installation and removal will be integrated into the design, construction, and environmental planning for the Navy's proposed second Explosives Handling Wharf (EHW-2). Future construction projects at the NBK Bangor waterfront may also benefit from the geotechnical data gathered for use in their environmental planning documentation. The Navy proposes to install the test piles in the location planned for the future EHW-2, which will be adjacent to the existing EHW-1 at NBK Bangor. The test pile program will require a maximum of 40 work days for completion. Hydroacoustic monitoring will be undertaken to assess the effectiveness of noise attenuation measures. The presence of marine mammals will also be monitored during pile installation and removal.

1.3 Description of Pile Driving Operations

The Test Pile program has been designed to collect adequate geotechnical and sound propagation data. Under the proposed action, the Navy will install 29 test and reaction piles in the Hood Canal. The pile lengths will range from 100 to 197 feet, and range in diameter from 30 to 60 inches. All piles will subsequently be removed at the completion of the test pile program. These test piles will be situated throughout the footprint of the future EHW-2, currently in the preliminary planning process. Figure 1-3 shows in detail the locations of each of the test piles.

The installation of the test piles will involve driving 18 steel pipe piles into the substrate. Additionally, three lateral load and two tension load tests will be performed. The lateral load test



(Source: Navy 2002; ESRI 2000)

Figure 1-1 Map of the Surrounding Vicinity

Figure 1-2 Proposed Project Area

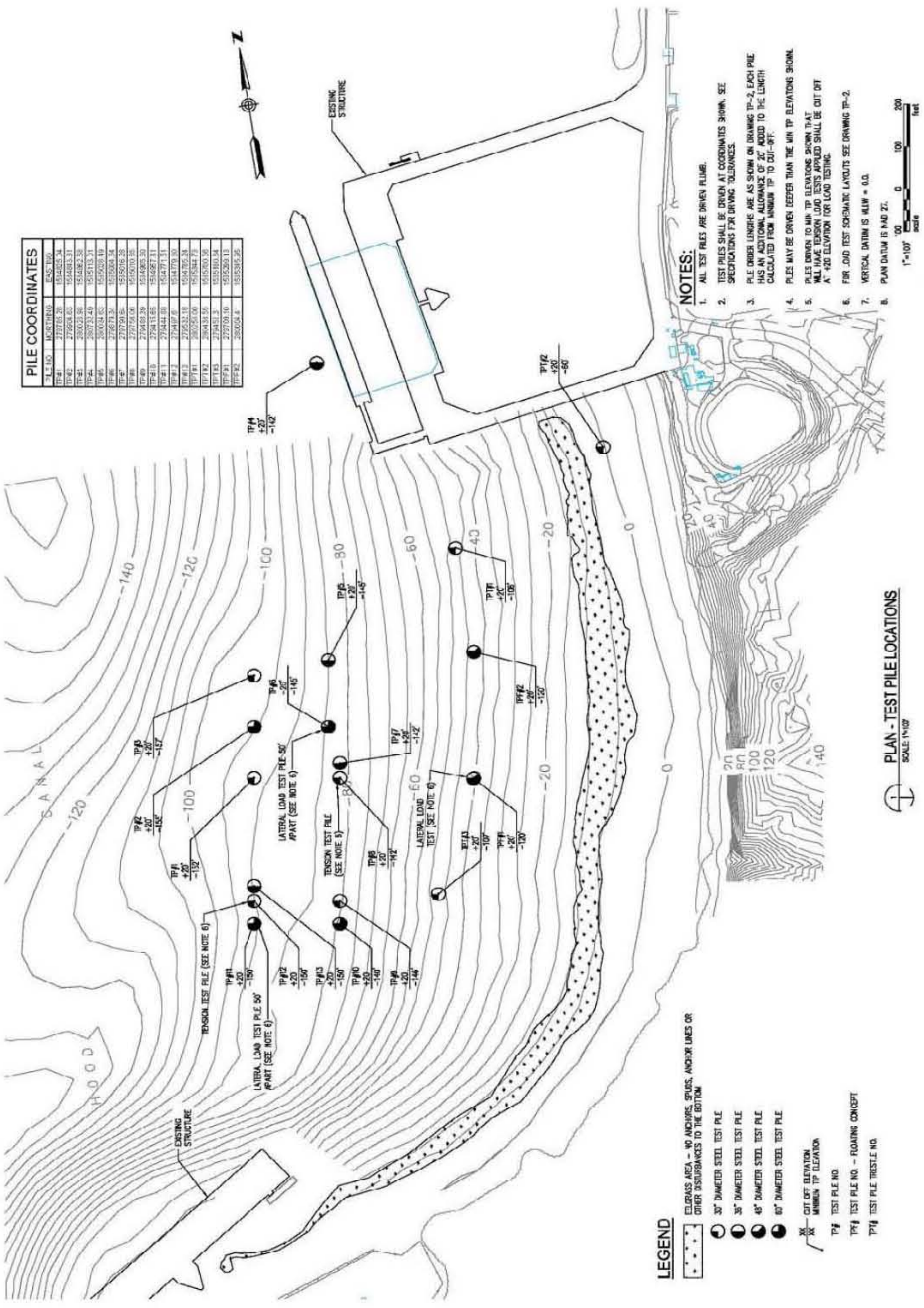


Figure 1-3 Locations of the Proposed Test Piles

involves measurements of lateral displacement versus load for the piles[3]. The lateral load tests will require re-installing two 60-inch piles and one 48-inch pile. The tension load test measures the vertical capacity of a pile[4]. The tension load tests will require driving four reaction piles for each of the two tension load tests. The lateral load test in combination with the tension load test will result in the installation of an additional 11 piles. The Navy expects that some of the initial 18 test piles will be removed and re-driven as part of lateral load and tension tests. Figure 1-4 provides a diagram of the lateral load and tension load tests, and Table 1-1 provides the implementation plan for the Test Pile Program, which provides more specific information regarding each test pile.

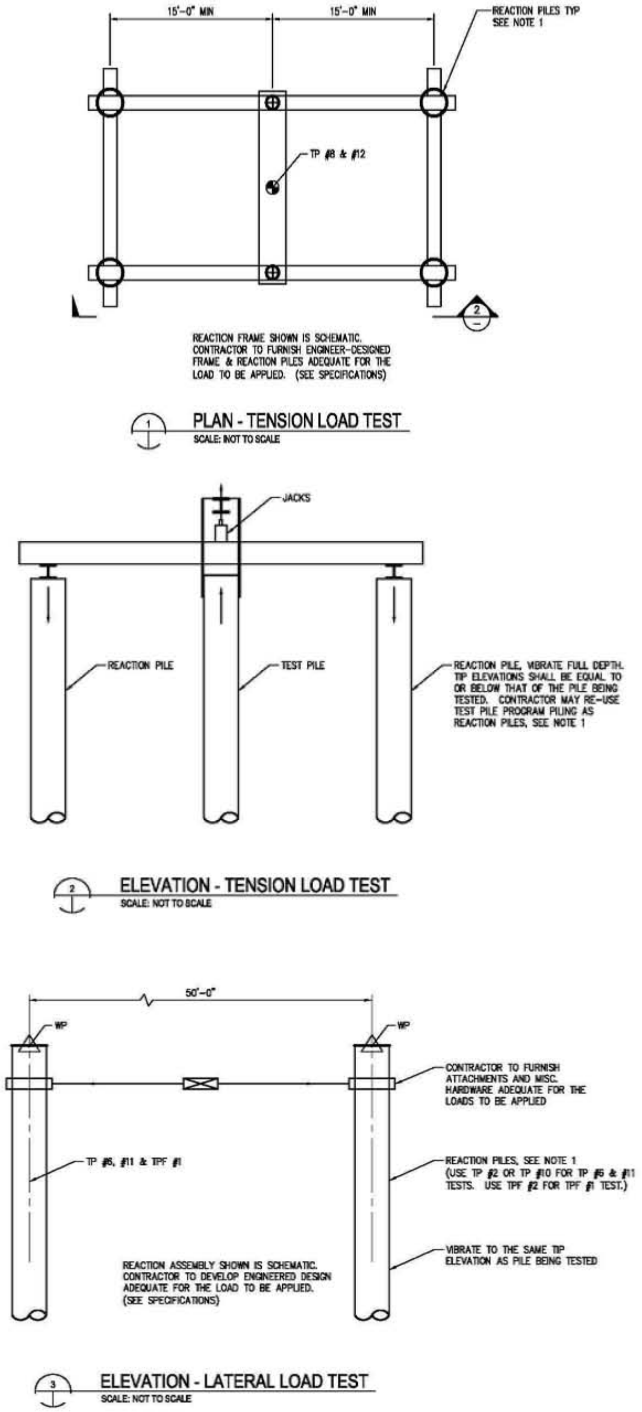
Previous soil boring studies, as well as experience at EHW-1, confirms the substrate appears to be relatively consistent in nature across the site. Therefore, all of the piles will be driven by a vibratory hammer to their initial embedment depths. The 18 test piles would likely require the use of an impact hammer to drive the piles the remaining 10-15 feet into the substrate and for proofing. The impact driver will perform a few blows to warm up the hammer and a number of blows to verify capacity. A Pile Dynamic Analyzer (PDA) will be utilized to confirm capacity. As a contingency, any piles that cannot be driven to their desired depth using the vibratory hammer may require the use of the impact hammer to finish installation. This contingency has been accounted for in the modeling analysis.

The contractor is expected to mobilize two floating barges, one large barge up to 80' wide x 300' long and one medium sized barge approximately 60' wide x 150' long, for the test pile program. These barges will be moved into location with a 44' tug boat. The two barges will share the work load, with the smaller barge working the inboard test piles and the larger barge working the outboard test piles. The smaller barge will likely be on site for approximately two weeks of pile driving while the larger barge will be on site for the full duration of the program which is expected to be approximately 40 days. Only one pile driving rig will be operated at a time.

Sound attenuation measures (*e.g.* Gunderboom Sound Attenuation System™ (SAS)/bubble curtain) will be used during all impact hammer operations, and on two of the vibratory driven piles, to test the practicability of using bubble curtains with a vibratory hammer. The Navy will monitor hydroacoustic levels, as well as the presence and behavior of marine mammals during pile installation and removal. Section 11 provides the details proposed to reduce or mitigate the impacts from the proposed action. All piles will be removed at or before the completion of the Test Pile Program because they could pose a potential navigation risk if left in place. Removal is also necessary because the test piles will not be incorporated into the proposed EHW-2, because exact pile locations for the future structure have not yet been finalized.

3The lateral load test is accomplished by installing two like sized piles to the design penetration depth below the mudline, then pulling the piles towards each other while plotting the deflection for a given load. This test helps to better define lateral load resistance performance and lateral stiffness.

4 The tension load test is accomplished by installing a pile to the design penetration depth below the mudline. Four temporary piles will then be installed around the pile to provide a foundation for a jacking frame. The frame will be constructed to allow for jacking against the four piles in compression while pulling up on the test pile in tension. The load versus displacement information is then recorded.



Source: Berger ABAM

Figure 1-4 Lateral Load and Tension Tests

Table 1-1 Test Pile Program Implementation Plan

Test Pile NO	Suggested Driving Sequence	Pile Type	Vibrate & Impact	Lateral Load Test	Tension Load Test
TP#1	11	30"Ø x 3/4"T x 192"L	X		
TP#2	12	60"Ø x 1"T x 195"L	X		
TP#3	13	30"Ø x 3/4"T x 197"L	X		
TP#4	1	36"Ø x 3/4"T x 182"L	X		
TP#5	2	36"Ø x 3/4"T x 185"L	X		
TP#6	3	60"Ø x 1"T x 185"L	X	X	
TP#7	4	36"Ø x 3/4"T x 182"L	X		X
TP#8	5	30"Ø x 3/4"T x 182"L	X		
TP#9	6	30"Ø x 3/4"T x 180"L	X		
TP#10	7	60"Ø x 1"T x 180"L	X		
TP#11	8	60"Ø x 1"T x 190"L	X	X	
TP#12	9	30"Ø x 3/4"T x 190"L	X		X
TP#13	10	36"Ø x 3/4"T x 190"L	X		
TP#1	2	30"Ø x 3/4"T x 138"L	X		
TP#2	1	30"Ø x 3/4"T x 100"L	X		
TP#3	3	30"Ø x 3/4"T x 147"L	X		
TP#1	2	48"Ø x 1"T x 160"L	X	X	
TP#2	1	48"Ø x 1"T x 160"L	X		

*1 – Welded end hardening using 90 ksi weld material
*2 – Inside edge cutting shoe
TP# - Test Pile Number (See figure 2-2 for locations)
Ø – Diameter of the test piles
L – Length = Mudline + 60' Embedment + 20 MLLW cut off + 20" Driving Allowance
T – Wall thickness
TBD – To Be Determined

2 DATES, DURATION, AND LOCATION OF ACTIVITIES

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

2.1 Dates of Construction

The proposed pile driving activities will only occur between July 16, 2011 through October 31, 2011. All in-water construction activities within the Hood Canal are only permitted during July 16 – February 15, and restricted at any other time of the year in order to protect spawning fish populations.

2.2 Duration of Activities

No work will begin on the proposed action until all required permits and approvals are in place. Under the proposed action, 29 test piles ranging from 30-60 inches in diameter will be driven. The test pile program will require a maximum of 40 work days for completion. A work day is limited to the hours from 2 hours post-sunrise to 2 hours prior to sunset. The 40 work day duration of the program includes the time for the initial pile installations, time for performing the loading tests, and time to remove all of the test piles. A 108 day authorization window (16 July – 31 October) was requested to take into account delays that could occur due to the permitting process, materials availability, and inclement weather that may preclude construction.

The contractor estimates that pile installation could occur at a maximum rate of four piles per day, however, it's more likely that an average of two piles will be installed and removed per day. For each pile installed, the driving time is expected to be no more than one hour for the vibratory portion of the project. The impact driving portion of the project is anticipated to take approximately 15 minutes per pile with no more than 100 blows executed per day. All piles will be extracted using a vibratory hammer. Extraction is anticipated to take approximately 30 minutes per pile. Overall, this results in a maximum of two hours of pile driving per pile, or approximately four hours per day. Therefore, while forty days of total in-water work time is proposed, only a "fraction" of the total work time will actually be spent pile driving.

An average work day (two hours post-sunrise to two hours prior to sunset) is approximately 8-9 hours, depending on the month. While it's anticipated that only 4 hours would need to be spent pile driving per day, to take into account deviations from the estimated times for pile installation and removal and to account for the additional use of the impact pile driver in case of failure of the vibratory hammer to reach the desired embedment depth the Navy modeled potential impacts as if the entire day could be spent pile driving.

Based on the proposed action, the total pile driving time from vibratory or impact pile driving would be less than 15 days (29 piles at an average of 2 per day, assuming a maximum of 8-9 hours of pile driving per day).

2.3 Project Area Description

NBK Bangor is located on the Hood Canal which is a long, narrow fjord-like basin of the western Puget Sound. Oriented northeast to southwest, the portion of the canal from Admiralty Inlet to a large bend, called the Great Bend, at Skokomish, Washington is 52 miles long. East of the Great Bend, the canal extends an additional 15 miles to the headwaters at Belfair. Throughout its 67-mile length, the width of the canal varies from 1-2 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 the northern Hood Canal. The proposed Project Area is located within this region.

The proposed location for the Test Pile Program is immediately south of Explosive Handling Wharf #1 (EHW-1). Two restricted areas are associated with NBK Bangor, Naval Restricted Areas 1 and 2 (33 CFR 334.1220), which are depicted in Figure 2-1 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 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 Area 1 at all times except when magnetic silencing operations are in progress.

2.3.1 Bathymetric Setting

In the northern Hood Canal, water depths in the center of the waterway near Admiralty Inlet vary between 300 to 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 has an important impact on deep circulation and seawater exchange. The NBK Bangor waterfront 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 2-2. The width of the canal is approximately 1.5 miles at the site, 2.2 miles at the northern end of NBK Bangor, and constricts to approximately 1.1 miles near the southern end near Brown 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 2-2).

