United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

In Reply Refer To:
13410-2011-F-0164

NOV 16 2011

Captain Pete Dawson
U. S. Navy Commanding Officer
Naval Base Kitsap
ATTN: Environmental (Kunz)
120 South Dewey St.
Bremerton, Washington 98314-5020

Dear Captain Dawson:

Subject: Second Explosives Handling Wharf at Naval Base Kitsap Bangor Endangered Species Act Section 7 Formal Consultation

This correspondence transmits the U.S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion), which is based on our review of the Second Explosives Handling Wharf (EHW-2), Naval Base Kitsap Bangor (NBKB) located in Hood Canal in Kitsap County, Washington. You requested initiation of formal consultation regarding anticipated adverse effects from the proposed action on the marbled murrelet (*Brachyramphus marmoratus*). You also requested our concurrence on your "may affect, not likely to adversely affect" determination for bull trout (*Salvelinus confluentus*). No marbled murrelet or bull trout critical habitat occurs within the action area. The enclosed Opinion describes the effects of the action on the marbled murrelet in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The U.S. Navy proposes to construct and operate a second explosives handling wharf to support current and future Trident Fleet Ballistic Missile program requirements for the eight Trident submarines currently homeported at NBKB. The Opinion addresses the proposed action's adverse effects on the marbled murrelet and includes mandatory terms and conditions intended to minimize the impact of incidental take. In addition, we concur that the action's foreseeable direct and indirect effects to the bull trout, their habitat, and prey base are insignificant.

This Opinion is based on information provided in the February 25, 2011, Biological Assessment, telephone conversations, site visits, and other sources of information. A complete record of this consultation is on file at the Service's Washington Fish and Wildlife Office in Lacey, Washington.

The U.S. Navy has recommended that our agencies develop an adaptive management approach for the proposed action. We concur that such an approach would be valuable to address the uncertainties related to the implementation and effects of the proposed action, specifically issues related to the number of impact strikes required, sound pressures generated, and marbled murrelet monitoring. We support the idea of regular meetings of an adaptive management group to address issues related to the construction, project design and monitoring of the proposed action. The frequency of these meetings would be scheduled as determined jointly by the Service and the U.S. Navy. The additional information that will be gained through completion of the Test Pile program will also be an important component of this adaptive approach.

We would also be interested in continuing our dialogue related to Recovery Crediting or other concepts which could address the conservation needs of marbled murrelets. We look forward to future discussions with you on the issue as the compensatory and tribal mitigation packages firm up.

If you have any comments or questions regarding this Opinion, or our joint responsibilities under the Endangered Species Act; please contact Nancy Brennan-Dubbs at (360) 753-5835 or Martha Jensen at (360) 753-9000, of this office.

Sincerely,

Ken S. Berg, Manager
Washington Fish and Wildlife Office

Enclosure(s)

Endangered Species Act – Section 7 Consultation

Biological Opinion

U.S. Fish and Wildlife Service Reference #
13410-2011-F-0164

Second Explosives Handling Wharf
Naval Base Kitsap Bangor

Agency:

U.S. Navy
Bremerton, Washington

Consultation Conducted by:
U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office

Ken S. Berg, Manager
Washington Fish and Wildlife Office

11/16/11
Date

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LIST OF ACROYNMS AND ABBREVIATIONS

Act	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)
BA	Biological Assessment
BMP	Best Management Practices
EHW-2	second Explosives Handling Wharf
EPA	U.S. Environmental Protection Agency
ILF	In-Lieu Fee
MHHW	Mean High Higher Water
MLLW	Mean Low Lower Water
Navy	U.S. Navy
NBKB	Naval Base Kitsap Bangor
Opinion	Biological Opinion
PAH	Polycyclic Aromatic Hydrocarbon
PSAMP	Puget Sound Ambient Monitoring Program
RPM	Reasonable and Prudent Measures
SEL	Sound Exposure Levels
Service	U.S. Fish & Wildlife Service
SPL	Sound Pressure Levels
TL	Transmission Loss
TTS	Temporary Threshold Shift

INTRODUCTION

This document transmits the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the proposed construction of a Second Explosives Handling Wharf (EHW-2) located at Naval Base Kitsap, Bangor (NBKB) in Hood Canal, Kitsap County, Washington, and its effects on the marbled murrelet (*Brachyramphus marmoratus*). This consultation is being conducted in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act). The Biological Assessment (BA) dated February 25, 2011, and letter requesting consultation was submitted by the U.S. Navy (Navy) to the Service's Division of Consultation and Technical Assistance and received on March 3, 2011. The Navy requested that the Service concur with a "may affect, likely to adversely affect" determination for marbled murrelet and a "may affect, not likely to adversely affect" for bull trout (*Salvelinus confluentus*).

The project will be funded by the Navy and requires permits from the U.S. Army Corps of Engineers under section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act. Both the Federal funding for the proposed action, as well as the issuance of the section 10 and section 404 permits, establishes a nexus requiring consultation under the Act. The Navy is the lead Federal agency for this consultation.

CONSULTATION HISTORY

This Opinion is based on information provided in the February 2011 BA, EHW-2 Draft Environmental Impact Statement, telephone conversations, site visits, and other sources of information. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington. A chronological list of significant communications related to the consultation history is provided below:

- May 26, 2010: The Navy met with the Service to brief us on the proposed EHW-2 proposed action.
- January 31, 2011: The Navy met with the Service to provide an update on the proposed EHW-2.
- March 3, 2011: The Navy requested formal consultation in their letter dated February 25, 2011, with the Service for a "may effect, but is not likely to adversely affect" determination for bull trout and a "may affect, likely to adversely affect" determination for marbled murrelets.
- March 2011: The Service notified the Navy that the interim criterion for determining the onset of injury to marbled murrelets due to underwater sound would be 183 dB Sound Exposure Levels (SEL). The Navy's analysis in the BA was based on 180 dB_{peak}.
- April 14, 2011: The Service participated by conference call in an information meeting on the Draft Environmental Impact Statement with the Navy and interested parties organized by the Governor's Office of Regulatory Assistance.
- April 19, 2011: The Service provided preliminary comments and questions on the BA to the Navy.

- May 9, 2011: The Navy provided a response to some of the Service's comments and questions.
- May 13, 2011: The Service provided additional questions regarding the BA to the Navy.
- May 23, 2011: The Navy conducted a conference call with the Service and National Marine Fisheries Service and provided a response to agency questions and comments.
- May 27, 2011: The Navy provided an update of responses to agency questions and comments.
- June 3, 2011: The Navy provided comments to the Service regarding the marbled murrelet exposure model.
- June 8, 2011: The Navy met with the Service to discuss mitigation options for EHW-2.
- June 10, 2011: The Navy provided the Service a white paper proposing 210 dB SEL as an alternative to 183 dB SEL as a criterion for establishing injury to marbled murrelets due to underwater sound.
- June 18, 2011: The Navy provided the Service a mitigation alternative regarding the use of "Recovery Credits" for marbled murrelets.
- June 20, 2011: The Navy and Service met to discuss outstanding issues and development of an expert panel to address the underwater sound injury threshold for marbled murrelets.
- June 24, 2011: The Navy met with the Service and National Marine Fisheries Service to discuss pile driving assumptions.
- July 6, 2011: The Service provided a response to the Navy's June 3, 2011, comments regarding the marbled murrelet exposure model and assumptions.
- July 8, 2011: The Navy provided the Service a revised marbled murrelet monitoring plan to address the use of 183 dB SEL as a threshold for determining injury due to underwater sound pressures.
- July 12, 2011: The Navy provided the Service a proposed revision to the number of pile strikes associated with impact pile driving.
- July 27 through 29, 2011: An expert panel of scientists and biologists were convened by the Service and Navy to develop and recommend a threshold and metric for the onset of injury to marbled murrelets (defined as hair cell loss) due to underwater sound pressures. On July 29, the panel recommended a threshold of 202 dB SEL for the onset of injury and 208 dB SEL for the onset of barotrauma.
- August 5, 2011: Ken Berg, Manager, Service, notified Captain Jorge Rios, Navy, that the Service would adopt the recommendations of the expert panel for determining the onset of injury associated with hair cell loss (202 dB SEL) and barotrauma (208 dB SEL), in marble murrelets due to underwater sound.
- August 9, 2011: The Service notified the Navy via conference call that sound pressures between 183 dB SEL and 202 dB SEL would be used in the interim for non- injurious temporary threshold shifts for marbled murrelets.

- August 16, 2011: The Service received a revised marbled murrelet monitoring plan based on the 202 dB SEL threshold.
- August 17, 2011: The Service provided comments to the Navy regarding the revised marbled murrelet monitoring plan.
- August 18, 2011: The Navy provided revisions to the marbled murrelet monitoring plan to the Service.
- August 18, 2011: The Service provided comments to the Navy regarding the revised marbled murrelet monitoring protocol.
- August 22, 2011: The Service met with the Navy to discuss marbled murrelet monitoring within the area of non-injury temporary threshold shift (beyond 55 meters [m]).
- August 24 to 29, 2011: The Navy modified the pile driving schedule. The final proposal removed the limit of 400 and 800 pile strikes per day and replaced it with a limit of 1,000 pile strikes per day. The number of days with impact pile driving increased from 349 to 400.
- August 31, 2011: The Navy notified the Service via email that they would implement marbled murrelet monitoring to Service protocol to a distance of 55 m during in-water impact pile driving operations.
- September 9, 2011: The Service provided the Navy with a draft copy of the Opinion.
- September 15, 2011: The Navy provided comments to the Service regarding the draft Opinion.
- September 20, 2011: The Navy met with the Service to discuss the draft Opinion and their comments.
- October 27, 2011: The Service provided the Navy with a second draft copy of the Opinion.
- November 6, 2011: The Navy provided comments to the Service regarding the second draft Opinion. Comments included describing an increase in the number of total piles to be installed. An additional 150 piles may be temporarily installed and removed using a vibratory pile driver.

Concurrence for Bull Trout

Please see the "Description of the Project" within the Opinion below regarding specific activities associated with the proposed action.

The proposed action includes impact pile driving of steel piles that will result in sound pressure levels that are known to injure fish. Although a bubble curtain will be used to attenuate underwater sound pressures, sound pressures may still reach injurious levels to bull trout if they reach or exceed 187 dB SEL(re: 1 μPa^2-sec)[1] . Other construction-related effects include

[1] From the Fisheries Hydroacoustic Working Group, Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities, June 12, 2008.

increased turbidity during pile installation, construction of bank stabilization, operation, and anchoring of barges and other large vessels, and associated boat scour. The proposed action may also result in effects to bull trout via impacts to their prey species.

The closest known population of bull trout is in the Skokomish River, approximately 35 miles south of the project area. Based on recent tagging information, bull trout in the South Fork Skokomish River appear to be largely fluvial (there is currently no documentation of anadromy based on tagged fish). Cushman Dam currently blocks all upstream access and most downstream access to the marine environment for bull trout in the North Fork Skokomish River. There are no records of bull trout in the Hood Canal marine environment or freshwater systems on the Kitsap Peninsula. As it is extremely unlikely that bull trout occur within the action area and the project will be conducted at a time of year when bull trout are least likely to be in the marine environment (July 16 to February 15), we consider the direct effects of the pile driving to bull trout to be discountable.

Effect to Bull Trout due to Changes in Water Quality

Although there is a low likelihood that bull trout would occur within the action area during the proposed in-water construction period, due to the life of the proposed project (through 2042), we evaluated operational effects that would occur when bull trout may be present in the marine environment (February 16 through July 15).

Contaminants may enter the marine environment due to stormwater runoff associated new pollution-generating surfaces associated with the trestle and wharf, new upland road surfaces, staging areas, and new upland structures and their associated parking lots and sidewalks.

The proposed action may also cause an increased risk of contaminants entering the marine environment due to fuel and oil leaks from the use of boats and barges and long-term use of the new facility. Although there is a risk of fuel and oil leaks from the surface water vessels, due to the relative light traffic on the wharf and proposed design for stormwater treatment, the amount of petroleum products that may impact water quality are expected to be negligible. Therefore, the effects of contamination due to fuel and oil are anticipated to be insignificant.

Construction effects on water quality will be minimized with the implementation of Best Management Practices (BMPs), including use of filters to treat stormwater discharged from catch basins. During operation of the new EHW-2, stormwater quality is expected to be similar to that discharged from the existing EHW and Bangor stormwater outfall OF-02. Monitoring data from the existing EHW show annual levels of total recoverable zinc averaging between 8 and 45 µg/l. No copper data are available for the existing EHW. Bangor stormwater outfall OF-02, which is monitored for copper, has had comparable zinc concentrations to those observed at the existing EHW. Zinc and copper concentrations typically show significant correlation in stormwater. Total recoverable copper annual average concentrations at OF-02 have ranged from 3 to 17 µg/l based on 5 years of monitoring. No comparable past data are available to predict petroleum concentrations in stormwater.

Finlayson and Verrue (1982) conducted continual-flow toxicity tests to determine the acute toxicity of dissolved copper and zinc in freshwater on juvenile Chinook salmon (*Oncorhynchus tshawytscha*). The mean concentration of dissolved copper causing 50 percent mortality of juvenile Chinook salmon in 96-hour exposures was 32 µg/l dissolved copper (range from 28 to 36 µg/l). For zinc, the mean concentration was 84 µg/l dissolved zinc (range from 36 to 132 µg/l). Adverse sublethal effects from exposure to dissolved copper and zinc on listed salmon occur at very low levels, ranging from 0.18 to 2.1 µg/l in freshwater for copper (Hecht et al. 2007, p. 2) and at 5.6 µg/l in freshwater for zinc (Sprague 1968, p. 369). Adverse sublethal effects of copper include interference with fish sensory systems (e.g., olfaction) and important behaviors that underlie predator avoidance, juvenile growth, and migratory success. Adverse sublethal effects of zinc include altered behavior, changes in blood and serum chemistry, impaired reproduction, and reduced growth (Eisler 1993, pp. 66-71). Effect thresholds for dissolved copper and zinc in estuaries or saltwater are not known. The salinity, hardness, and dissolved organic carbon contents of these habitats are considerably higher than in freshwater and may reduce the toxicity of dissolved metals for fish. However, Baldwin et al. (2003, p. 2269) did not find any influence of water hardness on the inhibiting effect of copper on coho salmon (*O. kisutch)* olfactory functions.

The proposed action will result in an additional 0.8 acre of new impervious surfaces associated with the construction of a new roads to access the wharf and for maintenance purposes. Stormwater runoff will be directed to a new stormwater treatment facility and then discharged via a new outfall into Hood Canal. Due to the size of the receiving body and limited area of new impervious surface created, we do not anticipate measurable changes in hydrology. Stormwater from the main wharf, warping wharf, and trestle will be treated in catch basins that contain filter cartridges prior to discharge into Hood Canal. However, stormwater, even if treated to meet state water quality standards, contains contaminants (e.g., copper and zinc) at levels known to negatively impact fish. The amount of contaminants that may be discharged in the treated stormwater is unknown, but would result in some additional loading of contaminants in Hood Canal.

Although copper and zinc may be discharged in stormwater into Hood Canal as part of the proposed action, we do not anticipate the effects to bull trout to be measurable for the following reasons.

1. Stormwater runoff from new buildings and associated impervious surfaces will either be fully infiltrated or will include at least partial infiltration (for the new pure water facility).

2. Stormwater runoff from new paved roads will be treated with filters that are effective at removing solids, which will also remove most of the copper and zinc prior to discharge into Hood Canal.

3. Filters will also be used at each of the 11 outfalls along the trestle and wharf, thus removing most of the copper and zinc. Any dissolved copper and zinc remaining in the stormwater following filter treatment will be rapidly diluted as the stormwater is discharged into Hood Canal and a significant level of exposure to bull trout is unlikely to occur.

Therefore, effects bull trout from contaminants associated with stormwater will be insignificant.

Indirect Effects to Bull Trout via Prey Species

Indirect effects to bull trout may occur due to impacts to their forage fish and to forage fish spawning habitat within the action area. Pacific herring (*Clupea pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) occur within the area and are important prey species for bull trout.

Effects to Forage Fish Habitat

The proposed action may result in temporary and permanent impacts to forage fish habitat, including spawning habitat. Although eelgrass beds occur on-site and may be used by Pacific herring for spawning, no spawning has been documented at the project site. No surf smelt spawning has been documented at the project site. Although Pacific sand lance spawning has been documented within the action area, the spawning area will not be impacted by the project.

Construction of the trestle and wharf will shade nearshore marine habitat and submerged aquatic vegetation in the immediate project vicinity of the proposed structure. Construction is expected to disturb 25.7 acres of benthic habitat and will shade 0.92 acre of eelgrass, algae, and kelp beds. Long-term shading impacts will account for approximately 0.09 acre of eelgrass impacts and 0.17 acre of macroalgae. Additionally, the concrete abutment for the trestle will be constructed 4 to 9 ft above mean higher-high water (MHHW), and may result in a temporary loss of upper intertidal potential forage fish spawning habitat during construction. Additionally, the abutment will block sediment supply to the beach. Under natural conditions, erosion provides sediments to the beach that are then redistributed along the beach by longshore drift. When the sediment supply is cut off, longshore drift will, over time, remove the finer materials, resulting in the loss of substrates that could be suitable for forage fish spawning in the future (Thom et al. 1994, p. 6-4; Williams and Thom 2001, p. 40).