2.3.2 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 NBK Bangor waterfront area. As a result, the degree of flushing that occurs

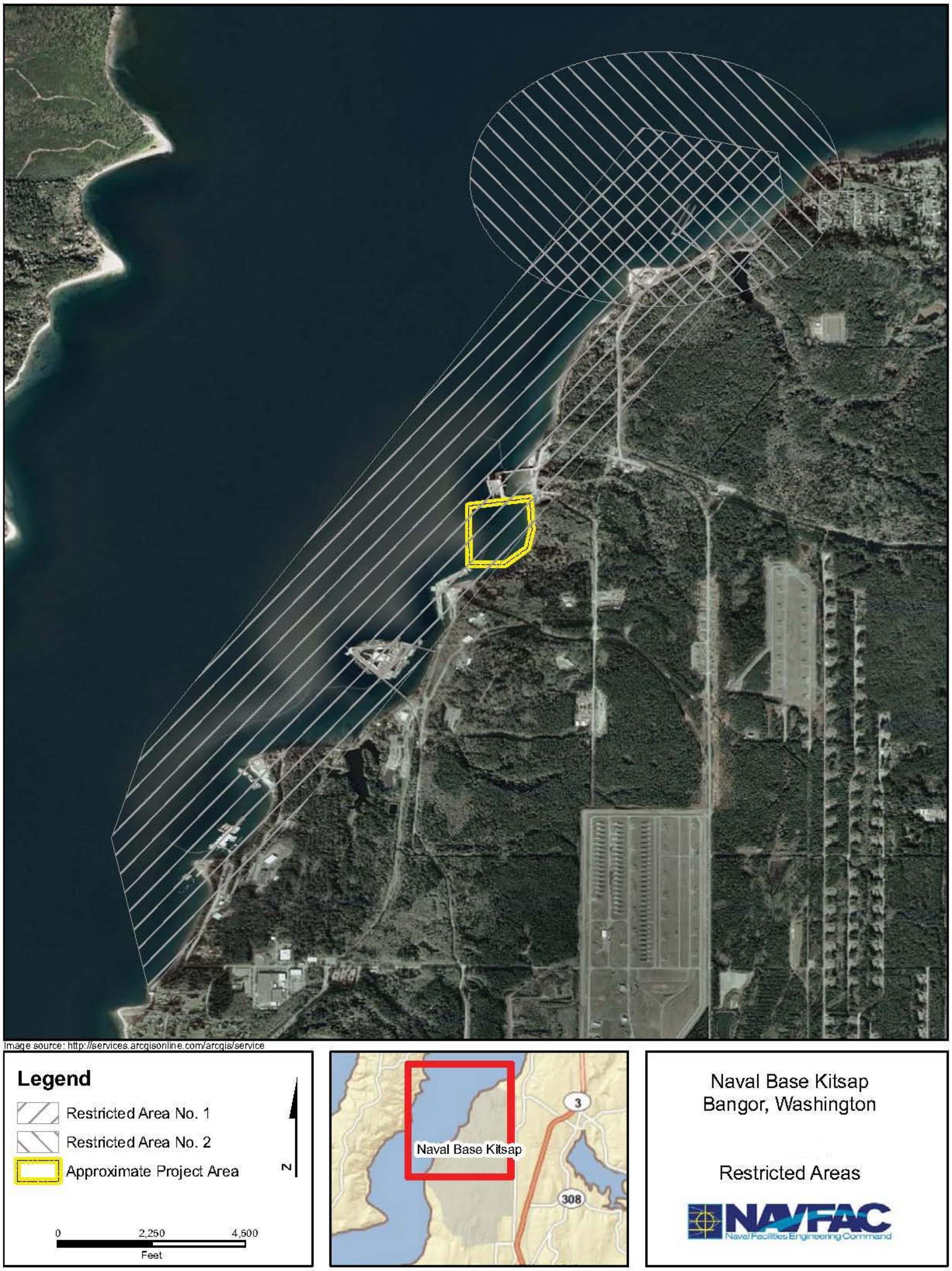


Figure 2-1 NBK Bangor Restricted Areas

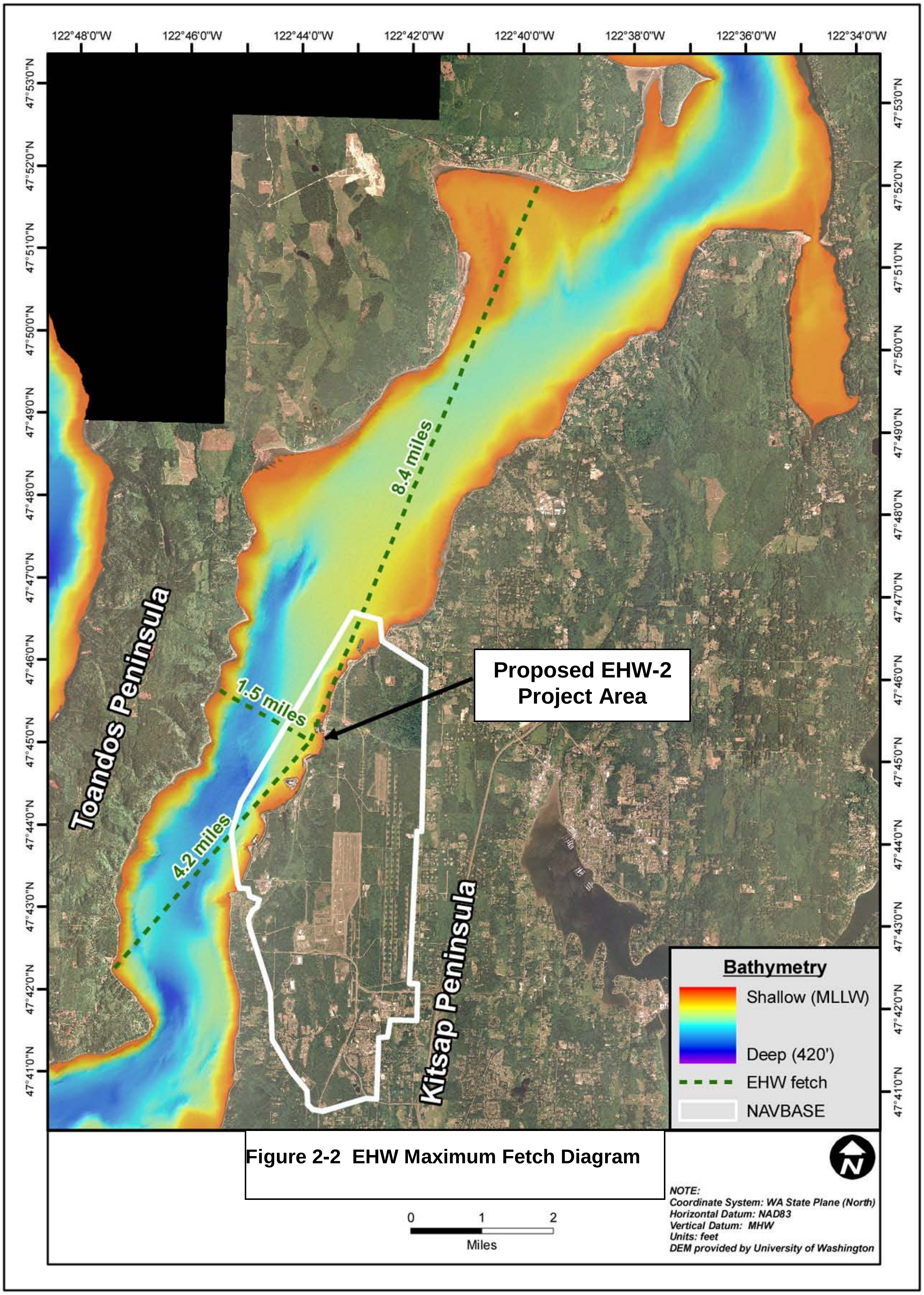


Figure 2-2 EHW Maximum Fetch Diagram

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.

2.3.3 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 on 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 range from 0 to 0.88 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 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 Project Area align 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).

2.3.4 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 2-2). 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) (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).

2.3.5 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 NBK Bangor waterfront are summarized in Table 2-1. Nearshore areas (water depths range from 1-60 m) 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 (2005, 2006)[1]	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.
--- No data were collected at this depth during this sampling month
Data are from 13 nearshore and 4 offshore stations along the NAVBASE Kitsap Bangor waterfront.

2.3.6 Dissolved Oxygen

Concentrations of dissolved oxygen (DO) in extraordinary quality marine surface waters should exceed 7.0 mg/L of DO, allowing for only 0.2 mg/L reductions in the natural condition by human-caused activities (WAC 173-201A). According to the WDOE Marine Water Quality Report for 1998 to 2000, fish are negatively affected by DO concentrations of less than 4.5 mg/L (Newton et al. 2002).

Data from WDOE's Marine Water Quality Monitoring Program for 1998 to 2000 and the Hood Canal Dissolved Oxygen Program (HCDOP) for 2002 to 2004 show that Hood Canal is particularly susceptible to low DO levels (Newton et al. 2002; HCDOP 2005). The 2008 Clean Water Act Section 303(d) list, the most recent list approved by the U.S. Environmental Protection Agency (USEPA), includes five segments within northern Hood Canal impaired by low DO levels (WDOE 2009a). Two of these segments are located along the NBK Bangor waterfront. The low DO for both of those segments is believed to be due to or influenced by human actions (WDOE 2009a). However, these stations are offshore in deep water and would not necessarily be representative of nearshore conditions at the NBK Bangor waterfront.

Although some waters along the NBK Bangor waterfront are on the 303(d) list, mean DO measurements during July 2005 through June 2006 indicate that nearshore stations at the NBK Bangor waterfront consistently met extraordinary quality standards for DO. From July 2005 through June 2006 and January 2007 through April 2008, DO levels met the extraordinary standard for surface waters (0 to 20 feet in depth) year round and for deep water (66 to 197 feet in depth) most of the year (deeper waters can drop to only a fair standard for DO in late summer). In late summer-early fall, DO levels in the action area drop from typical ranges of approximately 6 to 10 mg/L to a range of 4.7 to 9.1 mg/L (Phillips et al. 2009). The variation in mean DO measurements for deeper waters (66 to 197 feet in depth) near the project site was consistent with DO patterns within the rest of Hood Canal. During the late summer and early fall period (July through September 2005), mean DO measurements met fair to excellent quality standards. At 66 to 197 feet in depth, these measurements are on the upper range of low DO conditions measured historically throughout Hood Canal during the late summer and fall periods (Warner 2007). Mean DO measurements at 66 to 197 feet in depth from March through May 2006 met Extraordinary Quality standards.

2.3.7 Stratification and Salinity

The waters of Hood Canal surrounding the Project Area are stratified, with less saline, warmer water overlying colder, more saline bottom waters. 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 (WDOE 1981). Overland flow from much of the western portion of NBK 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).

Between June 2005 and July 2006, surface water salinity levels along the NBK Bangor waterfront ranged from 26 to 35 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 (26.7 PSU) was measured in January 2006 when input from fresh water may have been high due to winter storms and runoff. The range of salinity along the NBK Bangor waterfront is typical for marine waters in Puget Sound (Newton et al. 1998, 2002).

2.3.8 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 2-3. 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.

2.3.9 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 Project Area. 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 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 Hz to 2 kHz regime (Wilson et al. 1985). In addition, wakes from boat traffic causes 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 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 2007). 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.

Slater (2009) measured ambient noise levels along the NBK waterfront from several locations over an approximately one month period from July 10, 2007 – Aug 14, 2007. The location closest to the Project Area, designated as Mid-Point in the report, recorded data from two hydrophones deployed southwest of the Project Area and the existing EHW-1 facility.

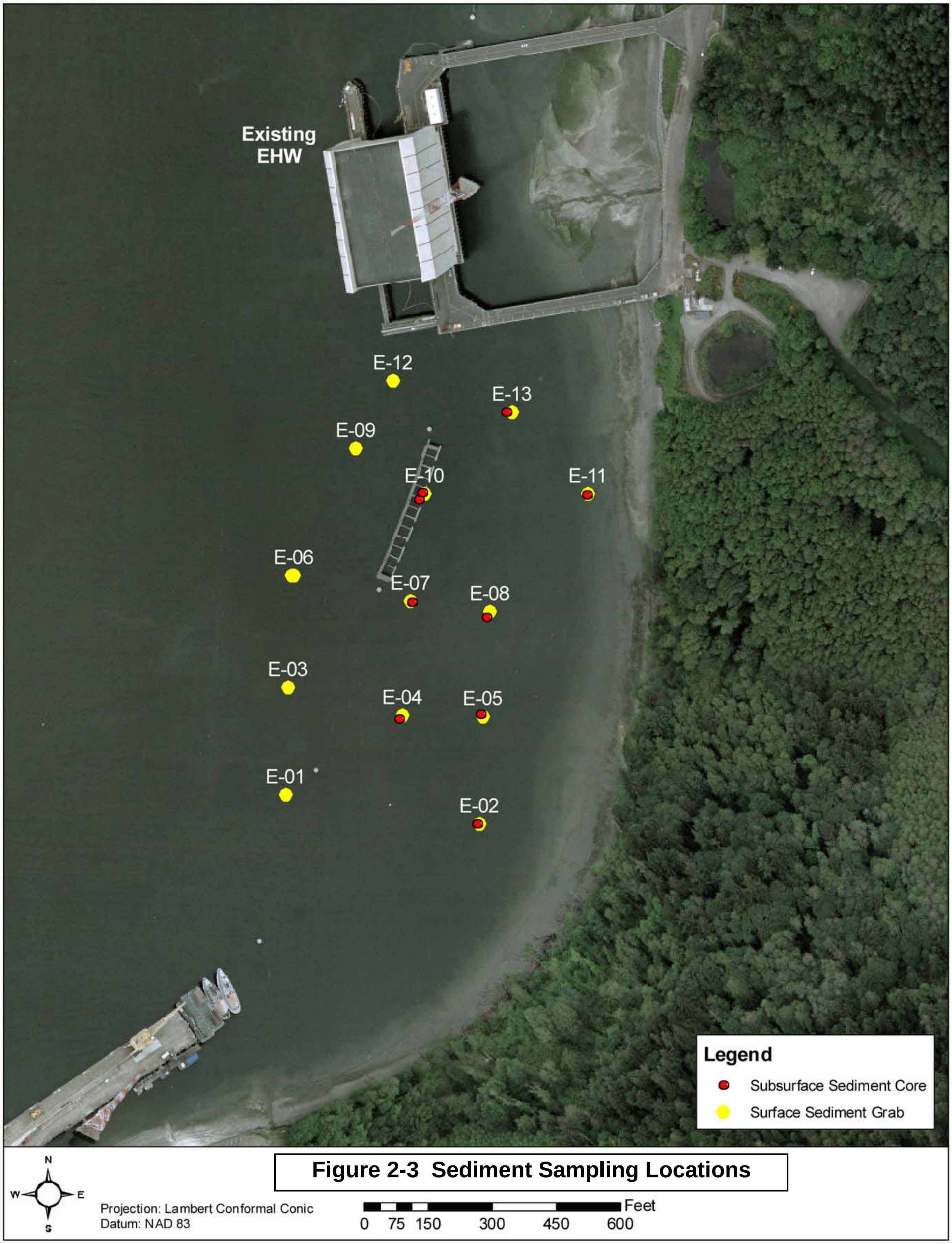


Figure 2-3 Sediment Sampling Locations

Recordings were made 5 minutes per hour throughout the entire study period. Average broadband ambient noise levels measured in the vicinity of the Project Area were 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 EHW-1, 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.

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 80 to 90 dB at the Everett Home Port, 145 dB at Mukilteo ferry terminal, and 131 to 136 dB (peak levels) at Friday Harbor (WSDOT 2007), 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 Project Area, 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 decibels (dB) re 1µPa between 100 hertz (Hz) and 20 kilohertz (kHz).

3 MARINE MAMMAL SPECIES AND NUMBERS

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

There are six marine mammal species, three cetaceans and three pinnipeds, which may inhabit or transit through the waters nearby NBK Bangor in the Hood Canal. These include the transient killer whale, harbor porpoise, Dall's porpoise, Steller sea lion, California sea lion, and the harbor seal. While the Southern Resident killer whale (SRKW) is resident to the inland waters of Washington State and British Columbia, it has not been observed in the Hood Canal in decades, and therefore was excluded from further analysis. The Steller sea lion is the only marine mammal that occurs within the Hood Canal which is listed under the Endangered Species Act (ESA); The U.S. Eastern stock/Distinct Population Segment (DPS) is listed at threatened. All marine mammal species are protected under the Marine Mammal Protection Act (MMPA). Section 3 summarizes the population status and 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 Bangor and their estimated densities within the Project Area.

Table 3-1 Marine Mammals Present in the Hood Canal in the Vicinity of NBK Bangor

SPECIES	STOCK(S) ABUNDANCE[1]	RELATIVE OCCURRENCE IN HOOD CANAL, WASHINGTON	SEASON(S) OF OCCURRENCE	DENSITY IN THE WARM SEASON (INDIVIDUALS PER KM^2)[a]
Steller sea lion *Eumetopias jubatus* Eastern U.S. stock/DPS	48,519[2]	Rare to occasional use	Fall to late spring (Nov – mid April)	0.00
California sea lion *Zalophus californianus* U.S. Stock	238,000[4]	Common	Fall to late spring (Aug –May)	0.410[c]
Harbor seal *Phoca vitulina* WA inland waters stock	14,612[3] (CV = 0.15)	Common	Year-round; resident species in Hood Canal	1.31[b]
Killer whale *Orcinus orca* West Coast transient stock	314[5]	Rare to occasional use	Year-round	0.038[d]
Dall's porpoise *Phocoenoides dalli* CA/OR/WA stock	48,376[3] (CV = 0.24)	Rare to occasional use	Year-round	0.043[e]
Harbor porpoise *Phocoena phocoena* WA inland waters stock	10,682[3] (CV=0.38)	Rare to occasional use	Year-round	0.011 [e]

Sources: [1] NMFS marine mammal stock assessment reports at: http://www.nmfs.noaa.gov/pr/sars/species.htm [2] Angliss and Outlaw, 2008; [3] Carretta *et* al., 2008; [6] Carretta *et* al., 2007; [7] Allen and Angliss, 2010; [a]Warm season refers to the period from May – Oct; [b] Jeffries et al., 2003 and Huber et al., 2001; [c] DoN, 2010a; [d] London, 2006; [e] Agness and Tannenbaum 2009a.

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 lbs and 10 feet in length; females average about 700 lbs 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 2008).

There are two distinct populations of Steller sea lions based on genetics and population trends, separated at 144°W longitude (Loughlin 1997; Angliss and Outlaw 2005). The Eastern U.S. stock, which is the population which may occur within the Project Area, includes the animals east of Cape Suckling, Alaska (144°W) (NMFS 1997; 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 U.S. Stock. The Eastern U.S. stock breeds on rookeries (places where they give birth and mate) located in southeast Alaska, British Columbia, Oregon, and California; there are no rookeries located in Washington.

Population Abundance

The U.S. Eastern stock was estimated to number between 46,000 and 58,000 animals in 2002, and has been increasing approximately 3 percent per year since the late 1970s (NMFS 2008; Pitcher *et* al. 2007). The most recent population estimate for the Eastern North Pacific stock of the Steller sea lion, which occurs along the WA coast and Puget Sound, is 48,519 individuals (Angliss and Outlaw 2008). The U.S. 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 central California). Since the mid-1970s the annual rate of increase has been approximately 3 percent (Angliss and Outlaw 2008). Although the stock size has increased, the status of this stock relative to its optimum sustainable population (OSP) is unknown (Angliss and Outlaw 2008).

3.2 Non-ESA Listed Marine Mammals

3.2.1 California Sea Lion

Species Description

California sea lions are also members of the Otarrid 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. 2007).

The California sea lion is sexually dimorphic. Males may reach 1,000 pounds and 8 feet in length; females grow to 300 pounds and 6 feet in length. Their color ranges from chocolate brown in males to a lighter, golden brown in females. At around 5 years of age, males develop a bony bump on top of the skull called a sagittal crest. The crest is visible in the "dog-like" profile of male sea lion heads, and hair around the crest gets lighter with age.

<u>*Population Abundance*</u>

The U.S. stock of California sea lions may occur in the marine waters nearby NBK Bangor. The estimated stock is 238,000 and the minimum population size of this stock is 141,842 individuals (Carretta *et* al. 2007). These numbers are from counts during the 2001 breeding season of animals that were ashore at the four major rookeries in southern California and at haulout 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. 2007). 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

<u>*Species Description*</u>

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. 2007). The inland waters of Washington state stock is the only stock that is expected to occur within the Project Area.

The average weight for adult seals is about 180 pounds and males are slightly larger than females. Male harbor seals weight up to 245 lbs and measure approximately 5 feet in length. The basic color of harbor seals' coat is gray and mottled but highly variable, from dark with light color rings or spots to light with dark markings (NMFS 2008c).

<u>*Population Abundance*</u>

Estimated population numbers for the inland waters of Washington, including the Hood Canal, Puget Sound, and the Strait of Juan de Fuca out to Cape Flattery, are 14,612 (CV = 0.15) individuals (Carretta *et* al. 2007). The Harbor seal is the only species of marine mammals that is consistently abundant and considered resident in the 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, 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

<u>*Species Description*</u>

Killer whales are members of the Delphinid family and are the most widely distributed cetacean (*e.g.* whales, dolphins, and porpoises) species in the world. Killer whales have a distinctive color pattern, with black dorsal (top) and white ventral (bottom) portions. They also have a conspicuous white patch above and behind the eye and a highly variable gray or white saddle area behind the dorsal fin. The species shows considerable sexual dimorphism. Adult males develop larger pectoral flippers, dorsal fins, tail flukes, and girths than females. Male adult killer whales can reach up to 32 ft in length and weight nearly 22,000 lbs (10,000 kg); females reach 28 ft in length and weigh up to 16,500 lbs (7,500 kg).

Based on appearance, feeding habits, vocalizations, social structure, and distribution and movement patterns there are three types of populations of killer whales (Wiles 2004; NMFS 2005). The three distinct forms or types of killer whales recognized in the North Pacific Ocean are: 1) Residents, 2) Transients, and 3) Offshores. The resident and transient populations have been divided further into different subpopulations based mainly on genetic analyses and distribution; not enough is known about the offshore whales to divide them into subpopulations (Wiles, 2004).

Within the transient ecotype, association data (Ford et al. 1994, 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) confirms that three communities of transient whales exist and represent three discrete populations: 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 is a trans-boundary stock, with minimum counts for the population of "transient" killer whales coming from various photographic datasets. Combining these counts of cataloged "transient" whales gives a minimum number of 314 individuals for the West Coast Transient stock (Allen and Angliss 2010). 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 the North Pacific Ocean. They can reach a maximum length of just under 8 ft and weight up to 480 lbs. Males are slightly larger and thicker than females, which reach lengths of just under 7 ft long. The body of Dall's porpoises is a very dark gray or black in coloration with variable contrasting white "throracic" panels and white "frosting" on the dorsal fin and tail that distinguish them from other cetacean species. These markings and colorations vary with geographic region and lifestage, with adults having more distinct patterns.

Based on NMFS stock assessment reports, Dall's porpoises within the Pacific U.S. Exclusive Economic Zone (EEZ) are divided into two discrete, noncontiguous areas: 1) waters off California, Oregon, and Washington, and 2) those in Alaskan waters (Carretta *et* al. 2008). Only individuals from the CA/OR/WA stock may occur within the Project Area.

Population Abundance

The NMFS population estimate, recently updated in 2008 for the California/Oregon/Washington stock, is 48,376 (CV – 0.24) which is based on vessel line transect surveys by Barlow and Forney (2007) and Forney (2007) (Carretta *et* al. 2008). Additional numbers of Dall's porpoise occur in the inland waters of WA state, but the most recent estimate obtained in 1996 (900 animals; CV = 0.40) is over 10 years old (Calambokidis et al. 1997) and 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 Pacific U.S. coast. Harbor porpoises are small with makes reaching average lengths of approximately 5 ft; Females are slightly larger with average length of 5.5 ft. The average adult harbor porpoise weights between 135 and 170 lbs. Harbor porpoises have a dark grey coloration on their backs, which their belly and throats are white. They have a dark grey chin patch and intermediate shades of grey along their sides.

Recent preliminary genetic analyses of samples ranging from Monterey, CA to Vancouver Island, BC indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers *et* al. 2002). Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nevertheless, based on genetic data and density discontinuities identified from aerial surveys, NMFS identifies 8 stocks in the Northeast Pacific Ocean. Pacific coast harbor porpoise stocks include: 1) a Monterey Bay stock, 2) a San Francisco-Russian River stock, 3) a northern California/southern Oregon stock, 4) an Oregon/Washington coast stock, 5) an Inland Washington stock, 6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. Only individuals from the Inland waters of Washington stock may occur in the Project Area.

Population Abundance

Aerial surveys of the inside waters of Washington and southern British Columbia were conducted during August of 2002 and 2003 (J. Laake, unpubl. data). 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 porpoise 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, unpubl. data). 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. 2008).

3.3 Marine Mammal Modeling Parameters

3.3.1 Spatial Distribution

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 productivity, lower predation, safe calving, foraging, etc. Density can occasionally be calculated for smaller areas that are used regularly by marine mammals, but more often than not there are insufficient scientific data to represent the spatial distribution of animals for small regions such as the construction area encompassed by the Project Area.

Therefore, given the lack of availability of NBK Bangor specific marine mammal data, this IHA application assumes that marine mammals are uniformly distributed in the Project Area.

3.3.2 Submergence

Cetaceans spend their entire lives in the water and spend most of their time (>90% 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% 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. A few seals and sea lions have been sighted hauling out in the vicinity of NBK Bangor. In the water, pinnipeds (seals and sea lions) 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 often 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 at NBK Bangor, the Navy assumed that that all three cetacean species and two pinniped species that may be found in the vicinity of NBK Bangor (Steller sea lion, California sea lion, killer whale, Dall's porpoise, and harbor porpoise) spend 100% 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 and Huber et al 2001).

4 STATUS AND DISTRIBUTION OF MARINE MAMMAL SPECIES OR STOCKS THAT COULD POTENTIALLY BE AFFECTED

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 mammals species within the marine waters adjacent to NBK 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 Endangered Species Act (ESA).

4.1 ESA-Listed Marine Mammals

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

Status and Management

The Steller seal lion was originally listed as threatened under the ESA in 1990. In 1997, the NMFS reclassified Steller sea lions as two subpopulations, listing the Western Stock as endangered under the ESA, and maintaining threatened status for the Eastern stock (NMFS 1997). There is a final revised species recovery plan that addresses both stocks (NMFS 2008).

Critical habitat has been designated for the Steller sea lion (NMFS 1993). Critical habitat includes so-called "aquatic zones" that extend 3,000 ft (1 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in Oregon and California (NMFS 2008). 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

Steller sea lions are found along the coasts of Washington, Oregon, and northern California where they occur at breeding rookeries and numerous haulout locations along the coastline (Jeffries *et* al. 2000; Scordino 2006). From breeding rookeries in northern California (St. George Reef) and southern Oregon (Rogue Reef), male Steller sea lions often disperse widely outside of the breeding season (Scordinoo 2006). Based on mark recapture sighting studies, males migrate back into these Oregon and California locations from winter feeding areas in Washington, British Columbia, and Alaska (Scordino 2006).

In Washington, Steller sea lions use haulout sites primarily along the outer coast from the Columbia River to Cape Flattery, as well as along the Vancouver Island side of the Strait of Juan de Fuca (Jeffries *et* al. 2000). Numbers vary seasonally in Washington with peak numbers present during the fall and winter months (Jeffries *et* al. 2000). Steller Sea lions are occasionally present in the Puget Sound at the Toliva Shauls haul-out site in south Puget Sound (Jeffries et al. 2000). At NBK Bangor, Steller sea lions were observed hauled out on submarines at Delta Pier on several occasions from 2008 through 2010 during winter and spring months (Bhuthimethee 2008, personal communication; Walters 2010, personal communication). Steller sea lions likely occupy habitats in Hood Canal similar to those of the California sea lion and harbor seal, which include marine water habitats for foraging and manmade structures for haul out.

<u>*Behavior and Ecology*</u>

Steller sea lions are opportunistic predators, feeding primarily on fish and cephalopods, and their diet varies geographically and seasonally (Merrick et al. 1997).Foraging habitat is primarily shallow, nearshore and continental shelf waters; some Steller sea lions feed in freshwater rivers (Reeves et al. 1992, Robson 2002). They also are known to feed in deep waters past the continental shelf break (Jefferson 2005). 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). Haulout and rookery sites are located on isolated islands, rocky shorelines, and jetties. Steller sea lions also haul out on buoys, rafts, floats, and Navy submarines in the Puget Sound (Jeffries et al. 2000, DoN 2001a). Females reach sexual maturity at 4 to 5 years of age (Pitcher and Calkins 1981). In the Pacific Northwest, breeding rookeries are located in British Columbia, Oregon, and northern California. There are no rookeries in Washington (NMFS 1992b, Angliss and Outlaw 2005).

<u>*Acoustics*</u>

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, in prep). 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). 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 (Mulsow and Reichmuth 2008). Maximum sensitivity was found at 10 kHz, where the subject had a mean threshold of 7 dB re 20 μPa.

The underwater hearing of two Steller sea lions were tested, the hearing threshold of the male was significantly different from that of the female. The range of best hearing for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1 μPa-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 1 μPa-m) at 25 kHz. However, because of the small number of animals tested, the findings could not be attributed to 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

<u>*Distribution*</u>

The geographic distribution of California sea lions includes a breeding range from Baja California to southern California. During the summer, California sea lions breed on islands from the Gulf of California to the Channel Islands and seldom travel more than about 31 miles (50 km) from the islands (Bonnell *et* al. 1983). The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente (Le Boeuf and Bonnell 1980; Bonnell and Dailey 1993). Their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability (Bonnell and Ford 1987).

The non-breeding distribution extends from Baja California north to Alaska for males, and encompasses the waters of California and Baja California for females (Reeves et al. 2008;

Maniscalco et al. 2004).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 (kilometers) offshore (Jefferson *et* al. 1993). Females and juveniles tend to stay closer to the rookeries (Bonnell *et* al 1983).

Peak abundance in the Puget Sound is September to May. Although there are no regular California sea lion haulouts within the Hood Canal (Jeffries et al. 2000), they often haul out at several opportune areas. They are known to utilize man-made structures such as piers, jetties, offshore buoys, and oil platforms (Riedman 1990). California sea lions in the Puget Sound even haul out on log booms and U.S. Navy submarines, and are often seen rafted off river mouths (Jeffries *et* al. 2000; DoN 2001). As many as 40 California sea lions have been observed hauled ot at NBK Bangor on manmade structures – submarines, the floating security fence, and barges (Agness and Tannenbaum 2009a; Tannenbaum et al 2009a; Walters 2009, personal communication). California sea lions have also been observed swimming in the Hood Canal in the vicinity of the Project Area on several occasions and likely forage in both nearshore marine and inland marine deeper waters (Navy 2001).

<u>Behavior and Ecology</u>

California sea lions feed on 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 fish such as hake, walleye pollock, herring, and spiny dogfish (Calambokidis and Baird 1994). In some locations where sea lions and salmon runs exist, California sea lions also feed on returning adult and out-migrating juvenile salmonids (London 2006). Sexual maturity occurs at around four to five years of age for California sea lions (Heath 2002). California sea lions are gregarious during the breeding season and social on land during other times.

<u>Acoustics</u>

On land, California sea lions make incessant, raucous barking sounds; these have most of their energy at less than 2 kHz (Schusterman et al. 1967). 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).

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. Octave band noise levels of 65 to 70 dB above the animal's threshold produced an average TTS of 4.9 dB in the California sea lion (Kastak et al. 1999). Center frequencies were 1,000 hertz (Hz) for corresponding threshold testing at 1000 Hz and 2,000 Hz for threshold testing at 2,000 Hz; the duration of exposure was 20 minutes.

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

<u>Distribution</u>

Harbor seals are coastal species, rarely found more than 12 miles (20 km) from shore, and frequently occupy bays, estuaries, and inlets (Baird 2001). Individual seals have been observed several miles upstream in coastal rivers. Ideal harbor seal habitat includes haulout sites, shelter during the breeding periods, and sufficient food (Bjorge 2002). Haulout areas can include intertidal and subtidal rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and recreational floats (Wilson 1978; Prescott 1982; Schneider and Payne 1983; Gilber and Guldager 1998; Jeffries *et* al. 2000). Human disturbance can affect haul-out choice (Harris *et* al. 2003).

Harbor seals occur throughout Hood Canal and are seen relatively commonly in the area. They are year-round, non-migratory residents, and pup (give birth) in Hood Canal. Surveys in the Hood Canal from the mid-1970s to 2000 show a fairly stable population between 600-1,200 seals (Jeffries et al. 2003). Harbor seals have been observed swimming in the waters along NBK Bangor in every month of surveys conducted from 2007 to 2010 (Agness and Tannenbaum 2009b; Tannenbaum et al. 2009b). On the NBK Bangor waterfront, 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 fence, buoys, barges, marine vessels, and logs (Agness and Tannebaum 2009a; Tannenbaum et al. 2009a). The main haul-out locations for harbor seals in Hood Canal are located on river delta and tidal exposed areas at Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Skokomish River mouths (see Figure 4-1), with the closest haul-out area to the Project Area being 10 miles southwest of NBK Bangor at Dosewallips River Mouth (London 2006).

<u>Behavior and Ecology</u>

Harbor seals are typically seen in small groups resting on tidal reefs, boulders, mudflats, man-made structures, and sandbars. 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). Although harbor seals in the Pacific Northwest are common in inshore and estuarine waters, they primarily feed at sea (Orr et al. 2004) during high tide. Researchers have found that they complete both shallow and deep dives during hunting depending on the availability of prey (Tollit et al. 1997). Their diet in Puget Sound consists of many of the prey resources that are present in the nearshore and deeper waters of NBK Bangor, including Pacific hake and Pacific herring and adult and out-migrating juvenile salmonids. Harbor seals in Hood Canal are known to feed on returning adult salmon, including threatened summer-run chum. Over a five year study of harbor seal predation in the Hood Canal, the average percent escapement of summer-run chum consumed was 8 percent (London 2006).

Harbor seals mate at sea and females live birth during the spring and summer; although the "pupping season" varies by latitude. In coastal and inland regions of Washington, pups are born

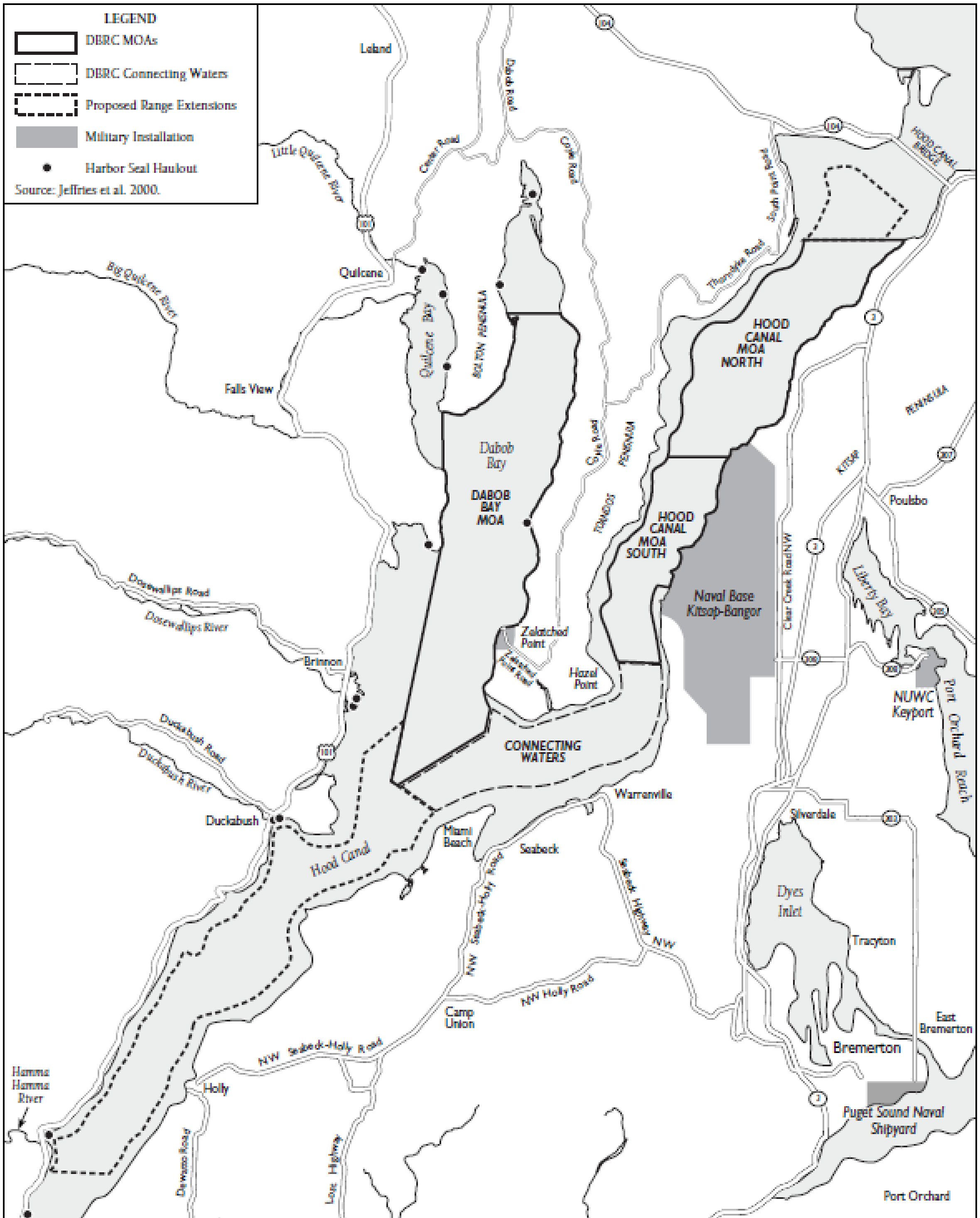


Figure 4-1 Pinniped Haulouts within the Vicinity of NBK Bangor

from April through January. Pups are generally born earlier in the coastal areas and later in the Puget Sound/Hood Canal region (Calambokidis and Jeffries 1991; Jeffries et al. 2000). Suckling harbor seal pups spend as much as 40 percent of their time in the water (Bowen et al. 1999).