Although the proposed action will result in short and long-term impacts to potential forage fish habitat, we do not anticipate the temporary and/or permanent loss of a small amount of forage fish habitat be of a magnitude as to measurably affect the bull trout that may forage in this area. Therefore, effects to bull trout via their prey are considered to be insignificant.

Effects to Forage Fish from Underwater Sound Pressure

Impact pile driving will occur over a period of three in-water work seasons (July 16 through February 15, 2012, through 2014). Restricting in-water work to this time period will reduce, but not eliminate, the potential for exposure to individual forage fish that may be present in the water all year. Additionally, Pacific sand lance spawning occurs within the action area. Pacific sand lance spawn from November through mid-February, and therefore, spawners and spawning areas may be exposed to high sound pressure levels during pile installation. Therefore, we anticipate that there is a likelihood that spawning Pacific sand lance, including their eggs and fry, may be exposed to high levels of underwater sound during pile driving. However, due to the proposed sound attenuation measures implemented during pile driving (e.g., bubble curtain) that will limit

the extent of the area of injury and loss of forage fish, we do not anticipate the temporary loss of individual forage fish to be of such a magnitude as to measurably affect prey availability for the small number of bull trout that may forage in Hood Canal. Therefore, we anticipate that the effects to bull trout via their prey associated with underwater sound pressure will be insignificant.

Effects to Forage Fish due to Changes in Water Quality

Contaminants in stormwater runoff from the new pollution-generating surfaces of the trestle and wharf, staging areas, new upland roads, structures, parking lots and sidewalks, may affect bull trout forage species that are present in the area. As described above (Effect to Bull Trout due to Changes in Water Quality), we anticipate the water quality discharged into Hood Canal after treatment to be at levels that would not result in measurable effects to forage fish. Therefore, effects to bull trout via their prey associated with project-related changes in water quality to be insignificant.

The proposed action may result in increased turbidity and sediment during construction due to the installation and removal[2] of piles, operation of the bubble curtain, construction of the bank stabilization, use of spuds and anchors, and boat scour. Additionally, if contaminants are present in the sediments where the piles are installed and removed, these may become available to bull trout indirectly through their prey.

Sediment may be dispersed up to 130 ft from the piles (Navy response to Service in email dated 7/18/2011 – in matrix attachment to email). Turbidity associated with the bubble curtain may occur higher in the water column compared to other actions due to the rising bubbles. Additionally, if any piling is removed, increased turbidity in the water column would also likely occur.

Surface sediments at the project site are coarse-grained, ranging from 82 to 100 percent sand and gravel in shallow areas (less than 40 ft below mean lower low water [MLLW]), 94 to 100 percent sand and gravel in mid-depth areas (40 ft to 60 ft below MLLW), and 65 to 100 percent sand and gravel in deeper areas (greater than 60 ft below MLLW) (Hammermeister and Hafner 2009 in BA). The BA further states that based on the size of sediment particles typical of the project site, the settling period for individual particles could be up to several hours depending on the water depth and distance above the bottom. Increased levels in turbidity may result in negative effects to forage fish due to gill abrasion or decreased fitness or an inability to locate prey. Increased sediments could impact forage fish spawning habitat, including smothering eggs. However, due to the composition of the substrates (primarily sand and gravels), the extent of the area that may be affected due to increased sediments and turbidity, we anticipate that these effects will be limited. Although some injury and loss of individual forage fish and temporary impacts to their spawning habitat may occur due to increased sediment and turbidity associated with project construction, and we do not anticipate that project-related impacts to bull trout prey will be at a magnitude as to measurably affect the limited number of bull trout that may forage in this area. Therefore, we anticipate that the effects to bull trout via their prey will be insignificant.

[2] Temporary piles may be installed help with alignment of the design piles. The "template piles "would be vibrated in to provide a frame to set up the other piles and would be removed.

Compensatory Mitigation Measures

To mitigate for project-related impacts to the marine environment, the Navy is proposing mitigation in the form of an In-Lieu Fee (ILF) program that is currently under development. The Navy has stated that they would implement permittee responsible mitigation if the ILF program is not be completed and approved at the time of permitting of the proposed action. Because the mitigation plan is still being developed, we are unable to evaluate the effectiveness of the proposed mitigation and/or its effects on bull trout or their prey.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The Navy proposes to construct a second explosives handling wharf (EHW-2) adjacent to the existing EHW in Hood Canal to support current and future Trident Fleet Ballistic Missile program requirements for eight Trident submarines that are currently homeported at NBKB. The EHW-2 is needed to offload/load missiles and perform routine operations and upgrades required to maintain the current fleet of Trident submarines at NBKB through 2042, the service life of the weapons system. The existing EHW alone is not be able to meet the needs to support Trident program requirements due to the physical condition of the existing structure and changing operational and weapon systems requirements. There will be an increase in the current level of operations at NBKB due to the proposed action. After the completion of the project, current operational levels will be divided between the existing EHW and the new EHW-2. However, no increase in vessel[3] traffic is anticipated. Any future increases in operations would require a separate National Environmental Policy Act analysis and separate consultation under the Act.

The wharf will cover approximately 6.3 acres of open water when completed. The wharf deck will consist of pre-cast concrete sections. The elevation of the top of the wharf deck will be 20.5 ft above MLLW, and the bottom of the wharf deck will be 13 ft above MLLW. Habitats that will be impacted or disturbed during construction include the seafloor within 150 ft of the proposed EHW-2 structure. A maximum of 25.7 acres of benthic habitat may be disturbed during construction, consisting of a 150-ft area surrounding the site where barges would be stationed and tug boats would maneuver the barges during pile driving.

The Navy will permanently install up to 1,250 steel piles that range in size from 24 inches to 48 inches in diameter (Figure 1 and 2, Table 1). The Navy anticipates that approximately 317 24-inch-diameter, 670 36-inch-diameter, and 263 48-inch-diameter steel piles will be installed. The actual number of piles by size is not known; however, for the purpose of this consultation we have assumed that the combined total of 36 and 48 inch-diameter piles will not exceed 933 piles. Pipe lengths range from 115 ft to 198 ft and will be installed using both a vibratory and impact hammer. Up to three vibratory and one impact hammer may be used at the same time. Up to 150 false work/temporary template steel piles may be required, in addition to the 1,250

[3] Vessel traffic includes all boats, submarines, and other marine vessels.

permanent piles for a total of up to 1,400 piles. The diameter of these piles is not known; however, they will not exceed 48 inches in diameter and will be installed and removed using a vibratory hammer.

Figure 1. Proposed EHW-2.

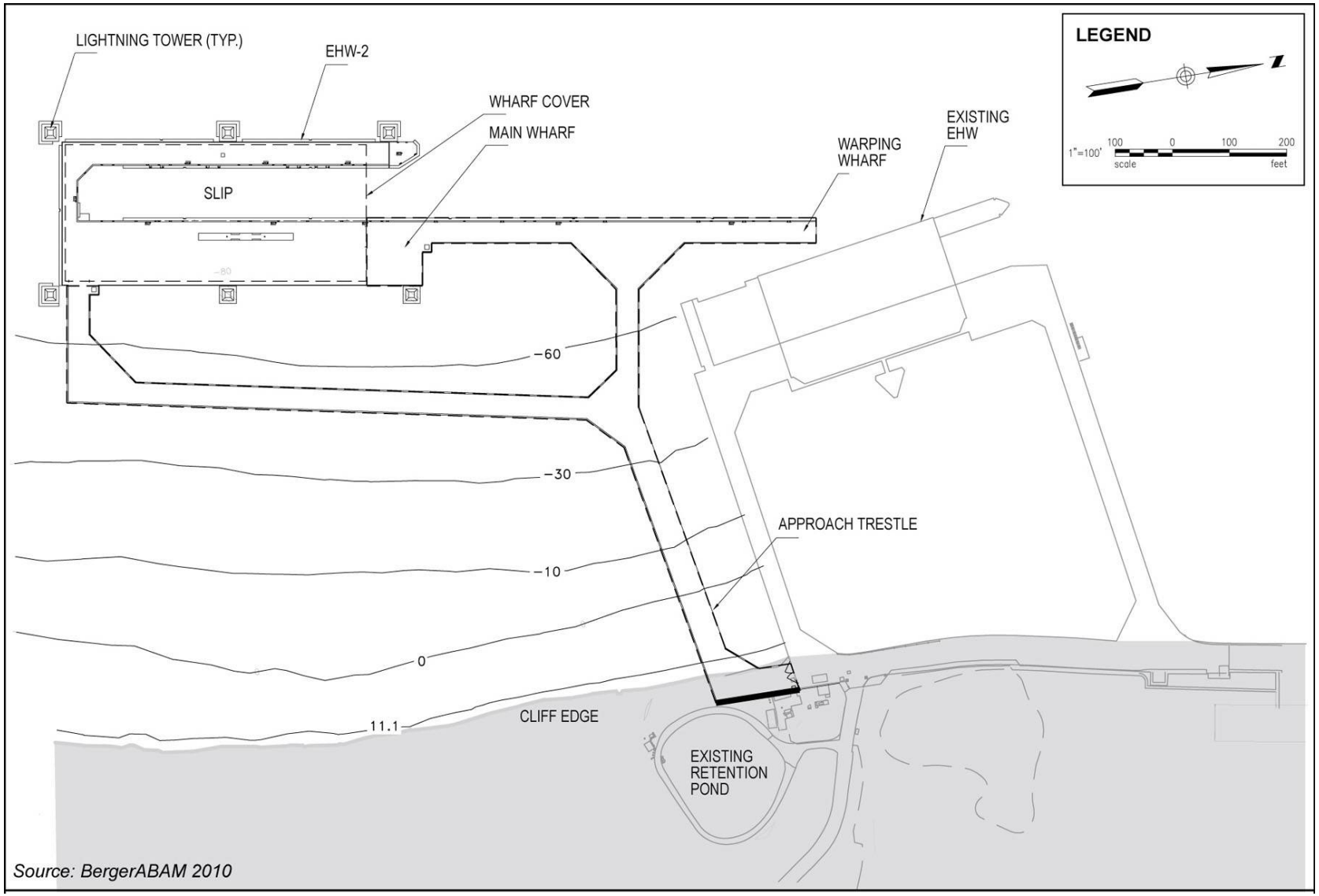

Figure 2. Plan view of proposed EHW-2.

Table 1. Anticipated number of piles to be installed by pile diameter, based on preliminary designs[4].

Pile Size (inches)	Number of Piles Permanently Installed	Number of Piles Temporarily Installed
24	317	150[5]
36	670	
48	263	

Maintenance of the new wharf may include painting, replacement of cathodic protection, concrete surface repair of deck, and stormwater filter replacement. Any unforeseen structural or major repairs are not part of this consultation and would undergo a separate consultation under the Act.

A 5-acre laydown area will be needed for the upland construction. The proposed site is currently vegetated, has no wetlands, and is located approximately 4,000 ft south of the proposed EHW-2. The area will be cleared and used for storage of material and equipment, as well as soil stockpiling. Following construction, this area will be revegetated with native forest species.

A permanent paved road extension will be built to connect the new trestle to an existing road. This road extension will be 50 ft wide and 140 ft long, creating approximately 0.2 acre of new impervious surface. Another permanent paved road will be built to provide access to the upland construction area along the shoreline, while avoiding a nearby retention pond. This road will be approximately 610 ft long and typically between 28 ft and 32 ft wide, but expanding to 115 ft wide in the turn-around area at the southern curve. The area of this road will be approximately 0.6 acre. A culvert will be installed under the road to provide drainage from a seep south of the road to Hood Canal. No stormwater from paved surfaces will enter the culvert. This paved road will be left in place to provide maintenance access to water lines and other facilities. Therefore, there will be a total of 0.8 acre permanently occupied by new paved roads. An additional 0.8 acre will be temporarily disturbed for cut and fill for the access road and for work on stormwater facilities and other utility work. This 0.8-acre area will be revegetated with native species following construction.

A new concrete abutment will be built at the face of the shore cliff, under where the trestle comes ashore. This abutment will be 10 ft high and 103 ft long and will have a 69-ft wide wing wall, requiring 520 tons of armor rock. Approximately 2,760 cubic yards of material will be excavated to construct the trestle abutment. All of the excavated material will be used for backfill either at the abutment or at another part of the adjoining upland construction site. The abutment will be pile-supported and constructed from the land side. The proposed plan is to form/pour the abutment during low tide. Following construction, the exposed part of the abutment will lie above MHHW. Some excavation and pile installation associated with the abutment will occur below MHHW. Beach contours will be restored to pre-construction

[4] The combined total of 36- and 48- inch-diameter steel piles permanently installed will not exceed 933 piles. Total piles installed will not exceed 1,400.
[5] Piles temporarily installed may range between 24 to 48 inches in diameter, and will not exceed 150 total piles.

conditions. Abutment construction will take about 20 days, including 11 days for pile installation. Approximately fifty five 24-inch diameter steel piles will be installed in uplands as part of the abutment (these piles are in addition to the 1,400 piles proposed for in-water construction.

Approximately 20 existing facilities and/or structures in proximity to the EHW-2 would be modified or demolished as part of the action to comply with Department of Defense Explosives Safety Board and Naval Ordnance Safety and Security Activity requirements to protect buildings located in the vicinity of explosives handling operations. Structural modifications to existing facilities will include interior and exterior modifications. No vegetated or undeveloped areas near the buildings will be impacted.

Three new buildings, paved and fenced storage areas, associated roads parking, and sidewalks will be constructed to replace some of the buildings that will be demolished. These new buildings and facilities will be constructed on an existing parking lot that is located approximately 4,900 ft from the shoreline. No native vegetation will be removed. Parking and staging areas lost due to this new construction will be replaced by expanding existing parking facilities in other existing industrial areas of the Lower Base. The buildings and associated roads, parking, and sidewalks would permanently occupy approximately 2.6 acres. An additional approximately 0.7 acre of shrubs and small trees associated with landscaped areas will be removed to construct the replacement parking spaces.

A fourth facility, the pure water facility, would be relocated along the Bangor shoreline, inland from Delta Pier, and south of the proposed and existing EHW structures. The new facility would cover approximately 0.5 acre and would consist of a treatment building, an auxiliary water storage tank, liquid nitrogen storage tank, sewage tank and pump, loading aprons, parking areas, and a new water line between the facility and Delta Pier. Two water line route alternatives are under consideration: one alternative would install the water line above ground along a route parallel to the existing roadway and the other would be to hang the new water line under the southern trestle of Delta Pier.

Since the sites for the pure water facility and water line routes are existing developed and disturbed areas, native vegetation and wildlife habitat would not be removed. The new buildings and parking spaces would include exterior lighting for security, similar to existing conditions.

The following is a more detailed description of the proposed action.

1. The duration of all in-water work (including mobilization, pile installation, demobilization) will require up to a total of 400 days between July 16 and February 15 over the three potential in-water construction seasons beginning in 2012 and ending in 2014. It is anticipated that pile driving (vibratory and impact) may occur each day. All project construction is expected to end in 2016.

2. All piles will be installed using a vibratory hammer and may occur on each day of in-water construction (up to 400 days).

3. Some piles will require impact driving for partial (proofing only) or total installation. The actual number of piles that will be installed by impact pile driving per day is unknown. However, the Navy has provided the following based on preliminary design information, which we have used for the purposes of this consultation. See Table 2 for a summary of assumed pile strikes based on this preliminary design information.

    a. All pile strike limits represent the upper limit for a day. For example, if 900 pile strikes occurred in 1 day, that would be counted as the next highest pile strike limit, or 1,000 pile strikes per day in this example. Pile strikes not used cannot be "banked" for later use.

    b. Multiple pile locations may require impact hammer installation within 1 day. Due to limited distance between piles that will be impact driven (approximately 25 ft), we assume for our analysis that all pile strikes in 1 day are associated with only one pile location.

    c. Proofing of one pile may require up to 200 strikes.

    d. Proofing of five piles per day may require up to 1,000 strikes.

    e. Full impact installation of a single pile may require 2,000 strikes per day.

    f. Up to 6,400 strikes may be needed for full impact driving of 3 piles per day and proofing of two piles per day.

    g. Impact proofing of 24-inch diameter piles will be needed along the trestle (approximately 50 piles). The remaining 24-inch diameter piles are fender piles that will be installed using a vibratory driver. It is anticipated that at least 10 percent of the fender piles may require some impact driving to install them to depth.

Table 2. Number of days of pile strikes by pile size and work period based on preliminary design information.