Acoustics

In air, harbor seal males produce a variety of low-frequency (<4 kHz) vocalizations, including snorts, grunts, and growls. Male harbor seals produce communication sounds in the frequency range of 100 to 1,000 Hz (Richardson et al. 1995). Pups make individually unique calls for mother recognition that contain multiple harmonics with main energy below 0.35 kHz (Bigg 1981, Thomson and Richardson 1995). Harbor seals hear nearly as well in air as underwater and had lower thresholds than California sea lions (Kastak and Schusterman 1998). Kastak and Schusterman (1998) reported airborne low frequency (100 Hz) sound detection thresholds at 65.4 dB re 20 μPa for harbor seals. In air, they hear frequencies from 0.25 kHz - 30 kHz and are most sensitive from 6 to 16 kHz (Richardson 1995, Terhune & Turnbull 1995, Wolski et al. 2003).

Adult males also produce underwater sounds during the breeding season that typically range from 0.025 to 4 kHz (duration range: 0.1 s to multiple seconds; Hanggi and Schusterman 1994). Hanggi and Schusteman (1994) found that there is individual variation in the dominant frequency range of sounds between different males, and Van Parijs et al. (2003) reported oceanic, regional, population, and site-specific variation that could be vocal dialects. In water, they hear frequencies from 1 to 75 kHz (Southall 2007) and can detect sound levels as weak as 60 to 85 dB re 1 μPa within that band. They are most sensitive at frequencies below 50 kHz; above 60 kHz sensitivity rapidly decreases.

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

Distribution

The geographical range of transient killer whales includes the northeast Pacific, with preference for coastal waters of southern Alaska and British Columbia (Krahn et al. 2002). Transient killer whales in the eastern North Pacific spend most of their time along the outer coast, but visit Hood Canal and the Puget Sound in search of harbor seals, sea lions, and other prey. Transient occurrence in inland waters appears to peak during August and September (Morton 1990; Baird and Dill 1995; Ford and Ellis 1999) which is the peak time for harbor seal pupping, weaning, and post-weaning (Baird and Dill 1995). In 2003 and 2005, small groups of transient killer whales (11 and 6 individuals, respectively) visited 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.

Behavior and Ecology

Transient killer whales show greater 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). Transient killer whales feed on marine mammals and some seabirds, but apparently no fish (Morton 1990, Baird and Dill 1996, Ford et al. 1998, Ford and Ellis 1999, Ford et al. 2005). 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 10 animals and their social organization generally is more flexible than the resident killer whale (Morton 1990, Ford and Ellis 1999). These differences in social organization probably relate to differences in foraging (Baird and Whitehead 2000). There is no information on the reproductive behavior of killer whales in this area.

Acoustics

Killer whales produces a wide variety of clicks and whistles, but most of their sounds are pulsed with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson 1995; Richardson et al. 1995). Source levels of echolocation signals range between 195 and 224 dB re 1 μPa-m peak-to-peak, dominant frequencies ranging from 20 to 60 kHz, and durations of about 0.1 sec (Au et al. 2004). Source levels associated with social sounds have been calculated to range between 131 to 168 dB re 1 μPa-m and vary with vocalization type (Veirs 2004).

Both behavioral and auditory brainstem response technique 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).

4.2.4 Dall's Porpoise (*Phocoenoides dalli*), CA/OR/WA Stock

Distribution

The Dall's porpoise is found 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 porpoise 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 porpoise are observed throughout the year in the Puget Sound north of Seattle (Osborne et al. 1998) and are seen occasionally in southern Puget Sound. Dall's porpoises may also occasionally occur in Hood Canal (Jeffries 2006, personal communication). Nearshore habitats used by Dall's porpoise could include the marine habitats found in the inland marine waters of the Hood Canal. A Dall's porpoise was observed in the deeper water at NBK Bangor in summer 2008 (Tannenbaum et al. 2009a).

Behavior and Ecology

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). Groups of Dall's porpoises generally include fewer than 10 individuals and are fluid, probably aggregating for feeding (Jefferson 1990 and 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 10-12 months. Breeding and calving 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 1989). Resident Dall's porpoise breed in Puget Sound from August to September.

Acoustics

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 between 120 and 160 kHz (Jefferson 1988). There is no published data on the hearing abilities of this species.

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

Distribution

Harbor porpoise 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 (Read 1999) or south of Point Conception (Hubbs 1960; Barlow and Hanan 1995). Harbor porpoises can be found year-round primarily in the coastal shallow waters of 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. 2002). Harbor porpoises are known to occur in Puget Sound year round (Osmek et al. 1996, 1998; Carretta et al. 2007), and may occasionally occur in Hood Canal (Jeffries 2006, personal communication). Harbor porpoise observations in northern Hood Canal have increased in recent years (Calambokidis 2010, personal communication). A harbor porpoise was seen in deeper water at NBK Bangor during 2010 field observations (SAIC staff observations 2010).

Behavior and Ecology

Harbor porpoises are non-social animals usually seen in small groups of 2 to 5 animals. Little is known about their social behavior. Harbor porpoises can be opportunistic foragers but primarily consume schooling forage fish (Osmek et al. 1996; Bowen and Siniff 1999; Reeves et al. 2002). Along the coast of Washington, harbor porpoise primarily feed on Pacific herring (C*lupea pallasii*), market squid and smelts (Gearin et al. 1994). Females reach sexual maturity at 3-4 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).

Acoustics

Harbor porpoise vocalizations include clicks and pulses (Ketten 1998), as well as whistle-like signals (Verboom and Kastelein 1995). The dominant frequency range is 110 to 150 kHz, with source levels of 135 to 177 dB re 1 μPa-m (Ketten 1998). Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range (Verboom and Kastelein 1995).

A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 μPa-m (Andersen 1970); however, auditory-evoked potential studies showed a much higher frequency of approximately 125 to 130 kHz (Bibikov 1992). The auditory-evoked potential method suggests that the harbor porpoise actually has two frequency ranges of best sensitivity. 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).

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 Incidental Harassment Authorization (IHA) for the take of small numbers of marine mammals, by Level B behavioral harassment only, incidental to conduction pile driving operations associated with the Test Pile Program at NBK Bangor, Washington. The Navy requests an IHA for incidental take of marine mammals described within this application for one year commencing in July 2011 (or the issuance date, whichever is later). It is anticipated that the Navy would request an annual renewal of the IHA, if the project was not completed within the year. The Navy is not requesting a multi-year Letter of Authorization (LOA) at this time because the activities described herein are not expected to rise to the level of injury or death, which would require a LOA.

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 C.F.R, 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 pers. comm. 2007a).

5.1 Take Authorization Request

Under Section 101 (a)(5)(D) of the MMPA, the Navy requests an IHA from NMFS for: Level B take (behavioral harassment) of small numbers 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, 2011.

The exposure assessment methodology taken in this IHA application 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% of the time, and the formulas used to estimate transmission loss used idealized parameters, which are unrealistic in nature. Modeling was conducted for the work window from 16 July – 31 October.

The analysis for the Test Pile Program predicts 1,180 potential exposures (see Section 6 for estimates of exposures by species and season) from pile driving over the course of the project that could be classified as Level B harassment as defined under MMPA. The Navy's mitigation procedures, presented in Section 11, include monitoring of mitigation zones prior to the initiation of pile driving, the use of sound attenuation devices (*e.g.* Gunderboom SAS™/bubble curtain) on all impulsive and some vibratory 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, though the amount of that decrease cannot be quantified.

The Navy does not anticipate that 1,180 actual harassment incidents will result from the Test Pile Porgram. 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 take (Level B harassment) of 1,180 marine mammals over the course of one year in this IHA application.

5.2 Method of Incidental Taking

Pile driving activities associated with the Test Pile Program as outlined in Sections 1 and 2 have the potential to disturb or displace small numbers of marine mammals. Specifically, the proposed activities may result in "take" in the form of 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 hammers 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, no impact pile driving will occur without the use of a noise attenuation system *(e.g*. Gunderboom SAS™/bubble curtain), 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 other nearby construction activities within the 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 National Marine Fisheries Service (NMFS) application for Incidental Harassment Authorizations (IHAs) 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 take 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 will be 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 take by Level B harassment. 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 1 μPa." 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 that human hearing 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.

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 one microPascal (dB re 1 µPa). 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 1 µPa unless otherwise noted.

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 1 µPa	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 1 µPa.
Root-Mean-Square (rms), dB re 1 µPa	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.[5]
Sound Exposure Level (SEL), dB re 1 μPa^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 6 to 12 Hz band-center frequency sound pressure over a frequency range (e.g., 10 to 10,000 Hz in this application).
A-Weighting Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A- or C-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.

[5] 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 (ms) period. Most of the energy was contained in the first 30 to 50 ms. 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-ms rise time) correlated to the rms level measured over the duration of the pulse.

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, 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.

Table 6-2 Representative Noise Levels of Anthropogenic Sources

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

In-water construction activities associated with the 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 produce 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 an increased capacity to induce physical injury as 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 of these 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, machinery operations such as drilling or dredging, vibratory pile driving, and active sonar systems (Southall et al. 2007). The duration of such sounds, as received at a distance, can be greatly extended in highly reverberant environments (Southall et al. 2007).

6.4 Sound Exposure Criteria and Thresholds

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

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 2005b). To date, no studies have been conducted that examine impacts to marine mammal from pile driving sounds from which empirical noise thresholds have been established. Current NMFS practice regarding exposure of marine mammals to high level sounds is that cetaceans and pinnipeds exposed to impulsive sounds of 180 and 190 dB rms or above, respectively, are considered to have been taken by Level A (*i.e.*, injurious) harassment. Behavioral harassment (Level B) is considered to have occurred when marine mammals are exposed to sounds at or above 160dB rms for impulse sounds (*e.g.*, impact pile driving) and 120dB rms for continuous noise (*e.g.*, vibratory pile driving), but below injurious thresholds. The application of the 120 dB rms threshold can sometimes be problematic because this threshold level can be either at or below the ambient noise level of certain locations. In fact, there is no evidence that pinnipeds will react to continuous sounds at this level and more research is needed (Hollingshead pers. comm. 2008). As a result, these levels are considered precautionary (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 current Level A (injury) and Level B (disturbance) thresholds are provided in Table 6-3.

6.4.1 Limitations of Existing Noise Criteria

The 120 dB rms threshold level for continuous noise originated from research conducted by Malme et al. (1984) for California gray whale response to industrial sounds (Hollingshead pers. comm. 2008). This 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 by 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 dB re 1 μPa rms generally do not appear to induce strong behavioral responses. In addition, Moulton et al. 2005 concluded that ringed seal densities were not significantly reduced by intense construction activities at the study site (Northstar). Ringed seal hearing in water (Terhune and Ronald 1975) and presumably in air is probably similar to that of other phocinid seals (e.g. harbor seals) (Richardson et al. 1995).

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)	Underwater Vibratory Pile Driving Criteria (*e.g.* non-pulsed/continuous sounds) (re 1 µPa)		Underwater Impact Pile Driving Criteria (*e.g.* pulsed sounds) (re 1 µPa)	
	Disturbance Guideline Threshold (Haulout)[1]	Level A Injury Threshold	Level B Disturbance Threshold	Level A Injury Threshold	Level B Disturbance Threshold
Cetaceans (whales, dolphins, porpoises)	N/A	180 dB rms	120 dB rms	180 dB rms	160 dB rms
Pinnipeds (seals, sea lions, walrus; except harbor seal)	100 dB rms (unweighted)	190 dB rms	120 dB rms	190 dB rms	160 dB rms
Harbor seal	90 dB rms (unweighted)	190 dB rms	120 dB rms	190 dB rms	160 dB rms

[1] Sound level at which pinniped haulout disturbance has been documented. Not an official threshold, but used as a guideline.
dB = decibel; N/A = not applicable; rms = root mean square

6.4.2 Ambient Noise

Ambient noise by definition is background noise and it has not 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 Project Area 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 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 Project Area, 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.

Airborne noise levels at NBK Bangor vary based on location but are estimated to average around 65 dBA (A-weighted decibels) in the residential and office park areas, with traffic noise ranging from 60 to 80 dBA during daytime hours (Cavanaugh and Tocci 1998). The highest levels of airborne noise are produced along the waterfront and at the ordnance handling areas where estimated noise levels range from 70 to 90 dBA and may peak at 99 dBA for short durations.

These higher noise levels are produced by a combination of sound sources including heavy trucks, fork lifts, cranes, marine vessels, mechanized tools and equipment, and other sound-generating industrial/military activities. All references to noise relate to noise in the air as opposed to underwater noise, and noise measurements are not corrected for distance unless specifically indicated.

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. The formula for transmission loss is:

$$TL = B * \log_{10}(R) + C * R, \text{ where}$$
B = logarithmic (predominantly spreading) loss
C = linear (scattering and absorption) loss
R = range from source in meters

For all underwater calculations in this assessment, linear loss (C) was not used (i.e. C=0) and transmission loss was calculated using only logarithmic spreading. Therefore, using practical spreading (B=15), the revised formula for transmission loss is $TL = 15 \log_{10}(R)$.

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. A large quantity of literature regarding sound pressure levels recorded from pile driving projects is available for consideration. In order to determine reasonable sound pressure levels and their associated affects on marine mammals that are likely to result from pile driving at NBK 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" diameter); 2. Hammer machinery - vibratory and impact; and 3. Physical environment - shallow depth (<100 foot). Table 6-4 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 which could be anticipated.

Table 6-4 Underwater Sound Pressure Levels from Similar In-situ Monitored Construction Activities

Project & Location	Pile Size &Type	Installation Method	Water Depth	Measured Sound Pressure Levels
Mukilteo Test Piles, WA[1]	36-inch Steel Pipe	Impact	7.3 m (24 feet)	195 dB re 1 µPa (rms) at 10 m
Richmond-San Rafael Bridge, CA[2]	66-inch Steel CISS Pile	Impact	4.0 m (13.1 feet)	195 dB re 1 µPa (rms) at 10 m
Unknown Location, CA[2]	72-inch Steel Pipe Pile	Vibratory	~5 m (16.4 feet)	180 dB re 1 µPa (rms) at 10 m

Sources: [1]WSDOT 2007; [2] Caltrans 2007

Several noise reduction measures can be employed during pile driving to reduce the high source pressures associated with impact pile driving. Among these is the use of bubble curtains, cofferdams, pile caps, or the use of vibratory installation. The efficacy of bubble curtains is dependent upon a variety of site-specific factors, including environmental conditions such as water current, sediment type, and bathymetry; the type and size of the pile; and the type and energy of the hammer. Thorson and Reyff (2004) determined that a properly designed bubble curtain could provide a reduction of 5 to 20 dB. Under certain conditions, bubble curtains may not provide the appropriate level of attenuation. In the event that the underwater monitoring demonstrates the proper attenuation is not being achieved, other mitigation techniques may be used (see Section 11). The use of a dewatered cofferdam (i.e., there is no water inside the cofferdam) represents the most effective way of reducing sound because the pile driving is completely decoupled from the surrounding water column. Reyff (2003) conducted measurements in the shallow water surrounding Pier 16E for the San Francisco-Oakland Bay Bridge (SFOBB) project during the driving of 2.4 meter cast-in-steel-shell (CISS) piles in a dewatered cofferdam. That study determined that the dewatered cofferdam reduced underwater sound pressures by 30 dB. However, this study also noted that low frequency levels were higher in one direction most likely based on the complex propagation path.

In addition to these techniques, cap materials have been used on the pile to reduce pile driving noise. Laughlin (2006) measured sound levels of a 12-innch diameter standard steel pile with bubble curtains and different pile cap materials. He found that using wood as a pile cap may provide 11 to 26 dB reduction; however, wood compressed easily or caught on fire and therefore does not warrant regular use. Conbest provided a 7 to 8 dB reduction, nylon provided 4 to 5 dB reduction, and Micarta provided 1 to 5 dB reduction. The use of vibratory installation versus impact driving can be considered a mitigation technique as well. Noise levels associated with vibratory pile driving are typically 15 to 20 dB less than impact pile driving, (Hastings and Popper 2005; WSDOT 2008).

For the Test Pile Program, the Navy intends to employ noise reduction techniques during impact pile driving, including the use of the Gunderboom SAS™ or traditional bubble curtain sound attenuation system. See Section 11 for more details on the impact reduction and mitigation measures proposed. Additionally, vibratory pile driving will be the primary installation method, which has lower source levels than impact pile driving. The calculations of the distances to the marine mammal noise thresholds were calculated for impact installation with and without consideration for mitigation measures. Distances calculated with consideration for mitigation assumed a 10 dB reduction in source levels from the of sound attenuation devices. The Navy will be using the mitigated distances for impact pile driving for all further analysis in this IHA. Calculations for the marine mammal noise thresholds for vibratory installation were done based on in-situ recordings of vibratory installation/extraction data from Caltrans (2007) which indicated a SPL of 180 db re 1µPa at 10m. This concurred with published literature from other studies which have in the past used a 15 dB reduction factor from source levels from impact driving recordings to calculate sources levels for vibratory pile driving. Sound levels associated with vibratory pile removal are the same as those during vibratory installation (Caltrans 2007) and have been taken into consideration in the modeling analysis. All calculated distances to and the total area encompassed by the marine mammal noise thresholds are provided in Tables 6-5 and 6-6, respectively.

Table 6-5 Calculated Distance(s) to Underwater Marine Mammal Noise Thresholds from Pile Driving

Description	Distance (m) to Threshold			
	Impact Level A – 190 dB[1]	Impact Level A – 180 dB[1]	Impact Level B – 160 dB[1]	Vibratory Level B – 120 dB[1]
Impact Driving, No mitigation	22	100	2,154	N/A
Impact Driving with bubble curtain – (Mitigation = 10 dB reduction in SPLs)	5	22	464	N/A
Vibratory pile driver	2	10	N/A	100,000[2]

All sound levels expressed in dB re 1 µPa rms.
CISS = cast-in-steel-shell; dB = decibel; N/A = not applicable; rms = root-mean-square; µPa = microPascal
Practical spreading loss (15 log, or 4.5 dB per doubling of distanced) used for water depths 10-50 feet.
[1]Sound pressure level used for calculations were:195 dB re 1 µPa @ 10m for impact and 180 dB re1 µPa @ 10m for vibratory
[2]Range calculated is greater than what would be realistic. Hood Canal average width at site is 2.4 mi, and is fetch limited from N to S at 12.6 mi.

Table 6-6 Calculated Area Encompassed (Per Pile) by the Underwater Marine Mammal Noise Thresholds from Pile Driving

Description	Area (km^2) Encompassed by theThreshold			
	Impact Level A – 190 dB[1]	Impact Level A – 180 dB[1]	Impact Level B – 160 dB[1]	Vibratory Level B – 120 dB[1]
Impact Driving with bubble curtain – (Mitigation = 10 dB reduction in SPLs)	0.000	0.002	0.676	N/A
Vibratory pile driver	0.000	0.000	N/A	31,416

The calculations presented in Tables 6-5 and 6-6 assume a field free of obstruction. This is unrealistic, however, because the Hood Canal does not represent open water conditions (free field) and therefore, sounds would attenuate as they encountered land masses or bends in the canal. As a result, some of the distances and areas of impact calculated cannot actually be attained within the Project Area. The actual distances to the behavioral disturbance thresholds for both impact and vibratory pile driving (464m and 100,000 m, respectively) may be shorter than those calculated 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. Table 6-7 and Figures 6-1 and 6-2 depict the actual distances for each threshold that are predicted to occur within Project Area due to pile driving for cetaceans and pinnipeds, respectively

Table 6-7 Actual Area Encompassed (Per Pile) by the Underwater Marine Mammal Noise Thresholds from Pile Driving

Description	Area (km^2) Encompassed by theThreshold			
	Impact Level A – 190 dB[1]	Impact Level A – 180 dB[1]	Impact Level B – 160 dB[1]	Vibratory Level B – 120 dB[1]
Impact Driving with bubble curtain – (Mitigation = 10 dB reduction in SPLs)	0.000	0.002	0.509	N/A
Vibratory pile driver	0.000	0.000	N/A	41.5

6.5.3 Airborne Sound Propagation Formula

Pile driving can generate airborne noise that could potentially result in disturbance to marine mammals (pinnipeds) which 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 the NBK Bangor to be exposed to airborne sound pressure levels that could result in Level B behavioral harassment. The appropriate airborne noise thresholds for behavioral disturbance for all pinnipeds, except harbor seals is 100 dB re 20 µPa rms (unweighted) and for harbor seals is 90 dB re 20 µPa rms (unweighted) (see Table 6-3). A spherical spreading loss model, assuming average atmospheric conditions, was used to estimate the distance to the 100 dB and 90 dB re 20 µPa rms (unweighted) airborne thresholds. The formula for calculating spherical spreading loss is:

$$TL = 20\log r$$

where:

TL = Transmission loss

r = Distance from source to receiver

*Spherical spreading results in a 6 dB decrease in sound pressure level per doubling of distance.

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. A large quantity of literature regarding sound pressure levels recorded from pile driving projects is available for consideration. In order to determine reasonable airborne sound pressure levels and their associated affects on marine mammals that are likely to result from pile driving at NBK 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" diameter); 2. Hammer machinery - vibratory and impact; and 3. Physical environment - shallow depth (<100 foot). Table 6-8 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 which could be anticipated.

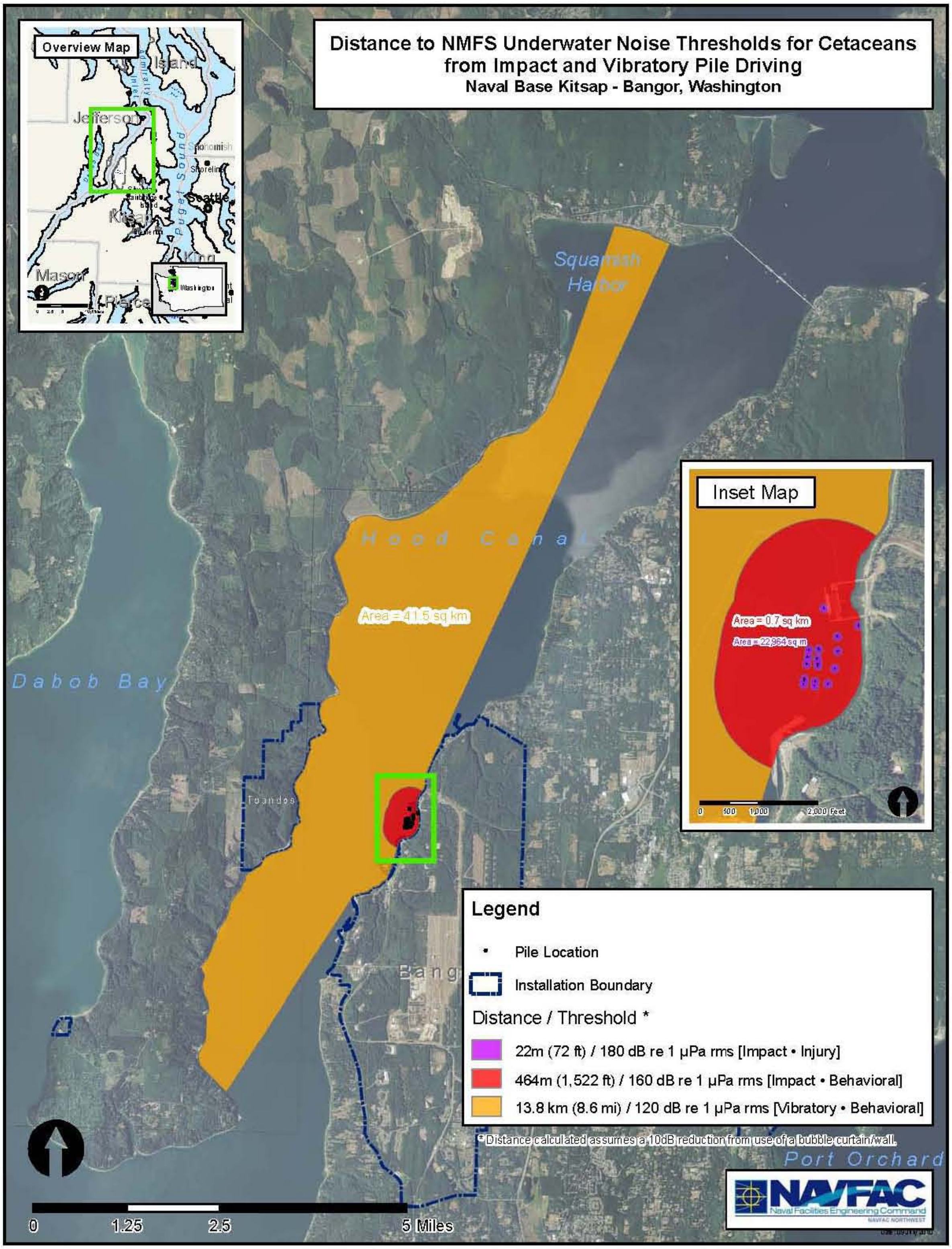


Figure 6-1 Distance(s) (m) to Underwater Sound Thresholds for Cetaceans from Pile Driving

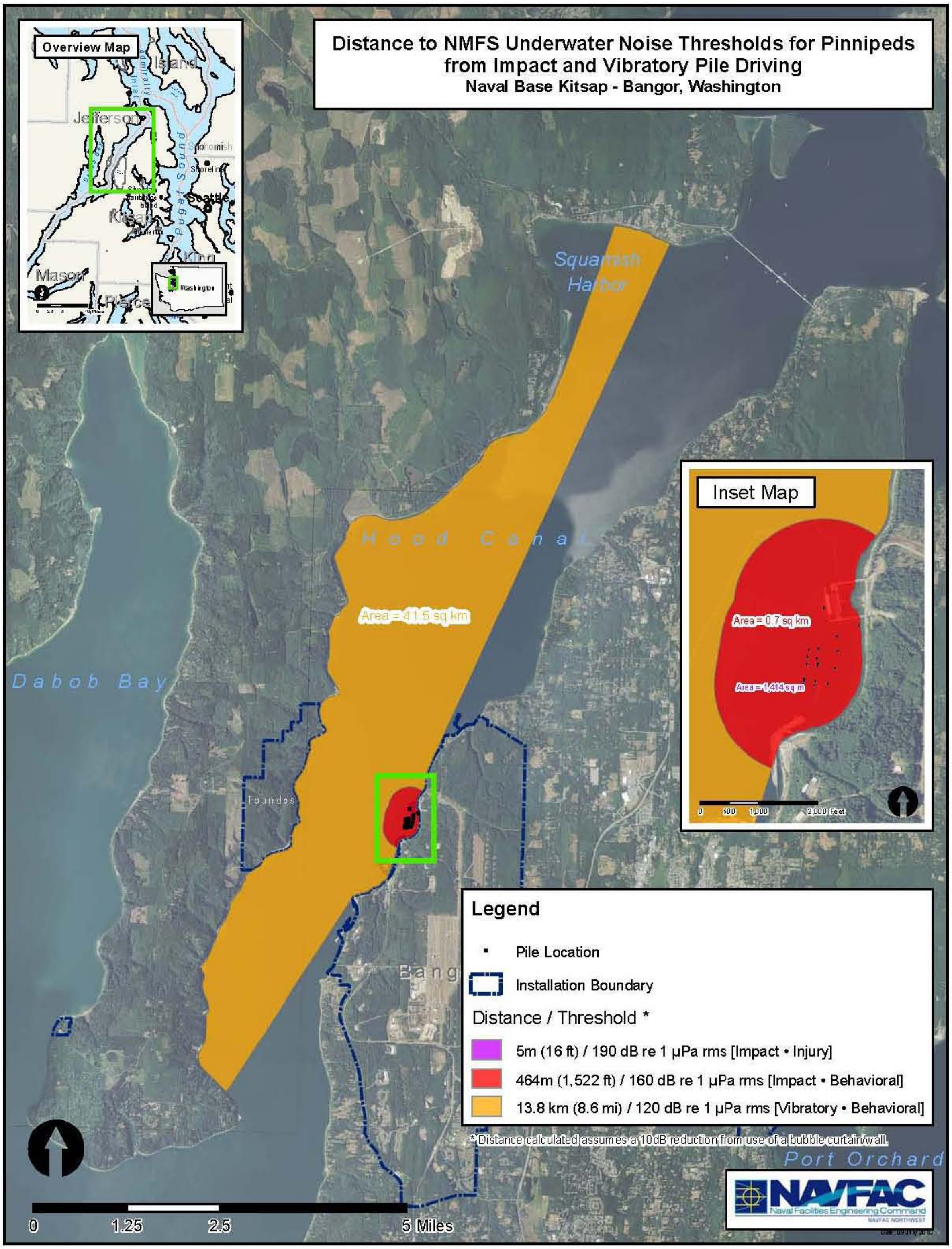


Figure 6-2 Distance(s) (m) to Underwater Sound Thresholds for Pinnipeds from Pile Driving

Table 6-8 Airborne Sound Pressure Levels from Similar In-situ Monitored Construction Activities

Project & Location	Pile Size &Type	Installation Method	Water Depth	Measured Sound Pressure Levels
Northstar Island, AK[1]	42- inch Steel Pipe Pile	Impact	~12 m (40 feet)	97 dB re 20 µPa (rms) at 525 feet
Keystone Ferry Terminal, WA[2]	30- inch Steel Pipe Pile	Vibratory	~9 m (30 feet)	98 dB re 20 µPa (rms) at 36 feet

Sources: [1]Blackwell et al. 2004; [2]WSDOT 2010

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 dB re 20 µPa (rms) at 525 feet and 98 dB re 20 µPa (rms) at 36 feet, respectively (Blackwell et al. 2004; WSDOT 2010). The distances to the airborne thresholds were calculated with the airborne transmission loss formula presented in section 6.5.3. All calculated distances to and the total area encompassed by the airborne marine mammal noise thresholds are provided in Tables 6-9 and 6-10, respectively..

Table 6-9 Calculated Distances (m) to the Marine Mammal Noise Thresholds in Air from Pile Driving

Species	Threshold	Airborne Behavioral Disturbance	
		Distance (m) to Threshold Impact Pile Driving	Distance (m) to Threshold Vibratory Pile Driving
Pinnipeds (seals, sea lions, walrus, except harbor seal)	100dB re 20 µPa rms (unweighted)	113 m (371 feet)	9 m (30 feet)
Harbor seal	90dB re 20 µPa rms (unweighted)	358 m (1175 feet)	28 m (92 feet)

Table 6-10 Calculated Area Encompassed (Per Pile) by the Marine Mammal Noise Thresholds In-air from Pile Driving

Species	Threshold	Airborne Behavioral Disturbance	
		Area Encompassed by the Threshold for Impact Pile Driving	Area Encompassed by the Threshold for Vibratory Pile Driving
Pinnipeds (except harbor seal)	100dB re 20 µPa rms (unweighted)	0.040 km^2	0.000 km^2
Harbor seal	90dB re 20 µPa rms (unweighted)	0.403 km^2	0.002 km^2

The distance to the sea lion airborne threshold would be 113 m (371 feet) for impact pile driving, and 9 m (30 feet) for vibratory pile driving. The distance to the harbor seal airborne threshold would be 358 m (1175 feet) for impact pile driving, and 28 m (92 feet) for vibratory pile driving. These distances are all less than the distances calculated for underwater sound thresholds. Since protective measures are in place out to the distances calculated for the underwater thresholds, the distances for the airborne thresholds will be covered fully by monitoring. All construction noise associated with the Project would not extend beyond the buffer zone that would be established to protect seals and sea lions. Figures 6-3 and 6-4 depict the distances and total area encompassed by each airborne sound threshold for pinnipeds that are predicted to occur at the Project Area due to pile driving.

6.5.5 Auditory Masking

Natural and artificial sounds can disrupt behavior by masking, or interfering with a marine mammal's ability to hear other sounds. Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher levels. If the second sound were man-made, it could be potentially harassing (according to the MMPA) if it disrupted hearing-related behavior such as communications or echolocation. It is important to distinguish temporary threshold shift (TTS) and permanent threshold shift (PTS), which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without a resulting in a threshold shift [TS]) is not associated with abnormal physiological function, it is not considered a physiological effect in this IHA application, but rather a potential behavioral effect.

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, sound from these sources would likely be within the audible range of Steller sea lions, California sea lions, harbor seals, transient killer whales, harbor porpoise, and Dall's porpoise. Impact pile driving activity is relatively short-term, with rapid pulses occurring for approximately 15 minutes per pile. The probability for impact pile driving resulting from this proposed action masking acoustic signals important to the behavior and survival of marine mammal species is therefore negligible. Vibratory pile driving is also relatively short-term, with rapid oscillations occurring for approximately 1.5 hours per pile. It is possible that vibratory pile driving resulting from this proposed action may mask acoustic signals important to the behavior and survival of marine mammal species, but the short-term duration and limited affected area would result in a negligible impact from masking. Any masking event that could possibly rise to Level B harassment under the MMPA would occur concurrently within the zones of behavioral harassment already estimated for vibratory and impact pile driving, and which have already been taken into account in the exposure analysis.