Pile Size (diameter)	**Dates of Work**	**Number of days with up to 1,000 pile strikes per day**	**Number of days with up to 2,000 pile strikes per day**	**Number of days with up to 6,400 pile strikes per day**
24-inch	July 16 – September 30	2	11	1
	October 1 – February 15	2	11	1
Total Days for 24-inch piles		4	22	2
36-inch or 48-inch	July 16 – September 30	96	68	22
	October 1 – February 15	105	68	13
Total Days for 36/48-inch piles		201	136	35

4. Between two to eight barges may be located on site during construction. Pile driving for the wharf portion will require one to two large derrick barges (approximately 70 ft by 200 ft) and one to two pile barges for the duration of pile driving. One derrick barge and two material barges will be needed for wharf deck construction. Construction of the lightning towers will require one derrick barge and one material barge. Tug boats will be used and no more than two will be in the construction area[6] at any time. Up to six smaller boats (less than 30 ft in length) will also be on site to perform both construction and species monitoring. Measures will be implemented to ensure that mooring and anchor lines do not drag on the seafloor or entangle vegetation.

5. Six lightning towers will be constructed around the wharf. The towers will extend approximately 230 ft above the wharf deck and will be connected by two rows of catenary wire cables. The catenary wires at the top of the towers will be 0.1285 inch diameter and the catenary wires halfway up the towers will be 0.1819 inch diameter. Bird deflectors will be installed on the wires every 15 ft and red blinking aviation lights will be installed on each tower.

6. Lighting on the wharf and access trestles will range from 100-Watt metal halide lights to 1,500-Watt quartz lights. Lights over the surrounding water will consist of pulse-start metal halide lights, plus 1,500-Watt quartz back-up lights.

Proposed Minimization Measures

The Navy proposes the following measures to minimize the effects of the proposed action on marbled murrelets and their prey species.

1. All impact pile driving will be performed between July 16 and February 15 of each construction season to minimize impacts to juvenile listed fish species.

2. Impact pile driving that is conducted during the marbled murrelet breeding season (April 1 through September 15) will not begin until 2 hours after sunrise and will end 2 hours before sunset[7].

3. Sound attenuation methods (e.g., bubble curtain system or other sound attenuating device), will be implemented during all impact pile diving.

4. Monitoring of underwater sound pressures will occur during the first 30 days of actual impact pile driving in order to obtain information that is representative of the conditions of the project site.

[6] The construction area in this context applies to the Waterfront Restricted Area (fenced marine area).
[7] Sunrise and sunset are to be determined based on the National Oceanic and Atmospheric Administration data which can be found at http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html.

5. Marbled murrelet in-water surveys will be conducted prior to and during impact pile driving. Surveys will be conducted out to 55 m preclude potential exposure to injurious underwater sound pressures. A copy of the marbled murrelet monitoring protocol is included in Appendix 1.

6. Marine Habitat Protection/Avoidance: Construction vessel operators will be instructed to avoid grounding on and potentially impacting the nearshore. Vessel operators will also be instructed to avoid using excess engine thrust in waters less than 30 ft and to avoid existing eelgrass habitat. Barges will not shade existing eelgrass for extended periods of time (more than one day). Spudding and anchoring in existing eelgrass habitats will be avoided. Contractors will submit a mooring and anchoring plan that identifies measures to be taken to avoid or minimize significant impacts to bottom habitats in areas identified on the construction drawings from line or anchor drag. Measures shall include: a) placement of anchors outside of special status areas (i.e., eelgrass), to the extent feasible; b) placement and retrieval of any anchors required within special status areas using a secondary work boat and/or vertical lift system to avoid/minimize dragging; and c) use of a buoy(s) (surface or subsurface) along the lower portion of mooring lines required within special status areas to avoid/minimize dragging. Previously shaded eelgrass must remain unshaded for at least 1 day before a barge can be repositioned above the habitat. Construction vessels will be excluded from shallow areas (less than 30 ft in depth) outside the immediate construction site (within 150 ft of the trestle or wharf). The contractor will prepare and implement a Debris Management Plan. Following completion of in-water construction activities, an underwater survey will be conducted to remove any remaining construction materials that may have been missed during previous cleanups. All areas of in-water and above-water work will be surrounded by floating debris barriers and a floating oil absorbent boom.

7. Spill Prevention Control: The existing facility response plans for the NBKB waterfront (COMNAVREGNWINST 5090.1, Integrated Contingency Plan, Annex G) provide guidance that will be used in a spill response, such as a response procedures, notification, and communication plan, roles and responsibilities, and response equipment inventories. In the event of an accidental spill, response measures will be implemented immediately to minimize potential impacts to the surrounding environment. In addition, the following measures will be implemented.

    a. Spill kits will be readily available.
    b. The contractor and crew will be trained in spill prevention and containment techniques.
    c. Spill prevention will be implemented daily by maintaining awareness in the construction crew and monitoring the activities.
    d. Clean and well-maintained equipment and tools will be used.
    e. Construction contractors will be required to retrieve and clean up any accidental spills.

f. During in-water construction activities, an absorbent oil containment boom will be placed around the construction area to contain accidental oil or hazardous materials spills to ensure that marine mammals or other fish and wildlife species are not impacted by spills.

8. Stormwater Pollution Prevention Plan: During project construction, stormwater discharges will be in accordance with a U.S. Environmental Protection Agency Construction General Permit.

9. Stormwater Treatment:

   a. Trestle and wharf stormwater will be collected and treated in a system consisting of steel catch basins that contain filter cartridges that Washington State Department of Ecology requirements for "Basic Treatment" associated with vehicular traffic. After the stormwater runoff passes through a cartridge(s), it will be released directly into Hood Canal. The maintenance schedule for the unit filters will follow industry standard guidelines. No stormwater treatment is proposed for roof runoff as it has a non-leaching finish and is not anticipated to contain any pollutants requiring treatment.

   b. One new stormwater outfall into Hood Canal is proposed to discharge water from areas not originating from impervious surfaces or areas with vehicle traffic. No treatment is proposed for this runoff. It will be discharged through the new outfall.

   c. Stormwater generated from new upland impervious surfaces (e.g., roadways) will be treated in a new catch basin using a filter cartridge. Following treatment, flows will be directed to the new outfall constructed through the new abutment wall and discharged into Hood Canal.

   d. After construction of the three new buildings and replacement parking spaces, the existing stormwater system will be upgraded in accordance with a National Pollutant Discharge Elimination System permit.

   e. Stormwater from a new pure water facility along the Bangor shoreline would be treated by routing the new parking lot and paved loading apron stormwater to an existing stormwater system. This stormwater system will be upgraded in accordance with a National Pollutant Discharge Elimination System permit, as required, prior to discharge into Hood Canal.

10. The Navy proposes to mitigate for unavoidable impacts to aquatic habitat due to the proposed action through the use of an ILF program. This program is currently under development. As an alternative to pursuing the development of an ILF program for Kitsap County/and or Hood Canal, the Navy is currently assessing nearshore permittee responsible mitigation opportunities within Hood Canal and Puget Sound.

11. The Navy is also in the early stages of pursuing acquisition of property to mitigate impacts to aquatic and tribal resources. This acquisition may provide incidental benefits to marbled murrelets. However, the extent of that benefit will not be known until those negotiations have concluded.

Interrelated and Interdependent Actions

No interrelated or interdependent actions are associated with the EHW-2 project. The Navy previously consulted on the test pile program to collect geotechnical and sound data for the proposed EHW-2 and may be used for other future pile driving projects at NBKB (Service Reference No. 13410-2010-I-0531). The test pile program will be completed prior to construction of the EHW-2 proposed action.

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment.

The action area was determined based on the anticipated sound pressure levels generated both above water and in-water during construction (impact and vibratory pile driving). The farthest-reaching stressors include 1) the distance that underwater sound generated by the action intersects with a land mass or where it attenuates to background levels, and 2) the areas that the above water sound attenuates to background levels (Figure 3).

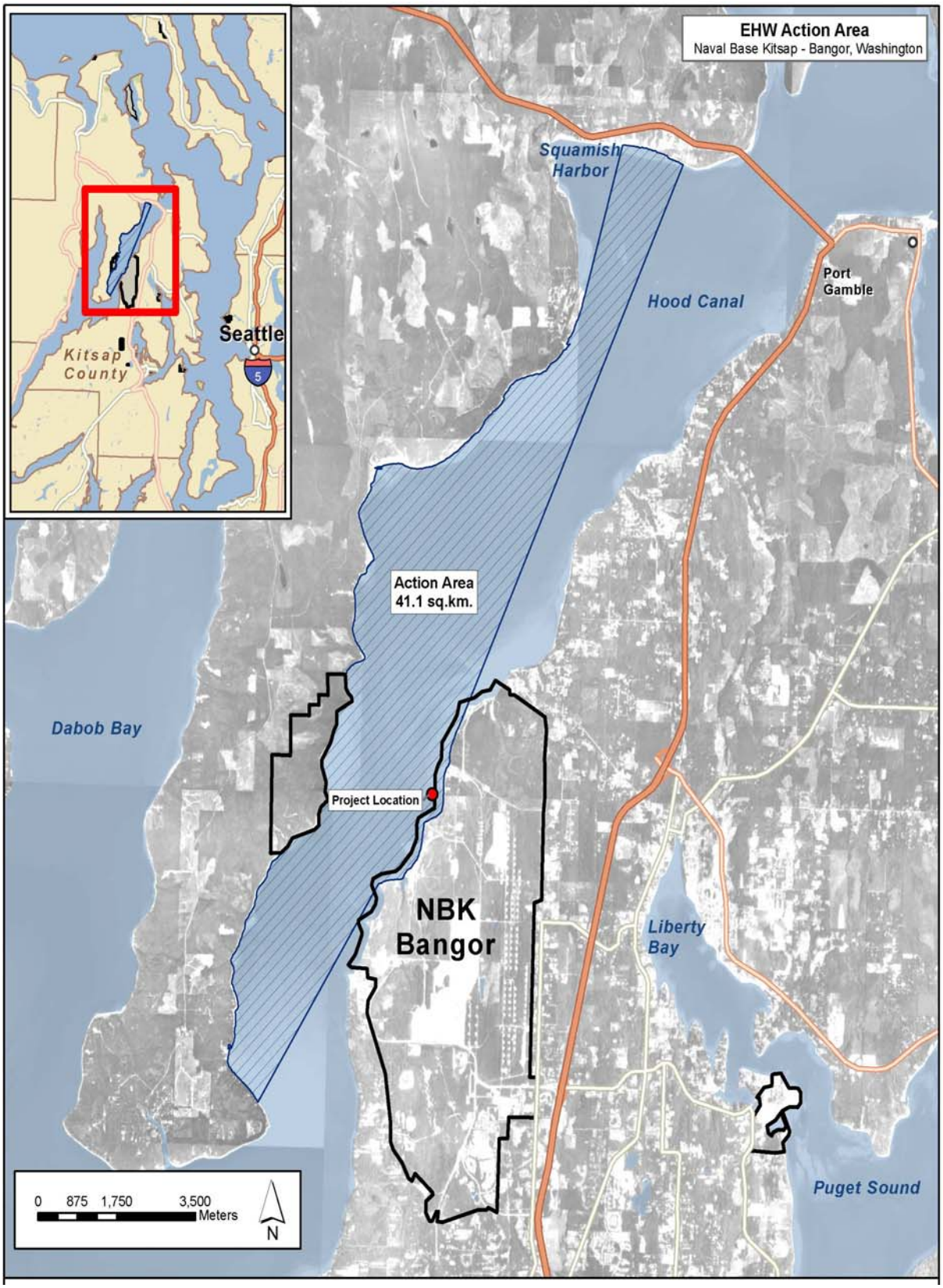

Figure 3. Explosives Handling Wharf 2 Action Area (from BA).

Temporarily elevated underwater sound pressure levels (SPLs) resulting from impact pile installation are expected to have the farthest reaching effects in the aquatic environment. To estimate the geographic area in which measureable effects to marbled murrelets may occur, the distance at which transmission loss (TL) attenuates to sound pressures below specified thresholds are determined. Calculating TL is extremely complicated, and is likely to be site-specific. A practical spreading model, as described by Davidson (2004, p. 2) [TL = 15*Log(R)] is used to estimate the distances at which injury and behavioral disruption to marbled murrelets are expected. This model assumes that underwater SPLs decrease at a rate of 4.5 dB per doubling distance. Additionally, the Navy calculated the sound pressures based on the operation of three vibratory pile driving rigs and one impact pile driver operating at the same time. The resulting sound pressures are higher than if a single machine were operating at a time. Based on the results of these calculations, the extent of the action area is approximately 41.4 km^2. This area is inclusive of all areas that would be ensonified above ambient sound levels associated with the proposed action.

For the purposes of this Opinion, the Service will focus on those areas that are likely to have sound pressures could result in measurable effects to marbled murrelets. Based on the greatest area that may be affected, this results in an area of approximately 14.2 km^2 based on sound pressures associated with a SPL of 150 dB_{rms} (Figure 4). Please see *Estimating the Geographic Extent of Underwater Sound Pressure Effects* for further discussion on sound levels and distance of attenuation.

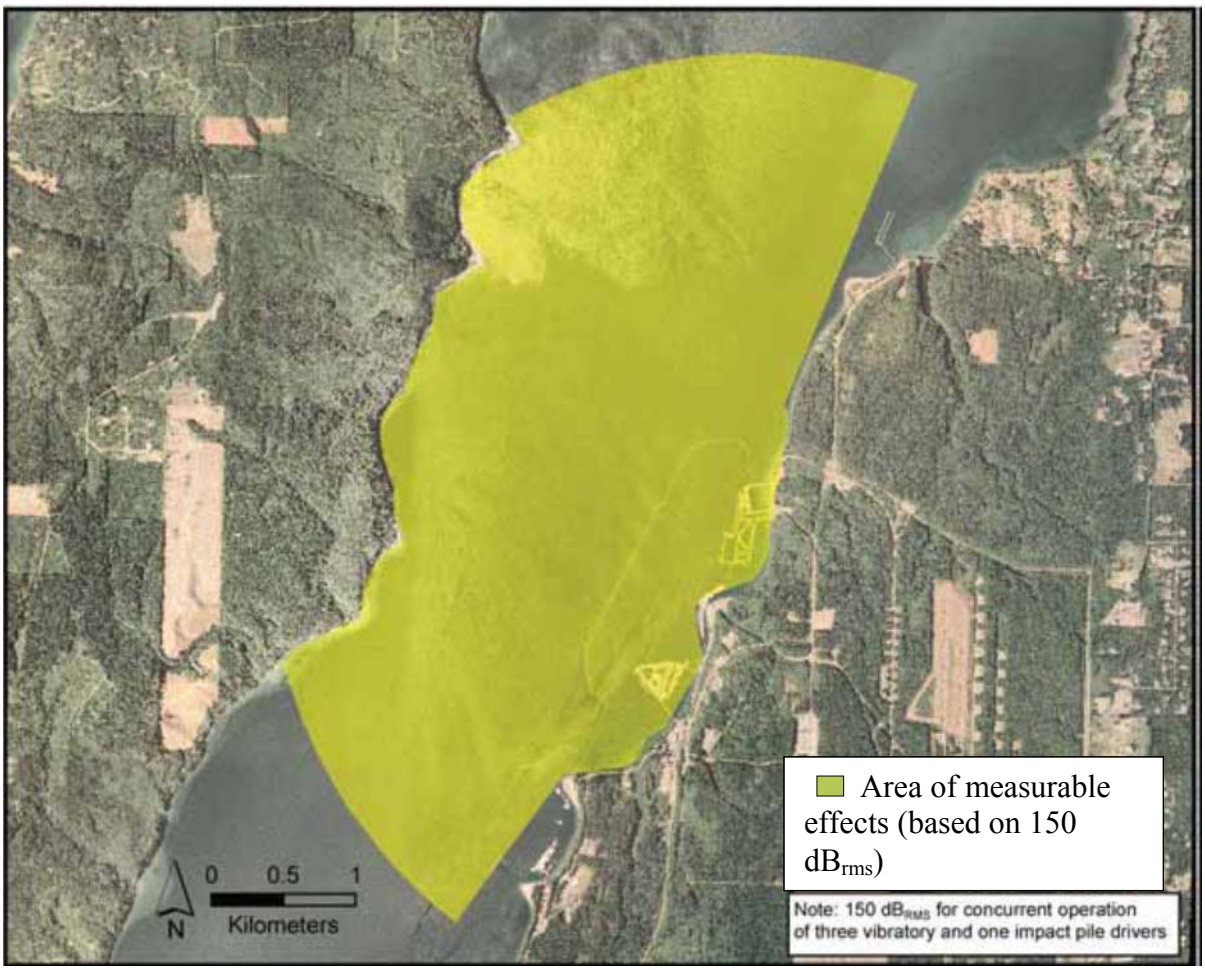

Figure 4. Action Area - Area of potential measurable effects to marbled murrelets.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY DETERMINATION

In accordance with policy and regulation, the jeopardy analysis in this Opinion relies on four components: 1) the *Status of the Species*, which evaluates the marbled murrelet rangewide condition, the factors responsible for that condition, and its survival and recovery needs; 2) the *Environmental Baseline*, which evaluates the condition of the marbled murrelet in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the marbled murrelet; 3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the marbled murrelet; and 4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the marbled murrelet.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the marbled murrelet current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the marbled murrelet in the wild.