6.6 Basis for Estimating Take by Harassment

The U.S. Navy is seeking authorization for the potential taking of small numbers of California sea lions, harbor seals, transient killer whales, Dall's porpoises, and harbor porpoises in the Hood Canal that may result from pile driving during construction activities associated with the Test Pile Program. Based on densities available for the Steller sea lion, this species is not likely to be present during the short duration of the project, therefore no takes were estimated. The takes 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

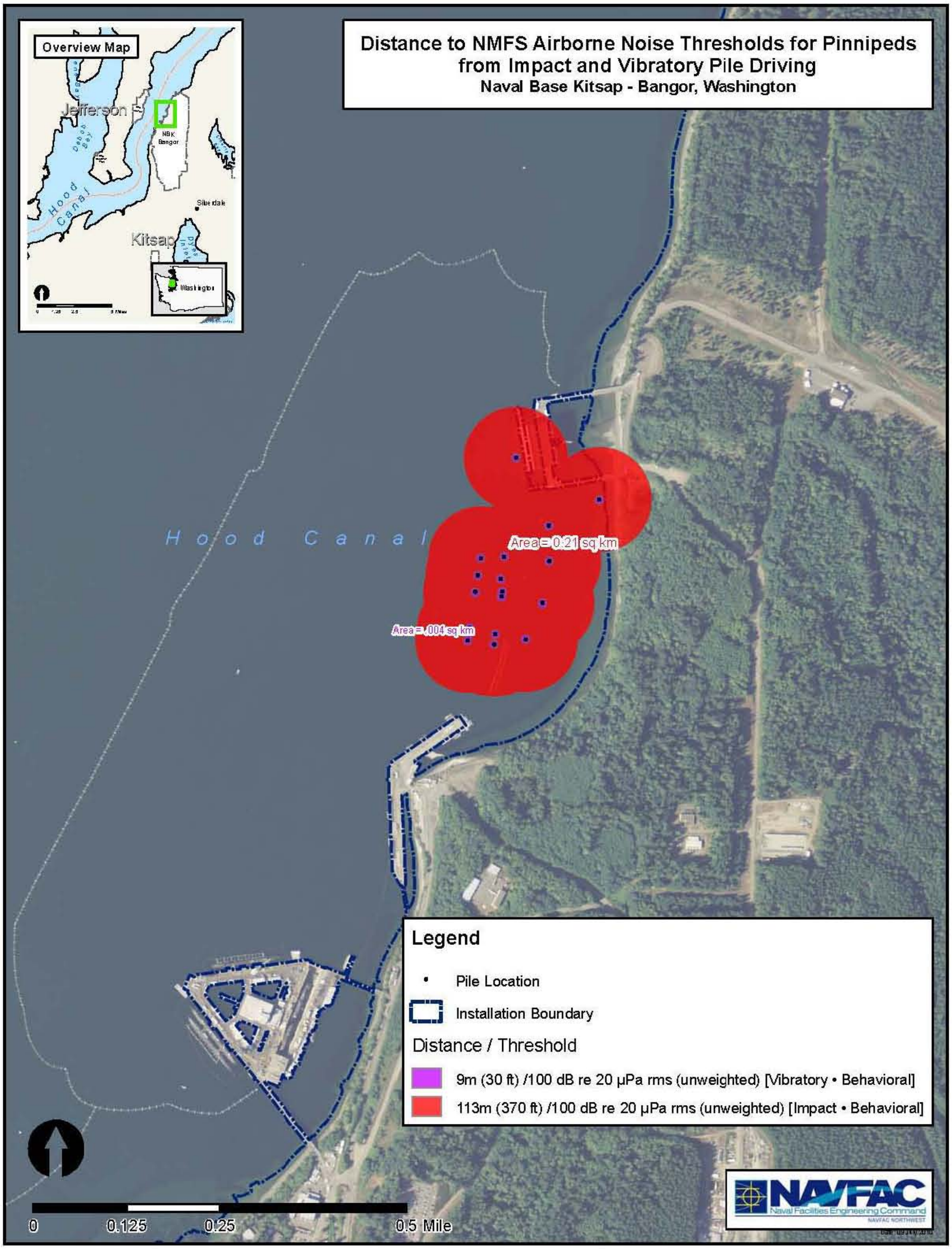


Figure 6-3 Distance(s) (m) to Airborne Sound Thresholds for Pinnipeds (except harbor seals) from Pile Driving

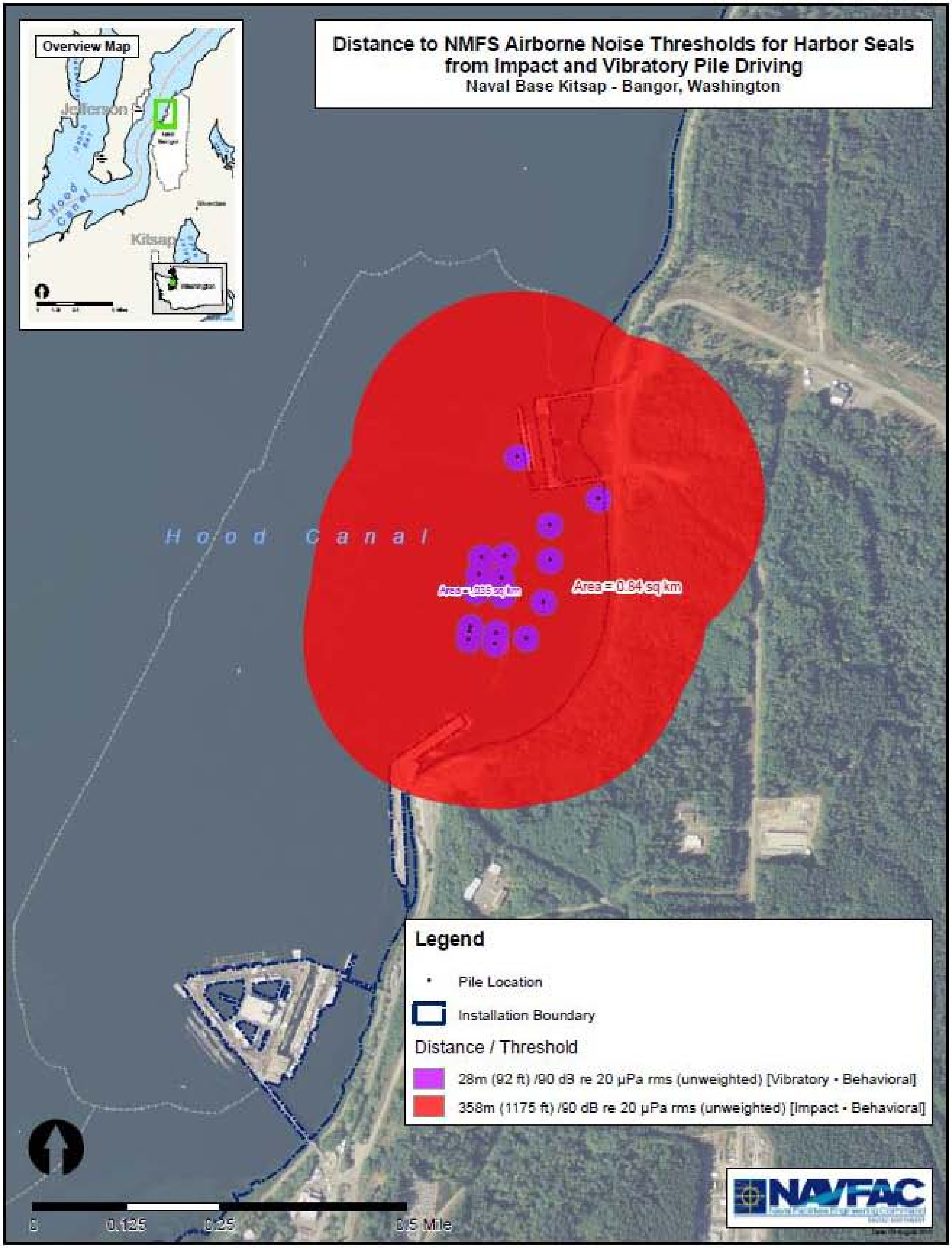


Figure 6-4 Distance(s) (m) to Airborne Sound Thresholds for Harbor Seals from Pile Driving

anticipated to be limited to short-term disturbance of normal behavior or temporary displacement of animals near source of the noise.

6.6.1 Steller Sea Lion

Steller sea lions are present in the Hood Canal, but are only expected as far as the project area during November through mid-April (cold season). Because this action will occur between July 16 – October 31, when Steller sea lions are not likely to be present in the project area, no acoustic impacts from pile driving operations are expected for this species.

6.6.2 California Sea Lion

California sea lions are present in the Hood Canal almost year-round with the exception of mid-June through August. The Navy conducted year round waterfront surveys for marine mammals at NBK Bangor in 2008 and 2009 (DoN 2010a). During these surveys, the daily maximum number of California sea lions hauled out for the months July – October (the timeframe of the Test Pile Program), were 0, 0, 12, and 47 in 2008 and 0, 1, 32, and 44 in 2009, respectively. The monthly average of the maximum number of California sea lions observed per day was 17 individuals. Females are rarely observed north of the California-Oregon border (NMFS 2008c), therefore only adult and sub-adult males are expected in the Hood Canal. Breeding rookeries are in California; therefore pups are not expected to be present in the Hood Canal.

Potential takes would likely involve sea lions that are moving through the area en route to submarine haulout or during the return trip to the ocean when pile driving would occur. California sea lions that are taken could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, California sea lions may move away from the sound source and be temporarily displaced from the areas of pile driving. With the absence of any major rookeries and only a few isolated haul-out areas near or adjacent to the project site, potential takes by disturbance will have a negligible short-term effect on individual California sea lions and would not result in population-level impacts.

6.6.3 Harbor Seal

Harbor seals are present in the Hood Canal year-round and would be expected as the project site. Harbor seal numbers increase from January through April and then decrease from May through August as the harbor seals move to adjacent bays on the outer coast of Washington for the pupping season. Harbor seals are the most abundant marine mammal in the Hood Canal. Jeffries et al. (2003) did a stock assessment of harbor seals in the Hood Canal in 1999 and counted 711 harbor seals hauled out. This abundance was adjusted using a correction factor of 1.53 to account for seals in the water and not counted to provide a population estimate of 1,088 harbor seals in the Hood Canal. The Navy conducted boat surveys of the waterfront area in 2008 from July to September (Agness and Tannenbaum 2009a). Harbor seals were sited during every survey and were found in all marine habitats including near and hauled out on man-made objects such as piers and buoys. During most of the year, all age and sex classes (except newborn pups) could occur in the Project area throughout the period of construction activity. From April through mid-July, female harbor seals haul out on the outer coast of Washington at pupping sites to give birth. Pups may be encountered near these areas during this time. Since there are no known pupping sites in the vicinity of the Project, harbor seal pups are not expected to be present during pile driving.

Potential takes would likely involve seals that are moving through the area on foraging trips when pile driving would occur. Harbor seals that are taken could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, harbor seals may move away from the sound source and be temporarily displaced from the areas of pile driving. With the absence of any major rookeries and only a few potential haul-out areas near the project site, potential takes by disturbance will have a negligible 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. Transients may be present in the Hood Canal anytime during the year and traverse as far as the project site. Resident killer whales have not been observed in Hood Canal, 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).

Potential takes would likely involve transient killer whales that are moving through the area on foraging trips when pile driving would occur. Killer whales that are taken could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, killer whales may move away from the sound source and be temporarily displaced from the areas of pile driving. 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 killer whales and would not result in population-level impacts.

6.6.5 Dall's Porpoise

Dall's porpoise may be present in the Hood Canal year-round and could occur as far as the project site. Their use of inland Washington waters, however, is mostly limited to the Strait of Juan de Fuca. The Navy conducted boat surveys of the waterfront area in 2008 from July to September (Agness and Tannenbaum 2009a). During one of the surveys a Dall's porpoise was sighted in August in the deeper waters off Carlson Spit.

Potential takes would likely involve Dall's porpoise that are moving through the area on foraging trips when pile driving would occur. Dall's porpoise that are taken could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, Dall's porpoise may move away from the sound source and be temporarily displaced from the areas of pile driving. 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 porpoise and would not result in population-level impacts.

6.6.6 Harbor Porpoise

Harbor porpoises may be present in the Hood Canal year-round, however their presence is rare. During waterfront survey of NBK Bangor over the past two years (2008 – present) only one harbor porpoise has been seen in 24 surveys.

Potential takes could occur if harbor porpoises move through the area on foraging trips when pile driving would occur. Harbor porpoises that are taken could exhibit behavioral changes such as increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, harbor porpoises may move away from the sound source and be temporarily displaced from the areas of pile driving. 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 harbor porpoises and would not result in population-level impacts.

6.7 Description of Take Calculation

The take calculations presented here relied on the best data currently available for marine mammal populations in the Hood Canal. The population data used is discussed in within each species take calculation subsection 6.7.1 – 6.7.5. The formula was developed for calculating take 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.
- 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 could potentially occur every day of the 40 day in-water work window. However, it is estimated that an average of 2 piles will be installed and removed per day Therefore, a best estimate of the number of days during which pile driving would occur is 15 days, and this was used in all modeling calculations.
- Some degree of mitigation (i.e. sound attenuation system, etc.) will be utilized, as discussed previously.
- That an individual can only be taken once per method of installation during a 24 hour period.

The calculation for marine mammal takes is estimated by:

$$\text{Take estimate} = (n * ZOI) * 15 \text{ days of total activity}$$

where:

n = density estimate used for each species/season
ZOI[6] = noise threshold zone of influence (ZOI) impact area
n * ZOI produces an estimate of the abundance of animals that could be present in the area for exposure, this must be a whole number, therefore, this value was rounded (down if <0.5, up if >0.5).

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 6-5 and 6-7, were used for the radius in the equation. All impact pile driving take calculations were based on the estimated threshold ranges using a bubble curtain with 10 dB attenuation as a mitigation measure. The ZOI impact area took into consideration the possible effected area of the Hood Canal from the furthest from shore pile

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

driving site with attenuation due to land shadowing from bends in the canal. As described in Section 6.5.2 with regard to the distances, because of the close proximity of some of the piles to the shore, the narrowness of the canal at the project area, and the maximum fetch, the ZOIs for each threshold aren't necessarily spherical and may be truncated.

Forty days of total in-water work time is proposed, however only a "fraction" of that is actual pile driving time. Some days there will only be 30 minutes of pile driving, other days several hours. The contractor estimates that pile installation could occur at a maximum rate of four piles per day, however, it's more likely that an average of two piles will be installed and removed per day. For each pile installed, vibratory pile driving is expected to be no more than one hour. The impact driving portion of the project is anticipated to take approximately 15 minutes per pile with no more than 100 blows executed per day. All piles will be extracted using a vibratory hammer. Extraction is anticipated to take approximately 30 minutes per pile. Overall, this results in a maximum of two hours of pile driving per pile, or approximately four hours per day.

An average work day (two hours post-sunrise to two hours prior to sunset) is approximately 8-9 hours, depending on the month. While it's anticipated that only 4 hours would need to be spent pile driving per day, to take into account deviations from the estimated times for pile installation and removal and to account for the additional use of the impact pile driver in case of failure of the vibratory hammer to reach the desired embedment depth the Navy modeled potential impacts as if the entire day could be spent pile driving.

Based on the proposed action, the total pile driving time from vibratory or impact pile driving would be less than 15 days (29 piles at minimum of 2 per day). Therefore, impacts were modeled as if the action were to occur for a duration of 15 days.

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 this mitigation is not reflected in exposure estimates. Results from acoustic impact exposure assessments should be regarded as conservative estimates that are strongly influenced by limited biological data. While the numbers generated from the pile driving exposure calculations provide conservative overestimates of marine mammal exposures for consultation with NMFS, the short duration and limited geographic extent of test pile project would further limit actual exposures.

6.7.1 Steller Sea Lion

Although Steller sea lions have been documented in Hood Canal, the numbers (at least at present) are still fairly low, and their presence is only expected in the project area during November through mid-April. Because this action will occur between July 16 – Oct 31, when Steller sea lions are not likely to be present in the project area, no acoustic impacts from pile driving operations are expected for this species.

6.7.2 California Sea Lion

California sea lions are present in the Hood Canal almost year-round with the exception of mid-June through August. California sea lions are likely present in the Hood Canal as far as the project site from January through mid-June, although this is changing every year. The Navy conducted year round waterfront surveys for marine mammals at NBK Bangor in 2008 and 2009 (DoN 2010a). During these surveys, the daily maximum number of California sea lions hauled out for the months July – October (the timeframe of the Test Pile Program), were 0, 0, 12, and 47 in 2008 and 0, 1, 32, and 44 in 2009, respectively. Because the proportion of pile driving that could occur in a given month is dependent on several factors (i.e. availability of materials, weather, etc.) the Navy assumed that pile driving operations could occur at any time in the construction window. Therefore, an average of the maximum number of California sea lions observed per day across the months of July – October was used in the modeling analysis. The monthly average of the maximum number of California sea lions observed per day was 17 individuals. Exposures were calculated using a density derived from this value (17 individuals), divided by the potential acoustic impact area (41.5 km^2) and 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 for each season.

Table 6-11 Number of Potential Exposures of California Sea Lions within Various Acoustic Threshold Zones

Season	Density of California Sea Lions	Underwater			Airborne
		Impact Injury Threshold (190dB)	Impact Disturbance Threshold (160dB)	Vibratory Disturbance Threshold (120dB)	Impact & Vibratory Disturbance Threshold (100dB)*
Warm (May-Oct)	0.410	0	15**	255	0

Note: The take estimates include both those from impact and vibratory pile driving.

* The airborne exposure calculations assumed that 100% of the in-water densities were available at the surface to be exposed to airborne sound.

** The modeling indicated that zero California sea lions were likely to be exposed to sounds that would qualify as behavioral harassment during impact pile driving (160 dB zone). However, the Navy feels based on the abundance of this species in the waters along NBK, including their presence at nearby haulouts, that it's likely that an individual could pass through this zone in transit to or from a haulout, Therefore, the Navy is requesting a behavioral take of California sea lion by impact pile driving each day of pile driving, for a total of 15 takes over the course of the proposed action.

California sea lions that are taken could exhibit behavioral reactions. Disturbance from underwater noise impacts is not expected to be significant because it is estimated that only a small number of California sea lions may be affected by acoustic harassment. Additionally, marine mammal observers will be monitoring the shutdown and buffer zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews when to begin or stop work due to presence of sea lions in or near the shutdown and buffer zones, reducing the potential for acoustic harassment. Based on the exposure analysis, no California sea lions are anticipated to experience airborne sound pressure levels that would qualify as harassment.

6.7.3 Harbor Seal

Harbor seals are the most abundant marine mammal in the Hood Canal. The Navy conducted boat surveys of the waterfront area in 2008 from July to September (Agness and Tannenbaum 2009a). Harbor seals were sited during every survey year and were found in all marine habitats including near and hauled out on man-made objects such as piers and buoys. Jeffries et al. (2003) completed a more comprehensive stock assessment of the Hood Canal in 1999 and counted 711 harbor seals hauled out. This abundance was adjusted using a correction factor of 1.53 to account for seals in the water and not counted to provide a population estimate of 1,088 harbor seals in the Hood Canal (Jeffries et al. 2003). Research by Huber et al. (2001) indicates that approximately 35% of harbor seals are in the water at any one time. Exposures were calculated using a density derived from the number of harbor seals that are present in the water at any one time (35% of 1,088 or ~381 individuals), divided by the area of the Hood Canal (291 km^2) and the formula presented in Section 6.7.

While Huber et al.'s (2001) data suggests that harbor seals typically spend 65% of their time hauled out; the Navy's waterfront surveys found that it is extremely rare for harbor seals to haul out in the vicinity of the test pile Project Area. Therefore, the only population of harbor seals that could potentially be exposed to airborne sounds are those that are in-water but at the surface. Based on the diving cycle of tagged harbor seals near the San Juan Islands we can estimate that seals are on the surface approximately 16.4 percent of the 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 population of harbor seals with the potential to experience airborne impacts (~63 individuals) can be obtained. Airborne exposures were calculated using a density derived from the maximum number of harbor seals available at the surface (~63 individuals), divided by the area of the Hood Canal (291 km^2) and the formula presented 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 for each season.

Table 6-12 Number of Potential Exposures of Harbor Seals within Various Acoustic Threshold Zones

Season	Density of Harbor Seals	Underwater			Airborne
		Impact Injury Threshold (190dB)	Impact Disturbance Threshold (160dB)	Vibratory Disturbance Threshold (120dB)	Impact & Vibratory Disturbance Threshold (90 dB)*
Warm (May-Oct)	1.31	0	15	810	0

Note: The take estimates include both those from impact and vibratory pile driving.
*Airborne densities were base on the percentage (16.4%) of in-water density available on surface to be exposed (Suryan and Harvey, 1998).

Harbor seals that are taken could exhibit behavioral reactions. Disturbance from underwater noise impacts is not expected to be significant because it is estimated that only a small number of harbor seals may be affected by acoustic harassment. Additionally, marine mammal observers will be monitoring the shutdown and buffer zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews when to begin or stop work due to presence of seals in or near the shutdown and buffer zones, reducing the potential for acoustic harassment. Based on the exposure analysis, no harbor seals are anticipated to experience airborne sound pressure levels that would qualify as harassment.

6.7.4 Killer Whale

Transients are uncommon visitors to Hood Canal. In 2003 and 2005, small groups of transient killer whales (6 – 11 individuals per event) visited Hood Canal to feed on harbor seals and remained in the area for significant periods of time (59 – 172 days) between the months of January and July (London 2006). These whales used the entire expanse of Hood Canal for feeding. Subsequent aerial surveys suggest that there has not been a sharp decline in the local seal population from these sustained feeding events (London 2006). Based on this data, the density for Transient killer whales in the Hood Canal for January to June is 0.038/km^2 (11 individuals divided by the area of the Hood Canal [291 km^2]). Since this timeframe overlaps the period in which the Test Pile Program will occur (July – Oct), this density was used for all exposure calculations. Exposures were calculated using the formula presented in Section 6.7. Table 6-13 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater for each season.

Table 6-13 Number Potential Exposures of Killer Whales within Various Acoustic Threshold Zones

Season	Density of Killer Whales	Underwater		
		Impact Injury Threshold (180dB)	Impact Disturbance Threshold (160 dB)	Vibratory Disturbance Threshold (120dB)
Warm (May-Oct)	0.038	0	9*	30

Note: The take estimates include both those from impact and vibratory pile driving.

* The modeling indicated that zero killer whales were likely to be exposed to sounds that would qualify as behavioral harassment during impact pile driving (160 dB zone). However, while Transient killer whales are rare in the Hood Canal, when these animals are present they occur in pods, so their density in the project area is unlikely to be uniform, as was modeled. If they are present during impact pile driving it's possible that one or more individuals within a pod could travel through the behavioral harassment zone. Therefore, the Navy is requesting nine behavioral takes of Transient killer whales – based on the average size of pods seen previously in the Hood Canal - by impact pile driving over the course of the proposed action.

Killer whales that are taken could exhibit behavioral changes Disturbance from underwater noise impacts is not expected to be significant 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 and buffer zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews when to begin or stop work due to presence of seals in or near the shutdown and buffer zones, reducing the potential for acoustic harassment.

6.7.5 Dall's Porpoise

Dall's porpoise may be present in the Hood Canal year-round and may be expected as the project site. Their use of inland Washington waters, however, is mostly limited to the Strait of Juan de Fuca. The Navy conducted boat surveys of the waterfront area in 2008 from July to September (Agness and Tannenbaum 2009a). During one of the surveys a single Dall's porpoise was sighted in August in the deeper waters off Carlson Spit. In the absence of an abundance estimate for the entire Hood Canal, a seasonal density (warm season only) was derived from the waterfront survey by the number of individuals seen divided by total number of kilometers of survey effort (6 surveys with approximately 3.9 km^2 of effort each), assuming strip transect surveys. In absence of any other survey data for the Hood Canal, this density is assumed to be throughout the Project Area. Exposures were calculated using the formula presented in Section

6.7. Table 6-14 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater for each season.

Table 6-14 Number of Potential Exposures of Dall's Porpoise within Various Acoustic Threshold Zones

Season	Density of Dall's Porpoise	Underwater		
		Impact Injury Threshold (190 dB)	Impact Disturbance Threshold (160dB)	Vibratory Disturbance Threshold (120 dB)
Warm (May-Oct)	0.043	0	1*	30

Note: The take estimates include both those from impact and vibratory pile driving.* The modeling indicated that zero Dall's porpoise were likely to be exposed to sounds that would qualify as behavioral harassment during impact pile driving (160 dB zone). Dall's porpoises are rare in the Hood Canal; only one animal, seen located in deep waters offshore the base has been seen in the project area in the past few years. However, it's possible that additional animals exist or that this single individual could pass through the behavioral harassment zone (160 dB) while transiting along the waterfront. Therefore, the Navy is requesting a single behavioral take of Dall's porpoise by impact pile driving over the course of the proposed action.

Dall's porpoise that are taken could exhibit behavioral reactions. Disturbance from underwater noise impacts is not expected to be significant 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 and buffer zones (see Section 11 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews when to begin or stop work due to presence of seals in or near the shutdown and buffer zones, reducing the potential for acoustic harassment.

6.7.6 Harbor Porpoise

Harbor porpoises may be present in the Hood Canal year-round, however their presence is rare.The Navy conducted boat surveys of the waterfront area from July to September over the past few years (2008 – present) (Agness and Tannenbaum 2009a). During one of the surveys a single Dall's porpoise was sighted in the deeper waters offshore the waterfront. In the absence of an abundance estimate for the entire Hood Canal, a seasonal density (warm season only) was derived from the waterfront survey by the number of individuals seen divided by total number of kilometers of survey effort (24 surveys with approximately 3.9 km^2 of effort each), assuming strip transect surveys. In the absence of any other survey data for the Hood Canal, this density is assumed to be throughout the Project Area. Exposures were calculated using the formula presented in Section 6.7. Table 6-15 depicts the number of acoustic harassments that are estimated from vibratory and impact pile driving both underwater for each season.

Disturbance from underwater noise impacts is not expected to be significant. Additionally, marine mammal observers will be monitoring the shutdown and buffer zones (see Chapter 4 for a detailed discussion of mitigation measures) for the presence of marine mammals, and will alert work crews when to begin or stop work due to presence of marine mammals in or near the shutdown zones, reducing the potential for acoustic harassment. Potential takes by disturbance would have a negligible short-term effect on individual harbor porpoises and would not result in population-level impacts.

Table 6-15 Number of Potential Exposures of Harbor Porpoise within Various Acoustic Threshold Zones

Season	Density of Harbor Porpoise	Underwater		
		Impact Injury Threshold (190 dB)	Impact Disturbance Threshold (160dB)	Vibratory Disturbance Threshold (120 dB)
Warm (May-Oct)	0.011	0	0	15*

Note: The take estimates include both those from impact and vibratory pile driving.

6.8 *** The modeling indicated that zero harbor porpoise were likely to be exposed to sounds that would qualify as behavioral harassment during vibratory pile driving (120 dB zone). However, while harbor porpoises are rare, one has been sighted in surveys over the last few years in the deep waters offshore the base. It's possible this offshore region is encapsulated within the vibratory disturbance zone due to its size (41.5 sq. km), Therefore the Navy feels based on the possibility of this animal to be present in the offshore waters during every day of construction, the Navy is requesting a single behavioral take of harbor porpoise by vibratory pile driving each day of pile driving, for a total of 15 takes over the course of the proposed action. Summary**

Based on the modeling results presented above, the total number of takes that the Navy is requesting for the five marine mammal species that may occur within the Project Area during the duration of the Test Pile Program are presented below in Table 6-16. In the warm season, there is the potential for 40 Level B disturbance takes (160 dB) of various species from impulsive pile driving operations, and an additional 1140 Level B disturbance takes (120 dB) of various species from vibratory pile driving due to underwater sound. The following species and numbers of Level B disturbance takes could occur due to underwater sound as a result of impact pile driving operations: 15 California sea lions, 15 harbor seals, 9 transient killer whales, and 1 Dall's porpoise. The following species and numbers of Level B disturbance takes could occur due to underwater sound as a result of vibratory pile driving operations: 255 California sea lions, 810 harbor seals, 30 transient killer whales, 30 Dall's porpoises, and 15 harbor porpoises. Due to their lack of presence within the project area during the timeframe for the Test Pile Program (July 16 – Oct 31), no ESA-listed Steller sea lions would be acoustically harassed. Lastly, no species of pinnipeds are expected to be exposed to airborne sound pressure levels that would cause harassment.

Table 6-16 Summary of Potential Exposures for All Species in the Warm (May – Oct) Season

Species	Underwater				Airborne	
	Impact Injury Threshold (190 dB)	Impact Injury Threshold (180dB)	Impact Disturbance Threshold (160dB)	Vibratory Disturbance Threshold (120dB)	Impact & Vibratory Disturbance Threshold (100dB)*	Impact & Vibratory Disturbance Threshold (90dB)*
California sea lion	0	N/A	15	255	0	N/A
Harbor seal	0	N/A	15	810	N/A	0
Killer whale	N/A	0	9	30	N/A	N/A
Dall's porpoise	N/A	0	1	30	N/A	N/A
Harbor porpoise	N/A	0	0	15	N/A	N/A
Total	**0**	**0**	**40**	**1140**	**0**	**0**

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 size, type, 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 standoff 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 further 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 which 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; DoN, 2001b).

<u>*Physiological Responses*</u>

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 impacts include hearing loss, which is caused by exposure to perceptible sounds. Severe damage, from a pressure wave, to the ear can include rupture of the tympanum, fracture of the ossicles, damage to the cochlea, hemorrhage, and cerebrospinal fluid leakage into the middle ear (NMFS, 2008b). Moderate injury implies partial hearing loss. Permanent hearing loss can occur when the hair cells are damaged by one 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), but it has not been documented in wild marine mammals exposed to pile driving. 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 which can result in damage.

No physiological responses are expected from pile driving operations occurring during the Test Pile Program within the Project Area for several reasons. Firstly, 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. Any use of impulsive pile driving will only occur from a short period of time (~15 min per pile) and only to proof the piles. Additionally, the mitigation measures which the Navy will be employing (see Section 11) will greatly reduce the chance that a marine mammal may be exposed to sound pressure levels that could cause physical harm. During impact pile driving the Navy will employ a sound attenuation system (*e.g.* Gunderboom SAS™/bubble curtain) to attenuate initial sound pressure levels. Furthermore, the Navy will have trained biologists monitoring a shutdown zone equivalent to the Level A Harassment zone (inclusive of the 180 dB re 1 µ Pa (cetaceans) and 190 dB re 1 µ Pa (pinnipeds) isopleths) to ensure no marine mammals are injured.

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, it's biological and social status (including age and sex), and its behavioral state and activity at the time of exposure.

Habituation can occur 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 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).

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; CALTRANS 2001, 2006; also see reviews in Gordon et al. 2004; Wartzok et al. 2003/04; and Nowacek et al. 2007). Responses to continuous noise, such as vibratory pile installation, have not been documented as well as responses to pulsed sounds.

With both types of pile driving, it is likely that the onset of pile driving could result in temporary, short term changes in the animal's typical behavior and/or avoidance of the affected area. A marine mammal may show signs that it is startled by the noise and/or may swim away from the sound source and avoid the area. Other potential behavioral changes could include increased swimming speed, increased surfacing time, and decreased foraging in the affected area. Pinnipeds may increase their haul-out time, possibly to avoid in-water disturbance (Caltrans 2001, 2006). Since pile driving will likely only occur for a few hours a day, over a short period of time, it is unlikely to result in permanent displacement. Any potential impacts from pile driving activities could be experienced by individual marine mammals, but would not cause population level impacts, or affect the long-term fitness 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 harassment, depending on their distance from pile driving activities. Airborne pile driving noise would have less impact on cetaceans than pinnipeds because noise from atmospheric sources does not transmit well underwater (Richardson et al. 1995); thus airborne noise would only be an issue for hauled-out pinnipeds in the Project Area. 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 habitat and move further from the source. Studies 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. Based on these observations marine mammals could exhibit temporary behavioral reactions to airborne noise, however, exposure is not likely to result in population level impacts. Despite taking into consideration all known and incidental haulout locations nearby the Project Area the exposure modeling indicated that no pinniped species would be exposed to airborne noise levels at sound pressure levels that would constitute Level B behavioral harassment during either impact or vibratory pile driving (see Section 6 for modeling results). Injury or Level A harassment is not expected to occur from airborne noise. In conclusion, this is a negligible impact.

7.2 Conclusions Regarding Impacts to Species or Stocks

Individual marine mammals may be exposed to sound pressure levels during pile driving operations at NBK Bangor which may result in Level B Behavioral harassment. Any marine mammals which are taken (harassed), may change their normal behavior patterns (i.e. swimming speed, foraging habits, etc.) or be temporarily displaced from the area of construction. Any takes 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 "take") is described in Sections 6 and 7. This level of effect is not anticipated to have any detectable adverse impact on population recruitment, survival or recovery (i.e., no more than a negligible adverse effect).

8 IMPACT ON 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 (hunt) several species of marine mammals including, but not limited to: harbor seals, Steller sea lions, northern fur seals, gray whales, and humpback whales (Norberg pers comm. 2007). Recently, several Pacific Northwest treaty Indian tribes have promulgated[7] tribal regulations allowing tribal members to exercise treaty rights for subsistence harvest of California sea lions and harbor seals (Caretta et al. 2007). The Makah Indian Tribe (Makah) has specifically passed hunting regulations for gray whales (Norberg pers comm. 2007b). However, the directed take of marine mammals (not just gray whales) for ceremonial and/or subsistence purposes was enjoined[8] by the Ninth Circuit Court of Appeals in a ruling against the Makah in 2002, 2003, and 2004 (Norberg pers comm. 2007b; NMFS 2007). 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 pers. comm. 2007). These issues also require National Environmental Policy Act (NEPA) 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.

- Tribes along the coast are most likely to still have regulations in place allowing a small number of directed takes for subsistence purposes. It is unlikely that those regulations have been exercised in recent years, but they are still likely on the books (Wright pers. comm. 2007).
- Many tribes in Puget Sound and on the coast do have additional 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 (T. Wright pers. comm. 2007).

8.1.1 Harbor Seals

There have been only a few reported takes of harbor seals from directed tribal subsistence hunts (Caretta et al. 2007). It is possible that very few seals have been taken in directed hunts because tribal fishers use seals caught incidental to fishing operations in the northern Washington marine set gillnet and Washington Puget Sound Region treaty salmon gillnet fisheries, for their subsistence needs before undertaking a ceremonial or subsistence hunt (Caretta et al. 2007). From communications with the tribes, the NMFS Northwest Regional Office believes that zero to five harbor seals from this stock (the Washington Inland Waters Stock) may be taken annually in directed subsistence harvests (Caretta et al. 2007).

7 To make known by open declaration; publish; proclaim formally or put into operation (a law, decree of a court, etc.).
8 To prohibit or forbid

No impacts to the availability of the species or stock to the Pacific Northwest treaty tribes are expected as a result of the proposed activities.

8.1.2 California Sea Lions

Current estimates of annual subsistence take are zero to two animals per year (Caretta et al. 2007).

No impacts to the availability of the species or stock to the Pacific Northwest treaty tribes are expected as a result of the proposed activities.

8.1.3 Gray Whales

The Makah ceased whaling in the 1920's after commercial whaling decimated the eastern North Pacific (ENP) gray whale population (NMFS 2007). On June 16, 1994, gray whales were removed from the endangered species list after a determination that the population has "recovered to near its estimated original population size and is neither in danger of extinction throughout all or a significant portion of its range, nor likely to again become endangered within the foreseeable future throughout all or a significant portion of its range." (59 FR 31094). On May 5, 1995 the Makah formally notified the U.S. Government of their interest in resuming treaty ceremonial and subsistence harvest of ENP gray whales, asking the Department of Commerce to represent them in seeking approval from the International Whaling Commission (IWC) for an annual quota (NMFS 2007). On October 18, 1997 the IWC approved an aboriginal subsistence quota of 620 ENP gray whales (with an annual cap of 140) for the Russian Chukotka people and the Makah (Angliss and Outlaw 2005; NMFS 2007). On May 17, 1999 the Makah hunt, strike and land one ENP gray whale (sic) (NMFS 2005).

On December 20, 2002 the Ninth Circuit Court of Appeals ruled that an Environmental Impact Statement (EIS) (rather than an Environmental Assessment [EA]) should have been prepared under the NEPA and that the Makah must comply with the process prescribed in the MMPA for authorizing take of marine mammals otherwise prohibited by a moratorium (NMFS 2007). This was further upheld at rulings in 2003 and 2004 (NMFS 2007).

At the most recent meetings of the IWC (59th Annual Meeting in Anchorage, Alaska from May 28 - 31, 2007), an aboriginal subsistence quota for gray whales was again approved for natives in Russia and 20 whales or 4 per year for 5 years for the Makah (Norberg pers comm. 2007), but under the Ninth Circuit Court ruling the Makah must first obtain a waiver of the MMPA take moratorium before harvesting under their IWC quota (Norberg pers comm. 2007b). NMFS is currently preparing an EIS to examine the alternatives for a decision to approve or deny such a waiver (Norberg pers comm. 2007b).

Gray whales migrate north and south along the coast of Washington and there is a regular group of gray whales that enter the Puget Sound waters (specifically Saratoga passage on the eastern side of Whidbey Island) to feed during early spring and summer (March through May/June) (Calambokidis pers comm. 2007). These whales movements do not overlap with the proposed activities.

Should the Makah tribe resume hunting gray whales, this hunt would occur along the outer coast of Washington, but not likely within the region of activity located in the inland waters of Washington. In addition, all in-water work for Hood Canal is restricted to only take place between July 16 through February 15 of any year (or a more compressed schedule within those dates), thus the proposed activities would not occur when the majority of the gray whales are present in Puget Sound (from March through May/June). Furthermore, underwater noise disturbance would not displace the whales because of the distance between Hood Canal and Saratoga Passage and the presence of landmasses between the two locations. Therefore, the proposed activities would not directly or indirectly interfere with or affect the hunt, should it occur during the proposed project activities.