The jeopardy analysis in this Opinion emphasizes consideration of the rangewide survival and recovery needs of the marbled murrelet and the role of the action area in the survival and recovery of the marbled murrelet. It is within this context that we evaluate the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

STATUS OF THE SPECIES: MARBLED MURRELET

Refer to Appendix 2 for the marbled murrelet Status of the Species.

ENVIRONMENTAL BASELINE (within the Action Area)

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

The aquatic and terrestrial action area associated with the proposed action is based on farthest-reaching stressor. This was determined to be the distance that sound generated by the action, specifically underwater and in-air impact pile driving, intersects with a land mass or where it attenuates to background levels. For the purposes of this analysis, we have focused our discussion of the environmental baseline on those portions of the action area where marbled murrelets could be measurably affected (Figure 4). Marbled murrelets may forage, breed, and loaf (sleep, rest, preen) in the marine waters in the affected area. The following sections describe existing conditions at the proposed project site and within this area.

The proposed location of the EHW-2 is to the south and adjacent to the existing EHW-1. The project area lies inside the West Watershed Resource Inventory Analysis Area 15 which extends from Foulweather Bluff at the mouth of Hood Canal southward along the shoreline to the terminus of the east arm of Hood Canal, and the eastern boundary extends to the headwaters of all streams draining to the east shore of Hood Canal (Kuttel 2003b, p. 37).

Hood Canal

Hood Canal is a long, narrow channel that branches from the Puget Sound Main Basin south of Admiralty Inlet and extends about 80 miles south, between the Olympic Mountains and the Kitsap Peninsula. The NBKB waterfront occupies approximately 4.3 miles of the approximately 67-mile long eastern shoreline of Hood Canal. The width of Hood Canal is approximately 1.5 miles at NBKB. Hood Canal includes intertidal and subtidal areas with extensive areas of eelgrass that provide breeding sites for many fish species and habitat for amphipods, copepods, and other aquatic invertebrates. Copepods and other zooplankton represent the major food base for Puget Sound, specifically for small and juvenile fish (Simenstad et al. 1979; Mauchline 1998 both in BA, p. 31), including Pacific herring, Pacific sand lance, surf smelt, and salmonids.

Land Use

The U.S. Naval Magazine was established at the NBKB in 1944, where until the early 1970s the facility primarily stored and transshipped ordnance, which arrived by trains and ships ((Naval Facilities Engineering Command Northwest 2005, p. 2-1). In 1977, the NBKB was commissioned as the West Coast home port for the Trident Submarine Launched Ballistic Missile System (Naval Facilities Engineering Command Northwest 2005, p. 2-1). The NBKB covers approximately 7,000 acres of mostly undeveloped land and the areas around the base are largely undeveloped with limited rural residential uses (Naval Facilities Engineering Command Northwest 2005, p. 3-1).

Contaminants and Associated Remediation

Potential hazards on the NBKB were brought to the attention of the U.S. Environmental Protection agency (EPA) in 1987, and were characterized in 1989. The NBKB is listed twice on the EPA's National Priorities List for investigation and cleanup of past waste disposal sites; the Bangor Ordnance Disposal site, which lies upland of Cattail Lake, was listed on the National Priorities List in 1987, and the rest of the NBKB was listed in 1990 (Naval Facilities Engineering Command Northwest 2005, p. 2-1). The NBKB entered into a Federal Interagency Agreement with the EPA in 1990, and Remedial Investigation/Feasibility Studies commenced in 1993. Several clean-up actions have been completed since 1993. Contaminants onsite consisted of a variety of chemicals located in the soils and/or groundwater, including but not limited to 2,4,6-trinitrotoluene (2,4,6-TNT), 2,6,-dintrotoluene (2,6-DNT), and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), explosive D (ammonium picrate) sludge, photo flash bombs and ammonium nitrate blocks, smokeless powder, black powder, rocket propellant, white phosphorus shells, compound B (TNT and RDX), Amatol, and propulsion missile grains (Naval Facilities Engineering Command Northwest 2005, pp. 3-2, 3-4). Also of concern were lead concentrations in the soil and their possible ecological affect to sensitive species (Naval Facilities Engineering Command Northwest 2005, p. 3-2).

In a 5-year review, the Navy evaluated information obtained during a site inspection performed in September 2004 (Naval Facilities Engineering Command Northwest 2005, p. ii). Sites that may affect the action area due to discharges into Hood Canal included Sites B and 26 (Figure 5) and will be discussed in more detail below.

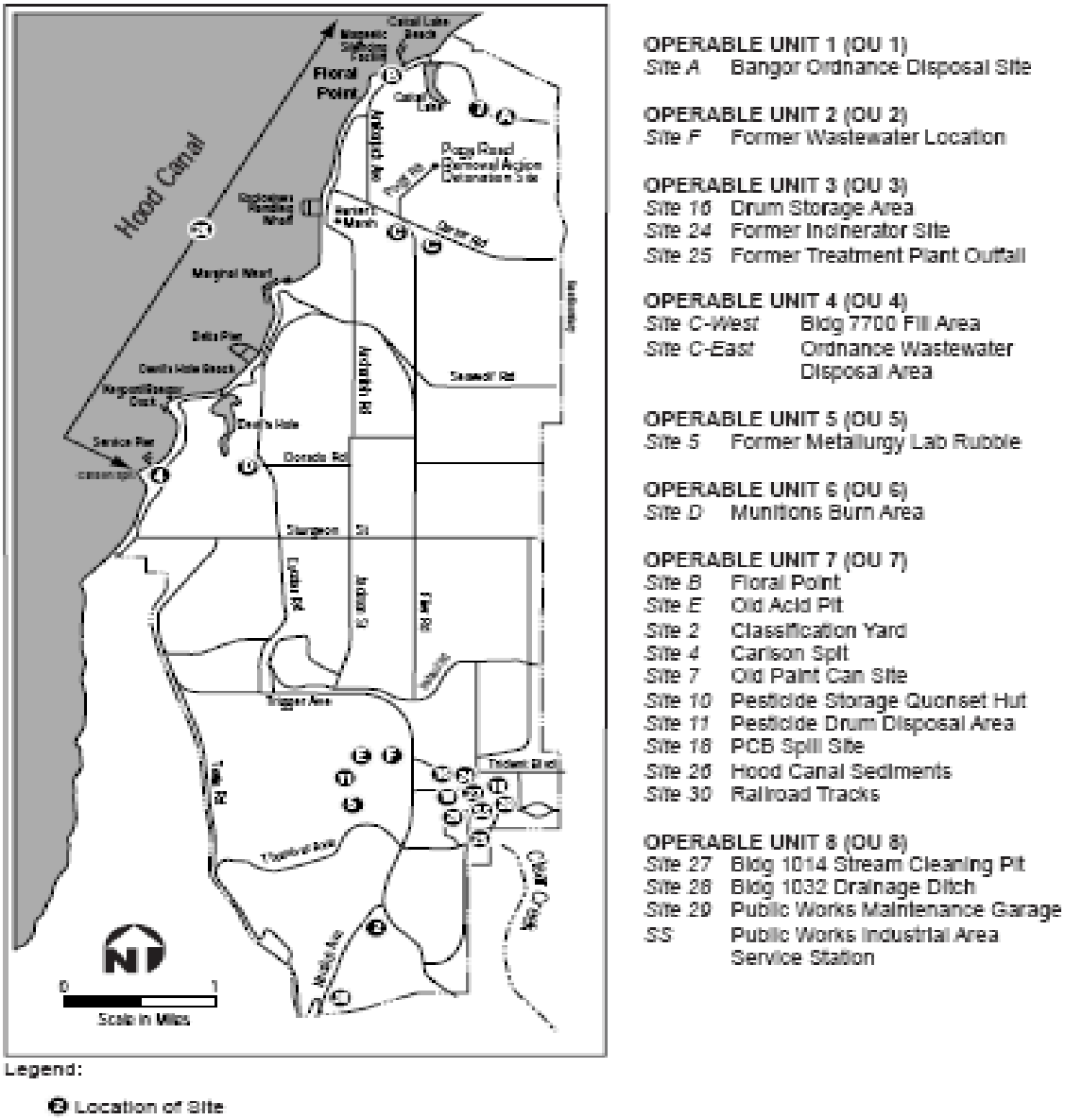

Figure 5. NBKB contaminated sites (Naval Facilities Engineering Command Northwest 2005, p. 1-4).

Site B – Floral Point

Site B (Floral Point) covers approximately 5 acres of natural shoreline along Hood Canal, just south of Cattail Lake and was used for pyrotechnic testing, burning black powder, dumping of station waste, including pit disposal, landfilling, trash burning, and open burning of RDX and TNT residuals ((Naval Facilities Engineering Command Northwest 2005, p. 3-5). Floral Point has no surface water drainages, and the risk assessment concluded that polycyclic aromatic hydrocarbon (PAH) and polychlorinated biphenyl in the soil here pose an "unacceptable cancer risk for an assumed future residential use and metals pose a marginal hazard to sensitive ecological receptors" (Naval Facilities Engineering Command Northwest 2005, p. 3-5).

In 1997, the following remedial actions were conducted at Floral Point:

- Metal debris was removed from the wetland area.
- Nine monitoring wells were decommissioned.
- Contaminated soils were covered by a 1-ft layer of soil overlain by a layer of mulch and then planted with native grasses and plants to prevent further contact with the underlying soils.
- A mix of sand and gravel was placed around the perimeter of the site to reduce erosion.
- Potential future beach erosion was monitored by placing control points at the top of the shoreline.
- A stormwater drainage system was installed by placing gravel in ditches and riprap below outfalls.
- A concrete turnaround was constructed at the boat ramp to prevent erosion from its use.
- WDOE determined that remedial action had been completed in accordance with the Record of Decision (WDOE 1999a in Naval Facilities Engineering Command Northwest 2005, p. 4-16).

Site 26 – Hood Canal Sediments

Site 26 (Hood Canal Sediments) consists of eight areas along the western shore of the NBKB where service piers are located: 1) Cattail Lake Beach/Magnetic Silencing Facility, 2) Floral Point, 3) EHW-1, 4) Marginal Wharf, 5) Delta Pier, 6) Devil's Hole Beach, 7) Keyport/Bangor Dock, and the 8) Service Pier (Naval Facilities Engineering Command Northwest 2005, pp. 3-5, 3-6). Possible ecological risks to marine receptors were identified at Marginal Wharf (south of proposed action), Devil's Hole Beach, Keyport/Bangor Dock, and the Service Pier (Naval Facilities Engineering Command Northwest 2005, p. 3-7). Chemicals constituting the estimated ecological risks were PAHs, pesticides, and bis(2-ethylhexyl)phthalate at Marginal Wharf; pesticides at Devil's Hole Beach; mercury and PAHs at Keyport/Bangor Dock; and PAHs, pesticides, and dibenzofuran at the Service Pier (Naval Facilities Engineering Command Northwest 2005, p. 3-7). The bis(2-ethylhexyl)phthalate concentrations at Marginal Wharf exceeded the Sediment Management Standards cleanup screening level for minor adverse effects; however, bioassay tests were below the Sediment Management Standards sediment quality standards for no adverse effects (Naval Facilities Engineering Command Northwest 2005, p. 3-7).

Effluent Discharges from the NBKB

The NBKB currently has a discharge permit (effective July 2007) that allows discharge from their Industrial Water Pretreatment Plant, an industrial oil/water separator, and other sources of effluent (WDOE 2007, p. 5-7). Effluent from multiple locations are allocated various maximum concentrations and flows, which are treated at the Central Kitsap Publicly Owned Treated Works plant and then discharged into Port Orchard Bay, Puget Sound, outside of the action area. As effects from these discharges are not within the action area, they will not be further addressed.

Underwater and Airborne Sound

Underwater sound measurements were recorded at four locations adjacent to NBKB, including two in the vicinity of the project site (near the Delta pier south of the proposed EHW-2) in 2007 (Slater 2009, p. 9). No other baseline underwater noise measurements have been taken at NBKB. Average broadband ambient noise levels near the project site were measured at 114 dB re 1μPa between 100 hertz (Hz) and 20 kHz. Peak spectral noise from industrial activity was noted below the 300 Hz frequency, with maximum levels of 110 dB noted in the 125 Hz band. In the 300 Hz to 5 kHz range, average levels ranged between 83 and 99 dB re 1μPa. The ambient sound conditions based on "root mean squared" were also recorded for the site. These values ranged from 103 dB_{rms} to 147dB_{rms}, with an average of 114 dB_{rms} (Slater 2009, p. 14). No values using the SEL metric were reported. The primary source of noise was due to industrial activity along the waterfront (such as at docks, piers, and wharves), small boat traffic, and wind-driven wave noise.

In-air sound measurements were taken during a two-day period in October 2010 within the waterfront industrial area near the project site. During this period, daytime noise levels ranged from 60 dBA to 104 dBA, with average values of approximately 64 dBA. Evening and nighttime levels ranged from 64 to 96 dBA, with an average level close to 64 dBA. Thus, daytime maximum levels were higher than nighttime maximum levels, but average nighttime and daytime levels were similar. These higher noise levels are produced by a combination of sound sources, including heavy trucks, forklifts, cranes, marine vessels, mechanized tools and equipment, and other sound-generating industrial/military activities. Measured levels were comparable to estimated noise levels from literature.

Gillnets

Gillnet fishing has been considered a conservation issue in Washington (Melvin et al. 1999; USFWS 1997b) for many species including marbled murrelets, and salmon fisheries using gillnets occur in the action area. There is little information available on marbled murrelet mortality in Hood Canal, although mortality has been documented in Puget Sound (Carter et al. 1995, p. 280). In the mid-1990s, a series of fisheries restrictions and changes were implemented to address mortality of all species of seabirds, resulting in a lower mortality rate of marbled murrelets (McShane et al. 2004, pp. 5-24, 5-25). Fishing effort has also decreased since the 1980s because of lower catches, fewer fishing vessels, and greater restrictions, although a resurgence in gillnet fishing is likely to occur if salmon stocks increase ((McShane et al. 2004, pp. 5-30, 6-33). In most areas, the threat from gill net fishing has been reduced since 1992, but threats to marbled murrelets are still present in Washington waters due to gill net mortality (McShane et al. 2004, p. 6-33). Entanglement in derelict fishing nets, which are nets that have been lost, abandoned or discarded in the marine environment, may also pose a threat to both murrelets and bull trout. Derelict gear can persist in the environment for decades and poses a threat to marine mammals, seabirds, shellfish, and fish.

A recent survey estimated 3,900 derelict nets need to be removed from Puget Sound, of which there are approximately 190 nets in Hood Canal (Northwest Straits Foundation 2007, p. 7). Over 50 percent of derelict nets in Puget Sound waters occur where marbled murrelet densities are the

highest. Derelict fishing gear may persist for years (over 20 years for gill nests) in Puget Sound (Northwest Straits Foundation 2007, p. 14).

Potential Marbled Murrelet Nesting Habitat

Most of the forests on and around NBKB were logged in the early 1900s. Second growth forests currently occupy the area (Kuttel 2003a, p. 16), providing very limited potential nesting habitat for marbled murrelets.

Potentially suitable nesting habitat for marbled murrelets may occur in a forested stand located on the northern portion of NBKB based on preliminary surveys. No surveys have been conducted to date to determine the specific suitability of the stand. However, there has been no documentation of marbled murrelet nesting on the Kitsap Peninsula, where NBKB is located.

Marbled Murrelet Occurrence in the Marine Portions of the Action Area

The action area provides marine foraging habitat for marbled murrelets. Marbled murrelets regularly use the action area throughout the year, although there are not any specific foraging areas or habitat features that have been described as regularly concentrating marbled murrelets.

Monitoring of marbled murrelets occurs within Hood Canal as part of the Northwest Forest Plan Murrelet Effectiveness Monitoring Program (Raphael et al. 2007a) (summer surveys, sampling between May 15 and July 31 each year) and the Puget Sound Ambient Monitoring Program (PSAMP) (winter surveys, sampling beginning in December and data available for 1993 through 2005), conducted by the Washington Department of Fish and Wildlife. The action area is within Conservation Zone 1, Stratum 2, and subunit 34 of the Northwest Forest Plan monitoring area. There is a primary sampling unit transect located directly across Hood Canal from the proposed action. Based on the survey data for the sampling unit across from NBKB, the mean density of marbled murrelets in the summer ranges from less than one to three birds per km^2 (http://www.reo.gov/monitoring/reports/murrelet/WA_PSU_density_00_07_detailed.pdf). No summer surveys are conducted immediately adjacent to the proposed project. Based on PSAMP monitoring conducted in the winter, from 0.4 to 5.2 marbled murrelets (average 1.9) per km^2 occur near the project. The range for winter density is based on the nearest neighbor survey areas adjacent to the project site (Appendix 3). Although surveys occur within the action area, there are no winter data from the project site from these surveys.

Marbled murrelet have been observed in the nearshore within the action area by the Navy and others (BA 2010, p.75). The most recent observations within the project area were recorded in 2007, 2008, and 2009 as part of marine bird surveys conducted at NBKB. The 2007 and 2008 surveys were for marine birds in general, and performed to describe the current use of the waterfront by marine birds. Twenty-two days of observations were performed in 2007 and 12 days in 2008. Winter surveys for marine birds were conducted in 2009 to 2010 for the Navy; however, the document is still in draft and will not be finalized until approximately the end of November 2011. Tables 3 and 4 provide the data for marbled murrelets observed during these surveys. The Navy also conducted marbled murrelet monitoring during the installation of five steel piles for the Carderock Division Research Facility Wave Deflection System, NBKB near

Carlson Spit for 5 days in January 2009. This site is several miles from the proposed EHW-2 location. Surveys were also required specifically for marbled murrelets as part of the section 7 consultation for this facility (Service Reference No. 13410-2009-I-0087). One to eight marbled murrelets were frequently observed and 12 to 31 marbled murrelets were intermittently sighted within a 1,000 m survey area. No marbled murrelet sightings occurred within the 300 m zone of potential injury [based on the injury thresholds in use at that time (e.g., 180 dB_{peak})] for marbled murrelets (BA 2010, p. 76).

Table 3. Marbled murrelets observed along the NBKB waterfront during bird surveys conducted from March through August 2007 (from Agness and Tannenbaum 2009, p. 12).

Date	Area	Number of Marbled Murrelets Observed	Behavior Observed	Approximate Distance from Shore (ft)
4/17/2007	Nearshore 6	2	Loafing	1,000
4/18/2007	Nearshore 2	2	Diving	150
4/18/2007	Nearshore 3	2	Loafing	500
4/30/2007	Nearshore 2	2	Diving	500
5/1/2007	Nearshore 2	2	Diving	200
5/1/2007	Nearshore 1	2	Loafing	500
5/14/2007	Nearshore 5	2	Loafing	1,500
5/25/2007	Nearshore 2	2	Diving	<50

Table 4. Marbled murrelets observed along the NBKB waterfront during bird surveys conducted from July to September, 2008 (Tannenbaum et al. 2009, p. 12).

Date	Area	Number of Marbled Murrelets Observed	Behavior Observed	Location
9/4/2008	Pier 5	1 (juvenile)	Swimming under Pier 5	Within 100 ft of human structure, under EHW-1 dock

Marbled Murrelet Prey Occurrence in the Action Area

Beach seine surveys were conducted from 2005 through 2008 along the shoreline of the NBKB (NAVFAC 2010, p. B-12 through B-28) (Table 6). The counts of fish fluctuated from year to year; however, the values demonstrate that this shoreline is highly productive habitat for forage fish and salmonids.

Table 5. Beach seine results from multiple collection sites along the shoreline of the NBKB. Values listed did not account for recapture rates, and may not be representative of total population abundance. Each sample site was defined and sampled multiple times over several weeks, and the values listed in the table represent these total accumulative counts of fish.

Beach Seine Results - Year	2005	2006	2007	2008
Total Number of Different Species Captured	32	38	39	39
Total Number of All Fish Captured	23,327	108,139	52,515	31,667
Chinook salmon (*Oncorhynchus tshawytscha*)	43	108	114	2
Chum salmon (*O. keta*)	24	16,865	28,755	10,124
Pacific herring (*Clupea pallasi*)	7	59,288	10,611	12
Pacific sand lance (*Ammodytes hexapterus*)	13	5,599	306	2,113
Surf smelt (*Hypomesus pretiosus*)	1,024	15,160	1,632	12,178
Shiner Perch (*Cymatogaster aggregata*)	20,047	6,124	6,063	1,479

Much of the shoreline along the NBKB property is identified as suitable and/or potential spawning habitat for forage fish, and documented Pacific sand lance spawning occurs along the shoreline of the proposed EHW-2 site (Figure 6). Washington State Department of Fish and Wildlife forage fish spawning surveys have documented Pacific sand lance spawning within the action areas during surveys conducted on November 25, 1996, December 4, 1995, January 21, 1997, and February 6, 1996 (Lowry, in litt. 2011). Although no spawning surveys were conducted at NBKB during other months, based on surveys that are conducted in other areas of Puget Sound, Pacific sand lance spawning has been documented from late October through late February. Bank armoring, bulkheads, and roads adjacent to shorelines limit sediment and large woody debris recruitment from bluffs and alter littoral drift of beach sediments (Kuttel 2003a, p. 66), which may negatively affect forage fish spawning habitat.

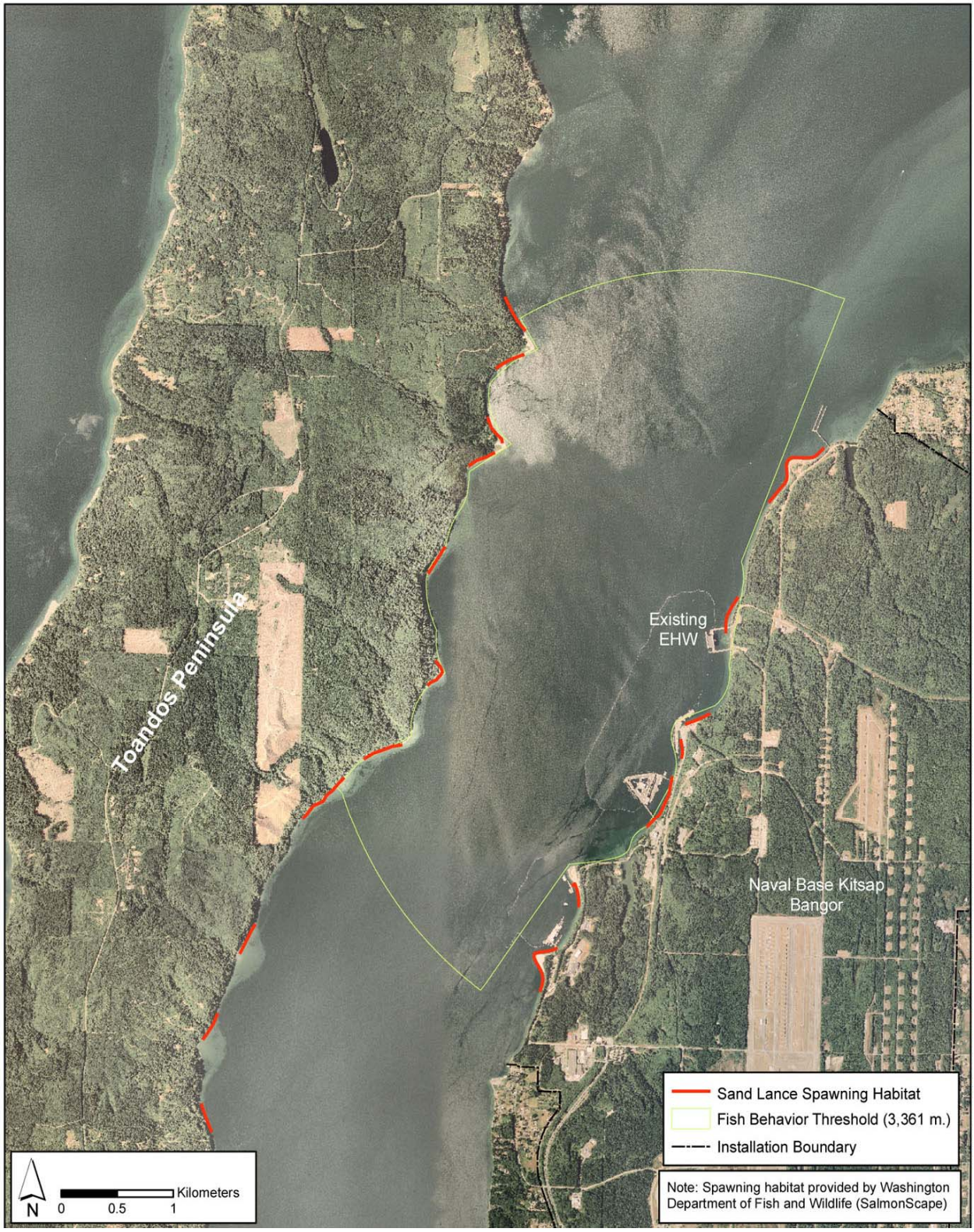

Figure 6. Pacific sand lance spawning habitat.

Consulted-on Actions to be Implemented in the Future

Cattail Lake is scheduled to be restored to a natural estuary in approximately 2012 as mitigation for the Naval Base Kitsap Waterfront Security Enclave project (Service Reference No. 13410-2010-I-0397). The installation of the Waterfront Security Enclave will result in the permanent loss of approximately 29 acres of forested and 13 acres of non-forested habitat, 2 acres of forested wetlands, and 2,380 linear ft (0.3 acre) of streams will either have culverts installed or extended. To mitigate for these impacts, the road prism that currently creates the lake will be removed and replaced by a bridge. The proposed mitigation will provide a total of 13 acres of new intertidal, freshwater forest/shrub, riparian forest, and upland habitats; 2 acres of estuarine habitat, 2.2 acres of upland forest habitat, 4.0 acres of forested riparian wetlands, 5.5 acres of wetlands and upland riparian forests, and will restore fish passage to Cattail Creek and its watershed. These alterations are likely to result in the loss of some established eelgrass beds that are directly outside of where Cattail Lake currently outfalls into marine waters.

EFFECTS OF THE ACTION TO MARBLED MURRELETS

The regulations in the Act define "effects of the action" as "the direct and indirect effects of an action on the species or habitat together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline" (50 C.F.R. 402.02). Direct effects result from the proposed action and include the effects of interrelated and interdependent actions. The proposed action may result in negative effects to adult, subadult, and fledged juvenile marbled murrelets in the marine environment during the construction and operation of the proposed facility. Marbled murrelets that are underwater or on the water's surface during the proposed action may be affected as a result of a) exposure to elevated in-air and underwater pressure levels; b) increased activity levels from watercraft used for construction, as well as, those used for monitoring purposes; c) exposure to contaminants; d) collision with lightning towers and wires; and e) reduced forage availability. No critical habitat has been designated for this species in the action area; therefore, none will be affected.

Effects to Marbled Murrelets Due to Exposure to Elevated Sound Pressures

The construction and operation of EHW-2 will generate both airborne and underwater sound primarily from impact and vibratory pile driving. Additional elevated sound levels will be generated from boat engines associated with boats used for monitoring, transport of personnel to barges, and tugboats during the proposed action. The installation of steel piles using an impact hammer is expected to produce the highest levels of sound of all construction-related activities. Although vibratory pile driving is also loud, the waveform and rise times (energy) of the sound is different than impact driving and does not result in the same risk of physical injury.

Sound is usually measured in decibels. A decibel (dB) is a relative measure that must be accompanied by a reference scale. The following are various sound pressure metrics that are used in this Opinion.

Description of Acoustic Terminology

- Frequency - the rate of oscillation or vibration of sound measured in cycles per second, or hertz (Hz). Ultrasonic frequencies are those that are too high to be heard by humans (greater than 20,000 Hz); and infrasonic sounds are too low to be heard (less than 20 Hz).
- Sound – vibrations in air, water, etc., that stimulate the auditory nerves and produce the sensation of hearing. The perception of a sound depends on two physical characteristics – amplitude and frequency, both of which can be measured.
- Sound pressure levels (SPL) – sound pressure that is expressed in dB. In this document, underwater SPLs are referred to in units of dB re: 1 μPa and are denoted as dB.
    - Peak pressure (peak) - the highest level or amplitude or greatest absolute sound pressure level during the time of observation. Sound pressure levels expressed as peak are used in discussing injury or mortality to aquatic species.
    - Sound exposure level (SEL) - a metric that incorporates both sound pressure level and duration. SEL is calculated as 10 times the logarithm of the integral, with respect to duration, of the mean-square sound pressure, referenced to μPa^2-sec. Using this metric, 0-dB SEL corresponds to a continuous sound whose rms sound pressure equals the reference pressure of 1 μPa at a duration of 1 s (Morfey 2001, p. 347). In this Opinion, these sound exposures are denoted as dB SEL.
    - Root mean square (rms) – is root square of the energy divided by the duration. Sound pressure levels expressed as rms are commonly used in discussing behavioral effects. Behavioral effects often result from auditory cues and may be better expressed through averaged units than by peak pressures.

In-air sound, measured on an A-weighted scale (which approximates human hearing), will always be re: 20 μPa in this document and will be denoted as dBA.

Anticipated Underwater Sound Pressures That May Result in Behavioral and Injurious Effects to Marbled Murrelets

There are few directly applicable scientific studies on the effects of underwater sound on marbled murrelets. Since beginning to evaluate these effects, the Service has applied interim criteria to section 7 consultations with the expectation that these criteria would be refined as information became available. Originally, the Service used a threshold of 180 dB dB_{peak} for estimating onset of injury. Recently, ongoing coordination among experts in hydroacoustics indicated that cumulative Sound Exposure Level was a better metric for evaluating effects from pile driving and the Service began using a dual criterion of 206 dB_{peak} or 183 dB SEL to identify onset of injury (Teachout 2011) (Appendix 4). However, substantial uncertainty remained around the thresholds, and on July 27-29 2011, the Service and the Navy convened an expert panel comprised of researchers, biologists, and acousticians to review the Service's current approach and to propose refinements as appropriate.

When evaluating the effects of acoustic overexposure on marbled murrelets, the Service associates auditory damage with onset of injury, as indicated by hair cell loss in the inner ear.

Based on their review of the best available information, the panel recommended that this would occur with exposure to a cumulative SEL equal to or exceeding cumulative 202 dB (re: 1 µPa). Furthermore, they suggested that other physical injuries (i.e., barotrauma), could be expected when sound exposure levels meet or exceed cumulative 208 dB SEL (SAIC 2011). Injuries associated with barotrauma include death, and/or hemorrhaging and rupture of internal organs. Subsequent to receiving the panel's recommendations for revising the criteria, the Service accepted the recommendation and notified the Navy on August 5, 2011, that these values would be applied in the EHW-2 section 7 consultation. Figure 7 illustrates the areas that would be affected due to impact pile driving associated with cumulative underwater sound exposure levels of at least cumulative 202 dB SEL.

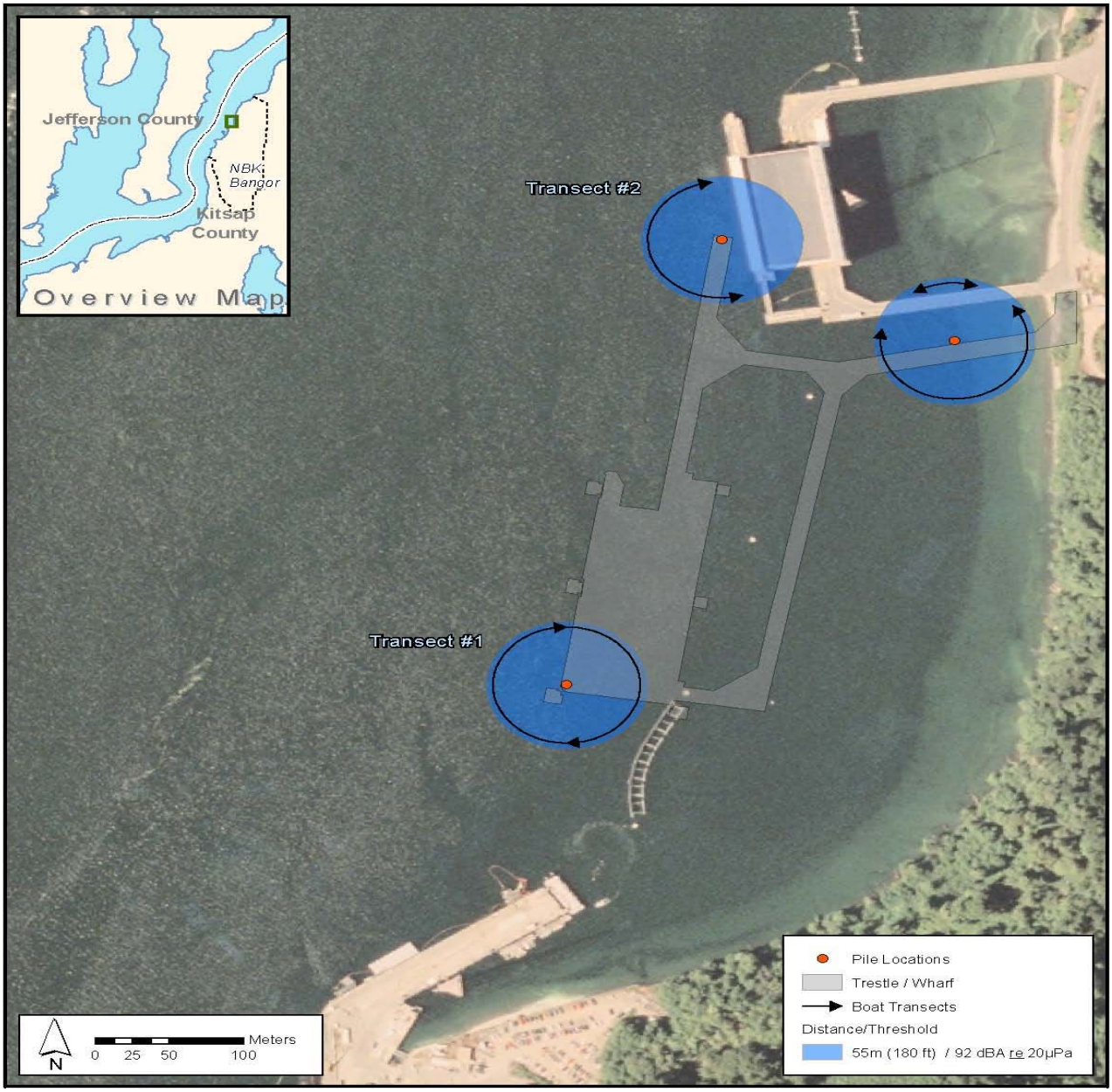

Figure 7. Example of areas of potential injury due to impact pile driving based on cumulative sound exposure levels of at least 202 dB SEL.