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 Bangor and will be limited to Level B harassment. Therefore, no impacts on the availability of species or stocks for subsistence use were found.

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 proposed activities at NBK Bangor will not result in permanent impacts to habitats used directly by marine mammals, such as haul-out sites, but may have potential short-term impacts to food sources such as forage fish and salmonids. There are no rookeries or major haul-out sites within 10km, 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. Therefore, the main impact issue associated with the proposed activity will be temporarily 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 occurs from pile driving effects on likely marine mammal prey (i.e., fish) nearby NBK Bangor and minor impacts to the immediate substrate during installation and removal of piles during the Test Pile Program.

9.1 Pile Driving Effects on Potential Prey (Fish)

Construction activities will produce both pulsed (i.e. impact pile driving) and continuous sounds (i.e. vibratory pile driving). Fish react to sounds which are especially strong and/or intermittent low-frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005, 2009) identified several studies that suggest fish may relocate to avoid certain areas of noise energy. Additional studies have documented effects of pile driving (or other types of continuous sounds) on file, although several are based on studies in support of large, multiyear bridge construction projects (Scholik and Yan 2001, 2002, Govoni et al. 2003, Hawkins 2005, Hastings 1990, 2007, Popper et al. 2006, Popper and Hastings 2009). Sound pulses at received levels of 160 dB re 1 μPa may cause subtle changes in fish behavior. SPLs of 180 dB may cause noticeable changes in behavior (Chapman and Hawkins 1969; Pearson et al. 1992; Skalski et al. 1992). SPLs of sufficient strength have been known to cause injury to fish and fish mortality (CalTrans 2001; Longmuir and Lively 2001). The most likely impact to fish from pile driving activities at the Project Area would be temporary behavioral avoidance of the area. 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. In general, impacts to marine mammal prey species are expected to be minor and temporary due to the short-time frame for the Test Pile Program. However, adverse impacts may occur to a few species of rockfish (bocaccio, yellowweye, and canary rockfish) and salmon (chinook and summer run chum) which may still be present in the project area despite operating in a reduced work-window in an attempt to avoid important fish spawning time periods. Impacts to these species could result from potential impacts to their eggs and larvae.

9.2 Pile Driving Effects on Potential Foraging Habitat

In addition, the area likely impacted by the Test Pile Program is relatively small compared to the available habitat in the Hood Canal. Potentially a maximum of 1.82 sq. meters (based on a 60-inch diameter pile) of marine mammal foraging habitat may have decreased foraging value as each pile is driven. Avoidance by potential prey (i.e. fish) of the immediate area due to the temporary loss of this foraging habitat is also possible. 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 the Hood Canal and nearby vicinity.

9.3 Summary of Impacts to Marine Mammal Habitat

Given the short daily duration of noise associated with individual pile driving\removal, the short duration of the entire Test Pile Program (40 work days), and the relatively small areas being affected, pile driving activities associated with the proposed action are not likely to have a permanent, adverse effect on any EFH, or population of fish species. Therefore, pile driving\removal is not likely to have a permanent, adverse effect on marine mammal foraging habitat at the Project Area.

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.

The proposed activities at NBK Bangor are not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, since pile driving will be temporary and all test pile will be removed after completion of the project. Based on the discussions in Section 9, there will be no impacts to marine mammals resulting from loss or modification of marine mammal habitat.

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. 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 zones of influences (ZOIs) discussed in Section 6 were used to develop mitigation measures for pile driving activities at NBK Bangor. The ZOIs effectively represent the mitigation 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 to support of the Test Pile Program.

1. Shutdown and Buffer Zone -
   - The shutdown zone shall include all areas where the underwater sound pressure levels (SPLs) are anticipated to equal or exceed the Level A (injury) Harassment criteria for marine mammals (180 dB isopleth for cetaceans; 190 dB isopleth for pinnipeds).
   - The buffer zone shall include all areas where the underwater sound pressure levels are anticipated to equal or exceed the Level B (disturbance) Harassment criteria for marine mammals (160 dB isopleths). The distance encompassing these zones will be adjusted to accommodate any difference between predicted and measured sound levels.
   - The shutdown and buffer zones will be monitored throughout the time required to drive a pile. If a marine mammal is observed entering the buffer zone, a "take" would be recorded and behaviors documented. However, that pile segment would be completed without cessation, unless the animal approaches/enters the shutdown zone, at which point all pile driving activities will be halted.
   - All buffer and 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 and buffer zones will be adjusted accordingly (increased or decrease) based on received sound pressure levels.
2. Visual Monitoring -

a. Impact Installation: Monitoring will be conducted for a 22 m shutdown zone and a 464 m buffer zone (Level B harassment) surrounding each pile for the presence of marine mammals before, during, and after pile driving activities. Monitoring will take place from 30 minutes prior to initiation through 30 minutes post-completion of pile driving activities.

   Vibratory Installation: Monitoring will be conducted for a 10 m shutdown zone. The 120 dB disturbance criterion predicts an affected area of 41.5 sq. km. Due to the difficulty of effectively monitoring such a large area, the Navy intends to monitor a buffer zone equivalent to the size of the Level B disturbance zone for impact pile driving (464 m) surrounding each pile for the presence of marine mammals before, during, and after pile driving activities. Sightings occurring outside this area will still be recorded and noted as a take, but detailed observations outside this zone will not be possible. Monitoring will take place from 30 minutes prior to initiation through 30 minutes post-completion of pile driving activities.

b. Monitoring will be conducted by qualified observers. A trained observer will be placed from 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 shut-down/delay procedures when applicable by calling for the shut-down to the hammer operator.

c. Prior to the start of pile driving activity, the shutdown and safety zones will be monitored for 30 minutes to ensure that it is clear of marine mammals. Pile driving will only commence once observers have declared the shutdown zone clear of marine mammals; Animals will be allowed to remain in the buffer zone and their behavior will be monitored and documented.

d. If a marine mammals approaches/enters the shutdown zone during the course of pile driving operations, pile driving will be halted and delayed until either the animal has voluntarily left and been visually confirmed beyond the shutdown zone or 30 minutes have passed without re-detection of the animal.

2. Sound Attenuation Devices – Sound attenuation devices (*e.g.* Gunderboom SAS™, bubble wall, etc.) will be utilized during all impact pile driving operations. Impact pile driving is only expected to be required to "proof" or drive the last 10-15 ft of each pile. The Navy plans to use a Gunderboom Sound Attenuation System™ (SAS) as mitigation for in-water sound during construction activities. The Gunderboom SAS™ is a multipurpose enclosure that absorbs sound, attenuates pressure waves, excludes marine life from work areas, and controls the migration of debris, sediments and process fluids. The Gunderboom SAS™ is comprised of a water-permeable double layer of polypropylene/polyester fabric. Compressed air is released at the bottom of the fabric and moves up to the top of the fabric inflating the fabric and creating a wall. A traditional bubble curtain/wall will be used as a backup mitigation if the Navy cannot obtain the Gunderboom SAS™ or if it does not achieve the proposed noise attenuation. The Navy will also test the feasibility and effectiveness of using sound attenuation devices with vibratory hammers. The Navy will employ the Gunderboom SAS™ or bubble curtain/wall on 2 of the vibratory driven piles to test the practicability of this concept and see if the air interface reduces the source energy level.

3. Acoustic Measurements – Acoustic measurements will be used to empirically verify the proposed shutdown and buffer zones. For further detail regarding our acoustic monitoring plan see Section 13.
4. Timing Restrictions - The Navy has set timing restrictions for pile driving activities to avoid in-water work when ESA-listed fish populations are most likely to be present. Therefore, all pile driving would only occur between 16 July – 31 October of the approved in-water work window from July 16 through February 15 to minimize the number of fish exposed to underwater noise and other disturbance. Additionally, these months (July – Oct.) were selected because they overlap with times when Steller sea lions are not expected to be present within the Project Area.
5. 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. The Test Pile Program will utilize soft-start techniques (ramp-up/dry fire) recommended by NMFS for impact and vibratory pile driving. These measures are as follows:

"*The soft-start requires contractors to initiate noise from vibratory hammers for 15 seconds at reduced energy followed by a 1-minute 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 from the impact hammer at 40 percent energy, followed by a 1-minute waiting period, then two subsequent 3-strike sets.*"

6. Daylight Construction – Pile driving will only be conducted between two hours post-sunrise through two hours prior to sunset.

11.2 Mitigation Effectiveness

It should be recognized that although marine mammals will be protected from Level A harassment by the utilization of a bubble curtain/wall and marine mammal observers (MMOs) monitoring the near-field injury zones, mitigation may not be one hundred percent effective at all times in locating marine mammals in the buffer zone. The efficacy of visual detection depends on several factors including the observer's ability to detect the animal, the environmental conditions (visibility and sea state), and monitoring platforms.

All observers utilized for mitigation activities will be experienced biologists with training in marine mammal detection and behavior. Due to their specialized training the Navy expects that visual mitigation will be highly effective. Trained observers have specific knowledge of marine mammal physiology, behavior, and life-history which may improve their ability to detect individuals or help determine if observed animals are exhibiting behavioral reactions to construction activities.

The Puget Sound region, including the Hood Canal, only infrequently experience winds with velocities in excess of 25 knots (Morris et al. 2008). The typically light winds afforded by the surrounding highlands coupled with the fetch limited environment of the Hood Canal result in relatively calm wind and sea conditions throughout most of the year. The Test Pile Program project site has a maximum fetch of 8.4 miles to the north, and 4.2 miles to the south, resulting in maximum wave heights of from 2.85-5.1 feet (BSS between 2-4), even in extreme conditions (30 knot winds) (CERC 1984). Visual detection conditions are considered optimal in BSS conditions of 3 or less, which align with the conditions that should be expected for the Test Pile Program at NBK Bangor.

Observers will be positioned in locations which provide the best vantage point(s) for monitoring. This will probably be an elevated position as they provide a better range of viewing angles. Also, the shutdown and buffer zone has a relatively small radius to monitor which should improve detectability.

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.

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 monitoring plan includes the following components: acoustic measurements and visual observations.

13.1.1 Acoustic Measurements

The Navy will conduct acoustic monitoring for impact driving of steel piles in order to determine the actual distances to the 190 dB re 1µPa rms/180 dB re 1µPa rms and the 160 dB re 1µPa rms isopleths and to determine the relative effectiveness of the bubble curtain/wall system at attenuating noise underwater. The Navy will also conduct acoustic monitoring for vibratory pile driving in order to determine the actual distance to the 120 dB re 1µPa rms isopleth for behavioral harassment relative to background levels. The monitoring plan addresses both underwater and airborne sounds from the Test Pile Program.

At a minimum, the methodology includes:

- A stationary hydrophone placed at mid-water depth and 10 meters from the source pile to measure the effectiveness of the bubble curtain system; A weighted tape measure will be used to determine the depth of the water. The hydrophone will be attached to a nylon cord or steel chain if current is swift enough, to maintain a constant distance from the pile. The nylon cord or chain will be attached to a float or tied to a static line at the surface 10 meters from the piles.
- All hydrophones will be calibrated at the start of the action and will be checked at the beginning of each day of monitoring activity.
- For each monitored location, a two-hydrophone set-up will be used, with the first hydrophone at mid-depth and the second hydrophone at ~1 meter from the bottom in order to evaluate site specific attenuation and propagation characteristics that by be present throughout the water column.
- In addition to determining the area encompassed by the 190, 180, 160, and 120 db RMS isopleths for marine mammals, hydrophones would also be placed at other distances as appropriate to accurately capture spreading loss which occurs at the Test Pile project area, or to determine the distance to the thresholds for fish and birds (these include peak, rms, and sound exposure levels [SEL]);
- Ambient conditions, both airborne and underwater, would be measured at the project site in the absence of construction activities to determine background sound levels. Ambient

levels are intended to be recorded over the frequency range from 10 Hz to 20 kHz. Ambient conditions will be recorded for 1 minute every hour of the work day, for one week of each month of the Test Pile Program.

- Sound levels associated with soft-start techniques will also be measured
- Underwater sound pressure levels would be continuously monitored during the entire duration of each pile being driven. Sound pressure levels will be monitored in real time. Sound levels will be measured in Pascals which are easily converted to decibel (dB) units.
- Airborne levels would be recorded as unweighted, as well as in dBA and the distance to marine mammal and/or avian thresholds (respectively) would be measured;
- The effectiveness of using a bubble curtain/wall system with a vibratory hammer will be tested during the driving of 2 vibratory piles. The following on/off regime will be utilized during the pile installation:

Pile Driving Timeframe	**Sound Attenuation Device Condition**
Initial 30 seconds	Off
Next minute (minimum)	On
Middle of pile driving segment 30 seconds	Off
Next minute (minimum)	On
Final 30 seconds	Off

- Environmental data would be collected including but not limited to: wind speed and direction, air temperature, humidity, surface water temperature, water depth, wave height, weather conditions and other factors that could contribute to influencing the airborne and underwater sound levels (e.g. aircraft, boats, etc.);
- The chief inspector would supply the acoustics specialist with the substrate composition, hammer model and size, hammer energy settings and any changes to those settings during the piles being monitored, depth of the pile being driven, and blows per foot for the piles monitored.
- Post-analysis of the sound level signals will include determination of absolute peak overpressure and under pressure levels recorded for each pile, Root Mean Square (RMS) value for each absolute peak pile strike, rise time, average duration of each pile strike, number of strikes per pile, Sound Exposure Level (SEL) of the absolute peak pile strike, mean SEL, and cumulative SEL (Accumulated SEL = single strike SEL + 10*log (# hammer strikes) and a frequency spectrum both with and without mitigation, between 10 and 20,000 Hz for up to eight successive strikes with similar sound levels.

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 trained in marine mammal identification and behaviors. 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 shut down zone and safety zone before, during, and after pile driving. Based on NMFS requirements, the Marine Mammal Monitoring Plan would include the following procedures for impact pile driving:

- MMOs would be located at the best vantage point(s) in order to properly see the entire shut down zone and safety 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;
- During all observation periods, observers would use binoculars and the naked eye to search continuously for marine mammals;
- To verify the required monitoring distances, the zones would be clearly marked with buoys or other suitable aquatic markers;
- If the shut down or safety zones are obscured by fog or poor lighting conditions, pile driving would not be initiated until all zones are visible;
- The shut down and safety zones around the pile will be monitored for the presence of marine mammals before, during, and after any pile driving activity;
- Pre-Activity Monitoring:
    - The shut down and buffer zones will be monitored for 30 minutes prior to initiating the soft start for pile driving. If marine mammal(s) are present within the shut down prior to pile driving or during the soft start, the start of pile driving would be delayed until the animal(s) leave the shut down zone. Pile driving would resume only after the MMO has determined, through sighting or by waiting approximately 30 minutes that the animal(s) has moved outside the shut down zone.
- During Activity Monitoring:
    - The shutdown and buffer zones will also be monitored throughout the time required to drive a pile. If a marine mammal is observed entering the buffer zone, a "take" would be recorded and behaviors documented. However, that pile segment would be completed without cessation, unless the animal enters or approaches the shutdown zone, at which point all pile driving activities will be halted. Pile driving can only resume once the animal has left the shutdown zone of its own volition or has not been re-sighted for a period of 30 minutes.
- Post-Activity Monitoring: Monitoring of the shutdown and buffer zones would continue for 30 minutes following the completion of pile driving.

13.1.4 Data Collection

NMFS requires that the MMOs use NMFS-approved sighting forms. NMFS requires that 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. wind, humidity, temperature);
- Tide state and water currents;
- Visibility;
- 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 sound pressure levels;
- Distance from pile driving activities to marine mammals and distance from the marine mammal to the observation point;
- Locations of all marine mammal observations;
- Other human activity in the area.

13.2 Reporting

A draft report would be submitted to NMFS within 45 days of the completion of acoustic measurements and marine mammal monitoring. The results would be summarized in graphical form and include summary statistics and time histories of impact sound values for each pile. A final report would be prepared and submitted to the NMFS within 30 days following receipt of comments on the draft report from the NMFS. At a minimum, the report shall include:

- Size and type of piles.
- A detailed description of the bubble curtain/wall, including design specifications.
- The impact or vibratory hammer force used to drive/extract the piles.
- A description of the monitoring equipment.
- The distance between hydrophone(s) and pile.
- The depth of the hydrophone(s).
- The depth of water in which the pile was driven.
- The depth into the substrate that the pile was driven.
- The physical characteristics of the bottom substrate into which the piles were driven.
- The ranges and means for peak, RMS, and SEL's for each pile.
- The results of the acoustic measurements, including the frequency spectrum, peak and RMS SPL's, and single-strike and cumulative SEL with and without the attenuation system.
- The results of the airborne noise measurements including dBA and unweighted levels.
- A description of any observable marine mammal, fish, or bird behavior in the immediate area and, if possible, the correlation to underwater sound levels occurring at that time.

- Results: Including the detectability of marine mammals, species and numbers observed, sighting rates and distances, behavioral reactions within and outside of safety zones.
- A refined take estimate based on the number of marine mammals observed in the safety and buffer zones. This may be reported as one or both of the following: a rate of take (number of marine mamamls per hour), or take based on density (number of individuals within the area).

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, U.S. Fish and Wildlife Service, U.S. Coast Guard, Federal Energy Regulatory Commission (FERC), U.S. Army Corps of Engineers (USACE), and the Washington Department of Fish and Wildlife (WDFW). The Navy will share field data and behavioral observations on all marine mammals that occur in the project area. Results of each monitoring effort will be provided to NMFS in one summary report within 45 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 five years the Navy has funded over $100 million in marine mammal research, with several projects ongoing in Washington.

The Navy sponsors 70% of all U.S. research concerning the effects of human-generated sound on marine mammals and 50% 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 National Marine Fisheries Service (NMFS) from research and development efforts; and future research as described previously.

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