In addition to physical injury associated with exposure to underwater sound pressure, the Service anticipates effects to hearing that do not result in injury (e.g. hearing fatigue, temporary threshold shift). We are currently in the process of evaluating when the onset of these effects would occur. Until we have completed our analysis, we continue to anticipate that underwater sound pressures above the cumulative 183 dB SEL threshold, which we previously described, and below the cumulative 202 dB SEL, may impact hearing at a level that does not result in physical injury. We refer to this hearing loss as non-injurious temporary threshold shift (non-injurious Temporary Threshold Shift [TTS]) in this Opinion.

Estimating the Geographic Extent of Underwater Sound Pressure Effects

To estimate the geographic area in which effects due to underwater sound pressures associated with impact pile driving are expected, we estimated the distance at which TL attenuates the sound pressures to below the levels where effects are expected. Calculating TL is complicated and site-specific.

The Service expects transmission loss for impact pile driving to occur in a manner most similar to practical spreading loss (as described by Davidson (2004, p. 2) [TL = 15*Log(R)]). In lieu of using site specific data, the practical spreading model is used to estimate the distances at which injury and behavioral disruption are expected. This model assumes that sound pressure decreases at a rate of 4.5 dB per doubling distance.

However, this model alone does not take into account the use of multiple pile drivers at the same time. Based on the values calculated by the Navy (BA, p. 102) and the anticipated sound pressures associated with impact pile driving with sound attenuation, the following distances are anticipated for sound pressure to reach the extent of measurable effects to marbled murrelets (Table 6).

Table 6. Underwater sound levels and threshold distances based on expected attenuated sound levels[8] of 204 dB peak[9], 175 dB SEL[10], and 185 dB_{rms}[11] at 10 m for underwater sound pressures for 36 inch and 48 inch diameter steel piles. A 168 dB SEL[12] attenuated underwater sound level is expected at 10 m for 24-inch piles.

			Distance to Onset Threshold with 10 dB Sound Attenuation(m)					
			24-inch pile			36/48-inch pile		
Species	Type of Effect	Onset of Effect	1,000 strikes (m)	2,000 strikes (m)	6,400 strikes (m)	1,000 strikes (m)	2,000 strikes (m)	6,400 strikes (m)
Marbled Murrelets	Injury Threshold	202 dB SEL (cumulative)	5	9	19	16	25	55
	Guideline for Assessing Non-Injury Threshold Shift	183 dB SEL (cumulative)	100	158	158	293	464	464
	Guideline for Assessing Behavioral Response	150 dB_{rms}	3,361	3,361	3,361	3,361	3,361	3,361

[8] Assumes a reduction of 10 dB due to sound attenuation device(s) used.
[9] Based on sound measured at the Carderock pile installation consultation (FWS
[10] Based on Illingworth and Rodkin (2007, Table I.2-3).
[11] Based on BA, p. 92.
[12] Based on Illingworth and Rodkin (2007, Table I.2-3).

Potential Effects from Underwater Sound Pressure Associated with Vibratory Pile Driving

Vibratory hammers produce underwater sound pressures that are less than those generated by impact pile driving. The SEL levels reported in Illingworth and Rodkin (2007, p. I.1-1) include pile sizes within the range of those proposed for installation at EHW-2. No values reported equal or exceed cumulative 183 dB SEL.

Therefore, we do not anticipate significant adverse effects to marbled murrelets in the form of physical injury or behavioral disruption associated with non-injurious TTS from vibratory pile installation.

Potential Effects to Marbled Murrelets from Exposure to Elevated Underwater Sound Levels from Impact Installation of Steel Piles

Effects to marbled murrelets associated with exposure to elevated underwater sound pressures could range from minor behavioral changes to injury and/or death. There are no published studies specific to impact pile driving and its effect on marbled murrelets, or any other seabird. Data specific to seabirds is primarily limited to evaluations of the effects of underwater blasting and seismic testing (Cooper 1982; Flint et al. 2003, p. 39; Lacroix et al. 2003; Stemp 1985; Yelverton and Richmond 1981, p. 3). Monitoring of seabird response to pile driving for bridge and ferry terminal projects in Washington, has generated some information on seabird responses to pile driving and has documented behaviors that could be indicative of physiological effects. During replacement of the Hood Canal Floating Bridge a pigeon guillemot (*Cepphus columba*) dove within 75 m of impact pile driving, surfaced quickly, was shaking its head, and appeared to have difficulty getting airborne (Entranco Inc. and Hamer Environmental 2005, p. 21). In 2007, monitoring staff at the Anacortes Ferry Terminal replacement project detected a marbled murrelet within 20 m of active pile driving. The bird was behaving aberrantly. It drifted very close to shore, was listing to one side, and was paddling with only one foot. While most seabirds were leaving the area during pile driving this bird did not dive or fly. After a few minutes the murrelet attempted to fly but had difficulty getting airborne (WSF 2007, pp. 4-5). These observations suggest how affected seabirds might behave when exposed to elevated underwater sound pressure levels. It is impossible to estimate the exact "dose" of underwater sound pressure that these observed seabirds might have received, other than to note that they were detected at distances from active pile driving where there was a potential for exposure to injurious levels of underwater sound.

Faced with the absence of controlled studies specific to seabirds we utilize evaluations of the effects of other types of underwater sounds on a variety of vertebrate species provide the basis for evaluating the effects of the high sound levels generated by pile driving on marbled murrelets. High levels of underwater sound are known to have negative physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981; Gisiner et al. 1998; Cudahy and Ellison 2002; U.S. Department of Defense 2002; Hastings and Popper 2005). Experiments using underwater explosives found that rapid change in underwater SPLs resulted in internal hemorrhaging and mortality in submerged mallards (*Anas platyrynchos*) (Yelverton et al. 1973, p. 49). During seismic explorations, it has been noted that seabirds were attracted to fishes killed as a result of the seismic work (Fitch and

Young 1948, p. 56; Stemp 1985). Fitch and Young (1948, p. 56) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed, but only when their heads were below water.

The potential for injury and/or mortality of any aquatic organism from pile driving depends on the type and intensity of the sounds produced. These are greatly influenced by a variety of factors, including the type of hammer, the type of substrate, and the depth of the water. Biologically, key variables that factor into the degree to which an animal is affected include size, anatomical variation, and location in the water column (Gisiner et al. 1998, p. 61). Observation of foraging marbled murrelets during impact pile driving at one project in Washington revealed that marbled murrelets will come fairly close (within 300 m) to active pile driving operations and continue to dive and forage despite elevated underwater sound (Entranco Inc. and Hamer Environmental 2005, p. 15).

Injuries from high underwater sound levels can be thought of as occurring over a continuum of potential effects ranging from a threshold shift in hearing to mortality. A threshold shift in hearing includes impaired or lost hearing. A threshold shift may be either temporary or permanent, depending on a number of factors, including duration pressure and loudness of the sound (National Institute of Health. http://www.nidcd.nih.gov/health/hearing/noise.asp accessed 8 3 2011). As noted above, the expert panel determined that the onset of hair cell loss would occur at cumulative 202 dB SEL. However, temporary threshold shifts may occur at lower sound levels without resulting in physical injury to the individual.

The severity of a threshold shift depends upon several factors such as the sensitivity of the subject, the received SPL, frequency, and duration of the sound (Gisiner et al. 1998, p. 25). Threshold shift in birds was studied within lab settings by Ryals et al. (1999) and in pinnipeds by Kastak et al. (2005) revealing that threshold shift increased more in response to an increase in duration than compared to an increase in SPL. Birds tested under these lab settings generally demonstrate greater tolerance to high SPLs than other taxa. Although these findings are not completely understood, there is general agreement that: 1) considerable variation occurs in individual responses, within and between species, 2) hearing loss occurs near the exposure frequency (Hz) in organisms (for narrow-band sound), and 3) hearing loss becomes irreversible under some combination of sound pressure level and exposure time, even in birds (Saunders and Dooling 1974, p. 1; Gisiner et al. 1998, p. 25; Ryals et al. 1999).

For fishes, a correlation between size and the impulse level needed to cause injury has been noted (Yelverton et al. 1975, p. 17; Hastings and Popper 2005). This type of analysis has not been done for birds. However, Yelverton and Richmond (Richmond et al. 1973; Yelverton and Richmond 1981, p. 12) and Yelverton et al. (1973) noted mass of the birds used in their studies and gave charge size and range of blasts. The mean mass of the birds used was 1.16 kg for mallards and 2.33 kg for Rouen ducks. Marbled murrelets are smaller, averaging 0.22 kg. The smallest juvenile marbled murrelet recorded in the marine environment in Washington was 0.16 kg (Emily Teachout and T. D. Bloxton, pers. comm. September 10, 2010). Given the correlations observed with fish and regarding size and impulse level, it was determined by the expert panel (SAIC 2011, in press) that marbled murrelets would be impacted by lower impulse levels than those identified for mallards and Rouen ducks.

Exposure to elevated SPLs can cause shifts in auditory thresholds. These shifts can be temporary (TTS) or permanent (permanent threshold shift) and decrease sensory capability. Ryals et al. (1999) documented hair cell loss in birds that experienced acoustic overexposure. Using scanning electron photomicrographs the authors were able to show that hair cell loss and damage on the surface of the papillae. Exposure to acoustic sources that involves loss and/or physical damage of hair cells is considered injury by the Service.

In regard to auditory damage, the inner ear is most susceptible to trauma, although intense sounds can also damage the middle and outer ear (Gisiner et al. 1998, p. 25). Not all frequencies of sound produce equivalent damage at the same exposure level, nor will the same frequency-exposure combination cause equivalent damage in all species (Gisiner et al. 1998, p. 25). The severity of a threshold shift depends upon several factors such as the sensitivity of the subject, and the level, frequency, and duration of the sound (Gisiner et al. 1998, p. 25). These effects are not completely understood, however, it is generally acknowledged that there is considerable variation within and between species, that for narrow-band noises, hearing loss centers around the exposure frequency, and that there is some combination of sound level and exposure time when hearing loss becomes irreversible (Saunders and Dooling 1974, p. 1; Gisiner et al. 1998, p. 25). The majority of studies [with cats and rodents (especially chinchilla)] used relatively long duration stimuli (greater than 1 hr.) and mid to low frequencies (1 to 4 kHz). These have noted that intensity and duration of exposure can act synergistically to broaden the extent of the hearing loss (Gisiner et al. 1998, p. 25). Repeated exposure to sounds that produce TTS, without adequate recovery periods, can also induce permanent, acute, hearing loss (Gisiner et al. 1998). An organism that is experiencing TTS may suffer consequences of not being able to detect biologically relevant sounds such as approaching predators or prey, and/or mates attempting to communicate.

Due to a lack of data on seabirds, the expert panel (SAIC 2011) relied on data from other vertebrate species to draw conclusions about levels of effect and thresholds for use in evaluating the extent of those effects. For estimating the expected onset of hair cell loss from underwater sound, they relied largely on data from other bird species (Dooling and Popper 2007, p. 27, Figure 6). With corrections to account for the different medium (air versus water), auditory sensitivity, and sound produced (continuous versus impulsive) similar morphological conditions, and expected overlap in auditory range, we conclude that these data provide the most appropriate information to be used as a surrogate for determining the onset of injury due to hair cell loss in marbled murrelets.

To estimate levels at which marbled murrelets will be physically affected by elevated underwater sound pressure from impact pile driving, we draw heavily from the analytical approach currently applied to evaluating effects to other vertebrates, including fish, mammals, and other bird species. SEL is recommended as a way to better account for both the negative and positive pressure excursions (Hastings and Popper 2005, p. 11).

Beginning with the values of the expert panel (SAIC 2011) for assessing the risk of direct injury, including hair cell loss, we consider 202 dB SEL (cumulative) to be the potential onset of hair cell loss and injury to marbled murrelets. The SEL, accumulated over all pile strikes exceeds

202 dB (re: 1 μPa^2-sec). The number of pile strikes is used to determine the cumulative SEL by applying the following equation:

Cumulative SEL = Single-strike SEL + 10*log(number of pile strikes)

The number of pile strikes is estimated per continuous work period. This approach assumes that there will be a break of at least 12 hours between work periods. A break of this duration is typical for most pile driving operations, and will provide a period for marbled murrelets to recover from exposure to elevated SPLs.

Potential for Exposure to Sound Pressure

Marbled murrelets spend a considerable amount of time on top of the water (not foraging) in any given day engaged in activities such as preening, resting, and breeding. While on the surface they are protected from being injured by underwater sound pressures, but are exposed to in-air sound pressures and other anthropogenic disturbance. When foraging, marbled murrelets are aggressive feeders. A typical diving bout is approximately 27 to 33 minutes (Jodice and Collopy 1999, p. 1412), with the birds spending approximately 49 to 62 percent of their time underwater during dive bouts. This compares to the results of Varoujean and Williams (1995) that spent approximately 18 minutes in dive bouts and 67 percent of their time underwater during their diving bouts (Varoujean and Williams 1995, p. 333).

Marbled murrelets occur year-round in the action area with their numbers increasing in late fall/early winter and declining in late winter/early spring. Several sources have documented marbled murrelet presence in the action area, as described above under "Environmental Baseline - Marbled Murrelet Occurrence in the Marine Environment." The proposed action will occur during the breeding season (April 1 through September 15) and non-breeding season (September 16 through March 30) for this species. However, due to the proposed in-water work window to protect listed fish, no in-water work will occur between February 16 and July 15 of each year. Construction work above water will occur year round.

During the late winter/early spring (approximately late February to mid-May) adults and subadults are undergoing the pre-alternate molt (Carter and Stein 1995, p. 99) and adults are preparing for breeding. In the spring/summer (approximately March to late September), breeding adults are incubating and provisioning newly fledged young (Hamer and Nelson 1995, p. 49); and in the summer/late fall (approximately mid-July to December) adults and subadults are undergoing the pre-basic molt when birds are flightless (Carter and Stein 1995, p. 99) and fledged young are coming into the marine environment. The in-water construction of the proposed project will occur between July 16 and February 15 over three construction seasons; therefore, one or more marbled murrelet life stages may be exposed, either directly or indirectly by the proposed action. In addition, because some activities will occur during the nesting season, chick mortality could occur if an adult is killed or injured, and thereby, unable to provide food to its young.

While the action area occurs within Conservation Zone 1, we cannot assume that the action will only affect marbled murrelets associated with Conservation Zone 1 for the following reasons: a) recent studies indicate marbled murrelets move freely between Conservation Zones 1 and 2 (the

Pacific Coast) during the breeding season when population surveys are conducted (Bloxton and Raphael 2006, p. 162) and b) studies indicate marbled murrelets may emigrate out of Conservation Zone 1 or may immigrate into Conservation Zone 1 from Conservation Zone 2 or British Columbia during the non-breeding season.

Marbled murrelet densities are greater in the winter in Conservation Zone 1 than in the breeding season, which is attributed to immigration of marbled murrelets from Conservation Zone 2 or British Columbia. However, there is considerable movement of marbled murrelets around Conservation Zone 1 in search of food sources or sheltered areas during inclement weather, and the origin of marbled murrelets in Conservation Zone 1 is not known. Therefore, for purposes of this analysis, we will consider a reasonable worst-case scenario by attributing all of the effects of the action to the Conservation Zone 1 population only.

Methods for Determining Likelihood for Marbled Murrelet Exposure to Underwater Sound Pressures from the Proposed Action

Marbled murrelets commonly occur in the marine environment in flocks that vary in size and by season (Nysewander et al. 2005, p. 65; Speich et al. 1992, p. 50). The distribution of marbled murrelet flocks in Puget Sound also appears to vary by season (Nysewander et al. 2005, p. 68; Speich et al. 1992, pp. 53-54).

Marbled murrelet summer density varies considerably temporally (within and between years) and spatially in Puget Sound, including Hood Canal. Specifically, there is considerable movement between strata 2 and 3 in Conservation Zone 1. To best address the annual variation in population estimates for these strata, which are used in the exposure analysis, we derived the marbled murrelet density during the proposed action based upon applying the average historical contribution of each stratum to the current abundance estimates (Table 7) in Conservation Zone 1 in the following manner.

Table 7. Reported marbled murrelet 2010 breeding season (summer) density and population size in Conservation Zone 1 and within each stratum (Falxa 2011).

Conservation Zone 1 Strata	Mean Density (birds/km^2)	Mean Population Size Estimate with 95% CI			Survey Area (km^2)
		Lower	Mean	Upper	
1	2.0	920	1,694	2,744	845.2
2	1.8	1,058	2,128	3,091	1,193.7
3	0.4	81	571	1,164	1,458
ALL	1.3	2,689	4,393	6,367	3,496.9

We first computed the proportion of marbled murrelets in each stratum for each survey year (2001 to 2010)[13] reported by Falxa (2011) and then averaged the proportions over the 10 years, which resulted in the following proportions for strata 1 to 3: 0.51, 0.25, and 0.24. We then

[13] 2000 data was not used due to data collection inconsistencies.

estimated the current abundance for each stratum based on the product of the strata proportions from the 10 years of surveys and the current overall abundance (Table 8).

For example, the proposed action is located in marbled murrelet survey stratum 2, where historically 25 percent of the marbled murrelets occur in Conservation Zone 1, based on the last 10 years of data for this conservation zone. Based on the current estimate of marbled murrelet abundance in Conservation Zone 1, stratum 2, we used an estimated mean abundance of 1,142 marbled murrelets (4,393 x 0.25) for the 2010 summer as the basis for the exposure analysis. The actual survey estimate in any one year could be greater or less than the abundance derived here.

Table 8. Adjusted marbled murrelet density and population size in Conservation Zone 1 for the 2010 breeding season (based on Falxa 2011).

Conservation Zone 1 Strata	Mean Density (birds/km^2)	Adjusted Mean Population Size Estimate with 95% CI			Survey Area (km^2)
		Lower	Mean	Upper	
1	2.6	1,345	2,197	3,184	845.2
2	1.0	699	1,142	1,655	1,193.7
3	0.7	645	1,054	1,528	1,458
ALL	1.2	2,689	4,393	6,367	3,496.9

To approximate the density of marbled murrelets in the winter, we developed an index using the results of winter surveys reported by Nysewander et al. (2005) for the Puget Sound Ambient Monitoring Program (1992 to1999). Although Nysewander et al. (2005) did not report summer marbled murrelet density, we developed an index based on a close examination of the changes in seasonal abundance of marbled murrelets in Puget Sound reported from summer and winter surveys. Based on our calculations using the Nysewander et al. (2005, pp. 10, 13) data, we calculated a 1.84 increase in marbled murrelets winter densities compared to summer densities Please see the Service's Opinion on the Navy's Northwest Training Range (Service Reference No. 13410-2009-F-1014 for a more detailed description of the development of the index).

To assess the likelihood of marbled murrelet exposure to underwater sound pressures within areas of interest, the following assumptions were made about marbled murrelet foraging bouts:

1. Marbled murrelets were assumed to occur at random points in space, but remain spatially constrained to the spatial unit under evaluations during the time it takes for the sound energy field to reach ambient levels.

2. Any occurrence of a marbled murrelet flock is independent of all other marbled murrelet flocks.

3. There was a zero chance of two or more marbled murrelet flocks occurring in the same spatial unit (i.e., two flocks will not be foraging at the same location at the same time) during one acoustic event.

4. The mean number of flocks within the area of ensonification remains constant throughout the given season of interest (i.e., there is a constant mean number of flocks for the winter and a separate mean for the summer).

In the case of an underwater sound field, determining the probability of a marbled murrelet foraging group encountering a sound field requires explicit knowledge of ensonified volumes within the foraging depth of marbled murrelets. To reduce this three-dimensional complexity, the following simplifying assumptions were adopted:

- The directivity of the energy field from the pile driving is omnidirectional.
- Assuming omnidirectional wave propagation, the energy field propagating through the forage zone resembles a cylinder-shaped sound field with a horizontally-growing diameter." The cylinder "top" is defined by the water's surface and the bottom of the cylinder corresponds to the sea floor.
- Due to the duration of the acoustic events under consideration in this consultation (up to 128 minutes of impact pile driving per day based on 6,400 strikes per day and 50 strikes per minute) and lack of 100 percent reliability on detecting all marbled murrelets within the potential area of injury, the mean subsurface density of murrelets within the area of potential injury (i.e., the mean number of marbled murrelets below the water during impact pile driving) is less than the surface density because not all marbled murrelets are expected to be foraging during the duration of pile driving.

Applying these assumptions, we constructed a conceptual spatial frame upon which we could simulate a marbled murrelet encounter for the purposes of quantifying the number of individuals that might be exposed to injurious underwater sound pressures. The simulation was based upon computing the likelihood (probability) of a marbled murrelet encounter while foraging based upon the species foraging behavior, implementation of the Navy's proposed pre-impact pile driving surveys within the zone of potential injury for marbled murrelets (≥ 202 dB SEL), and duration and extent of sound pressures associated with impact pile driving.

<u>Marbled Murrelet Surveys prior to and during Impact Pile Driving</u>

The Navy proposes to conduct surveys for marbled murrelets consistent with the Service's marbled murrelet monitoring protocol for impact pile driving (Appendix 1) and will delay or suspend the impact pile driving if/when a marbled murrelet is observed within the area of potential underwater sound injury (≥ cumulative 202 dB SEL; a distance of 55 m from the pile). The Navy proposes to survey for marbled murrelets up to 55 m to preclude potential underwater injury during impact pile driving. This survey area also includes a small portion of the area of potential non-injurious TTS (currently defined as ≥ cumulative 183 dB SEL and < cumulative 202 dB SEL). No surveys or suspension in pile driving are proposed for vibratory pile installation.

Although the intent of the survey is to avoid marbled murrelet exposure to injurious underwater sound pressures, we do not anticipate that these surveys will be 100 percent effective at detecting marbled murrelets, based on Evans-Mack et al. (2002, p. 868). The proposed marbled murrelet survey protocol based on Evans-Mack et al. (2002) (which included the use of two observers,

transect width of 100 m, boat speed equal to or less than 10 knots per hour, and one boat[14] surveying in a pattern designed to cover entire area twice), is anticipated to result in the probability of 0.78 to 0.95 of detecting a single marbled murrelet. We took a conservative approach and assume the probability of detection is 0.78. Therefore, we will assume that 78 percent of the marbled murrelets that may occur within the range where injury could occur due to impact pile driving will be detected during the survey and 22 percent will go undetected, and therefore, may be subject to mortality and/or injury due to exposure to injurious underwater sound pressures. Furthermore, we will assume that those marbled murrelets that are not detected will be underwater at the time of the survey and exposed to underwater sound pressures associated with pile driving occurring at that time. This is a conservative approach as marbled murrelets may not be detected due to other reasons (e.g., missed by an observer).

Likelihood of Occurrence within Area of Potential Negative Effects from Underwater Impact Pile Driving

To determine the likelihood that a marbled murrelet would be exposed to underwater sound pressures from impact pile driving at levels that may result in measurable effects, we used the methods described previously in the Service's Opinion on the Navy's Northwest Training Range (Service Reference No. 13410-2009-F-1014). Please see Appendix 5 for the calculations associated with the EHW-2 proposed action. A summary of these calculations and their results follows.

The sizes of the various sound fields that marbled murrelets may be exposed to were determined using radii associated with the attenuation distances to 202 dB SEL and183 dB SEL. Because the Navy only proposes to monitor out to 55 m, which does not encompass the area ensonified between 202 dB SEL to 183 dB SEL (a distance out to 464 m from a pile), our exposure analysis for non-injurious auditory sounds does not assume any minimization of effects within this zone that would otherwise be derived from marbled murrelet monitoring surveys. We then calculated the likelihood of a marbled murrelet flock encounter given the marbled murrelet density during the specific season of work (winter versus summer) within the area of interest based on a Poisson distribution that at least one marbled murrelet flock would encountering a sound wave within the area of the sound field of concern. The results of the exposure model represent a cumulative probability for the mean and upper and lower 95 percent confidence limits of the distribution (i.e., three probability values) associated with the annual, at sea marbled murrelet survey data.

To develop a biologically sensitive approach to quantifying marbled murrelet exposure derived from probabilities of exposure less than 100 percent, we chose to use a probability of 10 percent (**p** < 0.1) as the break point at or above which we consider one or more marbled murrelet groups to occur within the area of potential injury, and be subject to injury or mortality due to underwater sound associated with pile driving. For probabilities below 10 percent, we assume that no marbled murrelets would be exposed. This approach is consistent with a recent analysis the Service completed on underwater sound (USFWS 2008, p. 99).

[14] Two boats were used in the Evans-Mack et al. (2002) study. The Navy proposes to use one boat for the proposed surveys due to the small area to be surveyed (55 m).

Based on these calculations, the following values were obtained for the potential exposure of at least one marbled murrelet group within the area of potential injury (cumulative 202 dB SEL) (Table 9). As stated earlier, we have assumed that the density of marbled murrelets within the action area is best represented by the mean abundance values based on our comparison of calculated and survey data. Even if we assumed that marbled murrelets occurred in higher numbers (i.e., 95 percent confidence interval), the likelihood of exposure in all scenarios is still less than 10 percent. Therefore, we do not anticipate any marbled murrelets to be exposed to sound pressures of cumulative 202 dB SEL or higher. We conclude that injury or mortality to marbled murrelets is not anticipated due to underwater sound pressure associated with the proposed impact pile driving.

Table 9. Likelihood of exposure to at least one marbled murrelet group to sound levels of at least cumulative 202 dB SEL based on Poisson distribution, season of work, pile strikes per day, and pile size. Results assume that marbled murrelet surveys are performed and are 78 percent effective in detecting marbled murrelets and that sound attenuation results in at least a 10 dB reduction.

24 inch Piles		Likelihood of encounter at least one marbled murrelet flock based on adjusted estimate of marbled murrelet abundance			36/48 inch Piles		Likelihood of encounter at least one marbled murrelet flock based on adjusted estimate of marbled murrelet abundance		
Season	Pile Strikes	L95	Mean	U95	Season	Pile Strikes	L95	Mean	U95
Summer	1,000	0.0000	0.0000	0.0000	summer	1,000	0.0001	0.0001	0.0001
Winter	1,000	0.0001	0.0001	0.0002	winter	1,000	0.0001	0.0002	0.0003
summer	2,000	0.0000	0.0001	0.0001	summer	2,000	0.0003	0.0005	0.0007
winter	2,000	0.0001	0.0001	0.0002	winter	2,000	0.0007	0.0012	0.0017
summer	6,400	0.0004	0.0007	0.0010	summer	6,400	0.0035	0.0058	0.0084
winter	6,400	0.0010	0.0017	0.0024	winter	6,400	0.0086	0.0140	0.0202

Potential for Auditory and Non-Auditory Behavioral Effects due to Exposure to Elevated Underwater Sound Pressure

Exposure to increased sound pressure are expected to result in adverse effects such as temporary auditory effects that do not result from physical injury, as well as changes in marbled murrelet behavior. Non-injurious TTS may cause masking, delayed or interrupted foraging, and interference with mate identification, bonding, and courtship.

Based on anticipated sound pressures generated from impact pile driving and values generated from the previously described exposure model, we determined that marbled murrelets may be exposed to sound pressures that result in non-injurious TTS (Table 10).

Table 10. Likelihood of exposure to sound levels between cumulative 183 dB SEL and less than cumulative 202 dB SEL of at least one marbled murrelet group based on Poisson distribution, season of work, impact pile strikes per day, and pile size. Results assume that marbled murrelet surveys are performed out to 55 m and are 78 percent effective in detecting marbled murrelets and that sound attenuation results in at least a 10 dB reduction. All values in **bold** assume that at least one marbled murrelet flock is exposed to sound levels of at least cumulative 183 dB SEL.

24 inch Piles		Likelihood of encounter at least one marbled murrelet flock based on adjusted estimate of marbled murrelet abundance			**36/48 inch Piles**		Likelihood of encounter at least one marbled murrelet flock based on adjusted estimate of marbled murrelet abundance		
Season	Pile Strikes	L95	Mean	U95	Season	Pile Strikes	L95	Mean	U95
summer	1,000	0.0074	0.0120	0.0174	summer	1,000	0.0843	**0.1339**	**0.1879**
winter	1,000	0.0178	0.0289	0.0416	winter	1,000	**0.1920**	**0.2940**	**0.3962**
summer	2,000	0.0461	0.0747	**0.1073**	summer	2,000	**0.3436**	**0.5297**	**0.7189**
winter	2,000	**0.1098**	**0.1762**	**0.2502**	winter	2,000	**0.7326**	**1.0507**	**1.3208**
summer	6,400	**0.1153**	**0.1868**	**0.2682**	summer	6,400	**0.8590**	**1.3242**	**1.7972**
winter	6,400	**0.2745**	**0.4405**	**0.6256**	winter	6,400	**1.8316**	**2.6266**	**3.3020**

Exposure to elevated sounds may result in non-injurious TTS. An organism that is experiencing temporary hearing loss may suffer the consequences of not detecting biologically relevant sounds such as approaching predators or prey, and/or mates attempting to communicate. As mentioned earlier, a pigeon guillemot appeared disoriented and was observed having difficulty getting airborne after being exposed to underwater sound from impact pile driving (Entranco Inc. and Hamer Environmental 2005, p. 21). Although it is impossible to know whether this individual was suffering from non-injurious TTS, the behavior it was exhibiting likely made the individual more vulnerable to predators.

The behavioral response of seabirds, including marbled murrelets, was monitored during construction of the Hood Canal Floating Bridge Replacement project (Entranco Inc. and Hamer Environmental 2005). Observers noted that at the beginning of the pile driving work the majority of seabirds in the vicinity responded by flushing, but that this response lessened over time, indicating that there was some habituation. Their observations also noted that, despite ongoing construction disturbance, marbled murrelets came within close proximity of the project and continued to dive and forage.

For the purposes of this analysis, we estimated that the duration of daily impact pile driving will vary from 20 minutes per day to 128 minutes per day (Table 11). Exposure of marbled murrelets to sound pressures that may result in non-injurious TTS for this project is anticipated for exposure durations of at least 20 minutes (based on a 36/48 inch steel pile). As noted in Table 10 above, we do not expect marbled murrelets to be exposed to sound levels of up to cumulative 183 dB SEL for impact strikes of up to 1,000 strikes per day (winter and summer) and 2,000 strikes per day (summer only) for 24-inch diameter steel piles that are impact driven. Up to 385

days (187 days during the summer and 198 during the winter) of exposure to sound levels that may result in non-injurious TTS may occur over the 3 year pile installation period.

Table 11. Duration of impact pile driving. Numbers in bold represent the number of days that there is a potential that at least one marbled murrelet flock will be exposed to sound pressures that may result in non-injurious TTS. All values in **bold** assume that at least one marbled murrelet flock is exposed to at least cumulative 183 dB SEL per day. Duration of strikes is based on 50 strikes per minute.

	24 inch diameter			36/48 inch diameter		
strikes	minutes for x strikes	# days July 16 - Sept. 30 (Summer)	# days October 1 - Feb. 15 (Winter)	minutes for x strikes	# days July 16 - Sept. 30 (Summer)	# days October 1 - Feb. 15 (Winter)
1,000	20	2	2	20	**96**	**105**
2,000	40	11	**11**	40	**68**	**68**
6,400	128	**1**	**1**	128	**22**	**13**

During the nesting season (April 1 through September 15), impact pile driving would only occur between 2 hours after sunrise and 2 hours before sunset[15], reducing effects of disturbance to foraging marbled murrelets. Outside the nesting season, pile driving will only occur during daylight hours. No pile driving will occur from April 1 through July 15 due to the in-water timing restriction to protect fish. These restrictions limit, but do not preclude, the likelihood of marbled murrelets being exposed to elevated sound levels that could cause temporary hearing impairment and its associated effects on the individual's ability to forage and communicate with its mate.

Marbled murrelets can make substantial changes in foraging sites during the breeding season, but many birds routinely forage in the same general areas and at productive foraging sites (Becker 2001, pp. 122, 128-129; Carter and Sealy 1990, pp. 93, 100; Mason et al. 2002, p. 24; Whitworth et al. 2000, pp. 444-445). We anticipate that although marbled murrelets that are foraging during the proposed action may move between foraging areas, thus limiting their exposure to high underwater sounds, they are also likely to remain within the area of high underwater sound pressures due to their affinity to the area and forage availability.

During the pre-basic molt [between mid-July and the end of August (based on C. Thompson pers. comm. 2003) and from mid-July through December (Carter and Stein 1995, p. 99; Nelson 1997, p. 23)], flightless marbled murrelets must select foraging sites that provide adequate prey resources within swimming distance (Carter and Stein 1995, p. 104). Because of their inability to fly during part of the molt, marbled murrelets are likely more sensitive to disruptions of foraging and are more vulnerable to predation. Therefore, activities during this time of year that disrupt foraging can result in 1) increased energy expended attempting to relocate, 2) relocation

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

to a lower quality foraging area, 3) longer time taken to undergo the molt process, 4) increased stress, or 5) reduced fitness. The intensity of these effects is linked to the duration of the disruption.

Construction at EHW-2 is proposed for up to 6 days per week from July 16 through February 15 over three years. Marbled murrelets that are foraging in the vicinity of the project during construction may expend additional energy avoiding or moving away (which would not include flying when they are in pre-basic molt) from the pile driver and/or may relocate to another foraging area. Alternatively, marbled murrelets may habituate to the higher underwater sounds, especially if there are available prey resources in the area. If they remain in the area, they will continue to be exposed to the higher underwater sound pressures, lengthening the duration of time when they may experience hearing impairment.

We estimate that all marbled murrelets that are underwater within the unsurveyed portion of an ensonified area where non-injurious TTS may occur (area between cumulative 183 dB SEL and cumulative 202 dB SEL (Table 12) during impact pile driving will be exposed to elevated sound levels that is anticipated to cause temporary hearing loss or impairment. Responses to these exposures may result in flushing (diving or flying), relocation to another area, and interruption or delay of foraging or resting, or inability to hear conspecific communication. We anticipate that the responses to non-injurious TTS may be manifested in reduced foraging ability, increased energy expenditure, increased stress, and increased risk of predation. We assume that the effects of exposure to non-injurious TTS are reduced as the distance between the sound source and marbled murrelet increases. We do not anticipate that the proposed action will result in a missed feeding of a young still on the nest during the nesting season. While we presume marbled murrelets are primarily vision-oriented when foraging and detecting predators, they rely on their hearing to communicate with cohorts and mates, which may also facilitate predator avoidance in the marine environment. Additionally, the inability to communicate with their mates may affect pair bonding and potentially delay reproduction.

Table 12. Unsurveyed area (area between cumulative 183 dB SEL and cumulative 202 dB SEL) by pile size and strikes. Assumes 55 m from pile is surveyed to Service protocol.

	Area not Surveyed to Protocol (km2)							
	Summer				Winter			
Pile Strikes	area not surveyed per 24 inch pile	# days	area not surveyed per 36/48 inch pile	# days	area not surveyed per 24 inch pile	# days	area not surveyed per 36/48 inch pile	# days
1,000	NA	2	0.24	96	NA	2	0.24	105
2,000	NA	11	0.54	68	0.047	11	0.54	68
6,400	0.047	1	0.54	22	0.047	1	0.54	13

[1] NA - no exposure anticipated within ensonified area

Based on the area between cumulative 183 dB SEL and cumulative 202 dB SEL that will not be surveyed to protocol and the density of marbled murrelets within these areas during each of the events, we have estimated that individual marbled murrelets, including adults, sub-adults, and recently fledged chicks, could be exposed to non-injurious TTS over the 3 year construction period up to 385 days. The number of individuals exposed is expected to be less than 170. Individuals could be exposed multiple times for long durations (approximately 2 hrs). Although there are a variety of potential effects associated with non-injurious TTS that would result in measureable impacts to individual marbled murrelets, there is considerable uncertainty regarding the magnitude and duration of these effects to individuals. Many variables exist that influence the magnitude of these effects, ranging from the proximity of the marbled murrelet to the sound levels, duration of exposure to the high sound levels, and the condition of the individual. In addition, the number of marbled murrelets decreases at locations closer to the sound source. Therefore, we are unable to characterize how many individuals that may be exposed to these high sound levels would be adversely affected to the extent that that their normal behaviors would be affected due to non-injurious TTS, or to characterize the potential effect from non-injurious TTS that would occur. Nonetheless, we anticipate there will be a significant disruption in normal behavior to individual marbled murrelets within the area where non-injurious TTS may occur (0.48 km^2 cumulative total area- See Appendix 6) of marine habitat in Hood Canal as a result of behavioral responses to elevated SPLs and associated hearing impairments due to the daily duration (up to 128 minutes per day 6 days a week) for up to 385 days over a 3 year construction period. The total area was calculated by mapping the maximum extent of unsurveyed areas exposed to sound levels exceeding a cumulative 183 dB SEL over the duration of the project.

Other Behavioral Effects Anticipated due to Exposure to Elevated Underwater Sound Pressures Associated with Vibratory and Impact Pile Driving

High underwater sounds can cause a variety of behavioral responses not associated with non-injurious TTS that have not been well studied. There is no information on the effects of behavior disruption on marbled murrelets resulting from high underwater sound levels and limited information on other types of seabirds. Richardson et al. (1995, p. 59) speculated that a high underwater sound pulse (from underwater explosions) may interrupt foraging dives and cause a return to the surface, or that some might leave the area; however, he also found that available evidence suggested that the latter is unlikely. Stemp (1985, pp. 223-336) found the number of Northern fulmars (*Fulmarus glacialis*), blacklegged kittiwakes (*Rissa tridactyla*), and thick-billed murres (*Uria lomvia*) that were within a few hundred meters of a seismic vessel and were exposed to repeated underwater explosions did not differ consistently during periods with and without explosions.

Other data relevant to the effects of underwater sound on birds is from a study conducted on common eiders (*Somateria molissima*) (eiders) using underwater noise as means to deter them from preying on mussel farms (Ross et al. 2001). In this study, after actual hazing of the eiders with motor boats, recordings of motor boats were played underwater. The study concluded that playing the sound of motor boat underwater was effective at keeping eiders away. These findings suggest that some diving birds alter their behavior in response to noise that they relate to a known stressor (hazing).

With the exception of the few bird studies mentioned above, behavioral response information must be drawn and extrapolated from literature on fish in order to evaluate potential effects to marbled murrelets. Turnpenny et al. (1994) attempted to determine a level of underwater sound that would elicit behavioral responses in brown trout (*Salmo trutta*), bass, sole, and whiting. With brown trout, an avoidance reaction occurred above 150 dB_{rms} and other reactions (e.g., a momentary startle), were noted at 170 to175 dB_{rms}. The report references Hastings' "safe limit" (Turnpenny et al. 1994, p. 9) recommendation of 150 dB_{rms} and concludes that the Hastings' "safe limit" provides a reasonable margin below the lowest levels where fish injury was observed. Additionally, observations by Feist et al. (1992, p. 28) suggest that sound levels in this range may also disrupt normal behavior of juvenile salmon.

Fewtrell (2003) held fish in cages in marine waters and exposed them to seismic airgun impulses. The study detected significant increases in behavioral responses at SPLs between158 and163 $dB_{rms.}$ Observed behaviors included alarm responses, faster swimming speeds, and formation of tighter groups and movement toward the lower portion of the cage. It is difficult to discern the significance of these behavioral responses. However, such responses may result in greater energy expenditure by an individual or reduce foraging if the individual was feeding at the time of the disruption. The study also evaluated physiological stress response by measuring plasma cortisol and glucose levels and found no statistically significant changes. Conversely, Santulli et al. (1999) found evidence of increased stress hormones after exposing caged European bass to seismic survey sound.

Clearly, there is a substantial gap in scientific knowledge on this topic. The most recent study by Fewtrell (2003) presents, at least, some experimental data on behavioral responses of fishes to impulsive sounds above 158 dB_{rms}. Given the large amount of uncertainty that lies in extrapolating from experimental data to the field, between sound sources (airguns versus pile driving), and from one species to another, we believe it is appropriate to utilize a conservative threshold. As such, we anticipate that marbled murrelets will be exposed to elevated underwater sound pressures associated with vibratory and impact pile driving that may result in behavioral effects (not associated with temporary hearing loss) that may include aborted feeding attempts, avoidance and/or preclusion from foraging areas.

Marbled murrelets will be exposed to underwater sound pressure levels above 150 dB_{rms} due to both vibratory and impact pile driving. Sound pressures will extend out to approximately 3,361 m during pile driving when the impact and three vibratory pile drivers are operating. Behaviors that would indicate disturbance of marbled murrelets in the marine environment include aborted feeding attempts; multiple delayed feeding attempts within a single day, or across multiple days; multiple interrupted resting attempts; and precluding access to suitable foraging habitat. Alternatively, marbled murrelets may habituate to the higher underwater sounds and continue foraging.

As described earlier, Entranco and Hamer (2005, p. 20) noted that at the onset of pile driving, the response of seabirds was typically to flush. However, this response lessened over time, suggesting habituation may have occurred. In particular, marbled murrelets were observed in close proximity to active pile driving (within 300 m) and continued to dive and forage (Entranco

Inc. and Hamer Environmental 2005). Habituation appears to be an important consideration in measuring bird response in terms of whether or not the stressor causes a "disturbance" (Brown 1990, p. 587; Dooling and Popper 2007, p. 39; Rojek et al. 2007, p. 61).

Habituation is believed to be one of several forms of learning (Welty 1975, p. 177) and is believed to be the simplest. Other forms of learning include conditioned behavior, trial and error, and insight. Habituation as a form of learning is defined as the waning of a preexisting response as a result of repeated stimulation when the stimulation is not followed by any kind of reward or punishment (i.e., reinforcement) (Welty 1975, p. 178).

Based on the observations of Entranco and Hamer Environmental (2005, p. 20), we conclude that marbled murrelets are likely to habituate to underwater sound pressures up to 150 dB_{rms} associated with the proposed action. Because we expect that they will continue to forage within the sound field, we do not anticipate measurable effects to marbled murrelets associated with exposure to these underwater sound levels.

Effects of Exposure to Elevated In-Air Sound Pressures due to Pile Driving

We have previously evaluated the effects of sound-related disturbance in the terrestrial environment and determined that marbled murrelets could be adversely affected by sounds above 92 dBA (Service Reference No. 1-3-03-F-0833) (Livezey et al. 2007, p. 275). There are no known studies or data available that evaluate the response of marbled murrelets (or other alcids) to elevated in-air sound in the marine environment. For projects in the marine environment, we assume that marbled murrelet response to above-ambient sounds on the water would be similar to those expected in the terrestrial environment.

Based on sound measurements taken during impact installation of 24 inch diameter piles (*Biological Assessment Preparation Advanced Training Manual Version 02-2011* Pg. 7.13) (WSDOT 1994 , p. 4) and 36 inch diameter piles (based on Laughlin 2007, p. 44), we estimate that project-related in-air sound pressure levels may be 110 dBA Lmax at 50 ft (15.2 m) during impact pile driving. Using the practical spreading loss calculator (6 dB reduction per doubling distance) for open areas, 110 dBA Lmax sound levels will attenuate to 92 dBA at 121 m (397 ft). Although the WSDOT data is for piles of smaller sizes than the maximum 48 inch diameter that will be used on this project, it represents a more conservative value than that used by the Navy in their analysis (105 dBA) for impact pile driving in-air sound pressure.

Additionally, data also available from Laughlin (in litt. 2010, p. 10) indicates that in air sound pressures from vibratory pile driving of 30-inch diameter steel piles range from approximately 85 dBA Lmax to 96 dBA Lmax standardized to 50 ft. As more than one vibratory pile driver would be operating at a time, the in-air sound for vibratory pile driving may increase to 99 dBA[16]. Attenuation to 92 dBA for vibratory pile driving would occur at 34 m.

[16] This assumes that two similar sources combined together will increase noise levels by 3 dB over the level of a single piece of equipment by itself (WSDOT 2007 cited in BA).

Marbled murrelets may be exposed to above water sound pressures associated with vibratory pile installation for a total of 10 hours per day and up to 128 minutes (2.13 hours) per day for impact pile driving over a total of 400 days during the proposed in-water work period of July 16 through February 15 over the three construction seasons, from 2012 through 2014.

Birds, including seabirds, can exhibit a wide range of behavioral responses to anthropogenic disturbance (Klein et al. 1995, p. 1457), but relying solely upon behavioral responses as the indicator of a species' sensitivity to airborne sound stressors could lead to incorrect conclusions about the effects to the individual. For example, the findings of Ross et al. (2001), as well as observations of marbled murrelets foraging near active pile driving projects (Entranco Inc. and Hamer Environmental 2005, p. 20), suggest that marbled murrelets are unlikely to exhibit a detectable change in foraging behavior when exposed to elevated levels of in-air sounds.

Overall body condition and foraging success are proximate and synergistic factors that can cause animals to exhibit less behavioral response to disturbance stimuli when food intake is in high demand (Stillman and Goss-Custard 2002, p. 358). In the scenario where foraging success is high and body condition is low (i.e., during winter and for breeders during the breeding season), a marbled murrelet behavioral response to in-air sound would likely be less. Thus, adopting the conceptual framework offered by Gill et al. (1996), marbled murrelet response to the airborne acoustic stimuli (e.g., to leave the foraging area) are likely to represent trade-offs between food intake and a perceived predation risk.

When researchers examined the behavioral response of birds to the disturbance stimuli of people approaching birds in boats (Ross et al. 2001, p. 518) and on foot (Stillman and Goss-Custard 2002, p. 359), they observed flush responses based upon a perceived threat and no flush responses when the threats were not "rewarded." We infer from Ross et al. (2001), Stillman and Goss-Custard (2002), and Gill et al. (1996) that a bird's perceived risk of a threat, and whether or not the increased vigilance is rewarded, is fundamental to assessing the likelihood of a flush response. In other words, the experiences or learning that a bird acquires after exposure over time to a stressor, such as high in-air SPLs, plays a role in future responses to that stressor.

We expect that marbled murrelet response to high in-air SPLs will depend upon their perceived tradeoff between the energy needs at the moment and the perceived risk of the sound fields (similar to a predator). In general, we expect that some marbled murrelets (with no pre-existing exposure to high in-air SPLs will flush, dive, or swim away as an initial response to the increased sound. However, Navy personnel and vessels will not be directly pursuing marbled murrelets concurrent with their exposure to high SPLs. Although marbled murrelets may initially exhibit behaviors that could lead to termination or interruption of a foraging bout, we expect this behavior will lessen over time in the absence of reinforcement (i.e., a real anthropogenic threat associated with impact or vibratory pile driving.

Based on the observations of Entranco and Hamer Environmental (2005, p. 20), we conclude that marbled murrelets are likely to habituate to in-air sound fields associated with the proposed action. Because we expect that they will continue to forage within the sound field, we do not anticipate measurable effects to marbled murrelets' foraging behavior associated with exposure to these in-air sound levels.

Masking

In-air sounds may mask marbled murrelet vocalizations when impact and vibratory pile driving are within the same frequency range as marbled murrelet vocalizations. There is currently no information on the hearing range for marbled murrelets; therefore, we will use the known range of their vocalizations to estimate their hearing range.

We have limited data on the frequency spectra of in-air sounds from impact and vibratory pile driving. Impact pile driving of 12-inch diameter steel piles was shown to have acoustical energy concentrated at 250 Hz (0.25 kHz) and 1,000 Hz (1 kHz) and at 250 Hz (0.25 kHz) and 2,000 Hz (2 kHz) (Illingworth & Rodkin 2007, p. I.3-1, 3-3). Vibratory installation of 72-inch diameter steel piles was concentrated below 600 Hz (0.6 kHz), although frequencies of 5,000 Hz (5 kHz) were measured (Illingworth & Rodkin 2007, p. I.3-6). Although these pile sizes are outside the range of those to be used by the proposed action, we rely on these data since none are available for the proposed pile sizes.

These frequencies are within the lower end of the estimated hearing range for marbled murrelets of 0.187 kHz (Dechesne 1998, p. 45) to over 11 kHz (Nelson 1997, p. 10). Additionally, these frequencies fall within the range of greatest sensitivity in hearing for most birds (1 kHz to 5 kHz) Dooling et al. (2000, p. 311) and are assumed to be applicable to marbled murrelets. Additionally, non-songbirds, including marbled murrelets, tend to hear better at lower frequencies than songbirds (Dooling et al. 2000, p. 311). Sensitivity to frequencies greater than 10 kHz tends to be poor in birds (Dooling 1980, p. 262). Sound in the spectral region of a bird's vocalizations (generally 2 to 4 kHz) has a much greater masking effect on detection of communication signals than do sounds outside this range (Dooling and Popper 2007, p. 5). Therefore, we assume that marbled murrelets are able to detect the sound associated with impact and vibratory pile installation and the frequencies produced are likely to mask their vocalizations.

Airborne sounds have a high potential to mask biologically important acoustic stimuli for marbled murrelets due to the broad-band frequencies and SPLs associated with pile driving activities. If masking occurs at locations of biological importance (foraging and breeding habitat) and is of sufficient duration to impair reception of biologically important stimuli, normal marbled murrelets behavior, such as foraging, pair bonding, and reproduction, may be significantly disrupted.

Marbled murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997, p. 9). After surfacing following a forage dive, individuals of a pair vocalize after surfacing apart from each other (Strachan et al. 1995, p. 247). Vocalizations among pairs also occur after a disturbance (Strachan et al. 1995, p. 428). When pairs are separated by boats, most will vocalize and attempt to reunite (Ralph (unpublished data) and Miller (pers.comm.) both in Strachan et al. 1995, p. 248). Strachan et al. (1995, p. 248) believe that foraging plays a major role in marbled murrelet pairing and that some sort of cooperative foraging technique may be employed. This is evidenced by the fact that most pairs of marbled murrelets consistently dive together during foraging and that they often swim towards each other before diving (Carter and Sealy 1990, p. 96). Assuming vocalization plays a role in a cooperative feeding strategy, interruption of vocal

communication could negatively impact foraging efficiency. Similarly, at-sea courtship could be negatively impacted. Courtship begins in early spring, continues through summer, and has also been noted in winter (Nelson 1997, p. 13; Speckman 1996, p. 60).

Masking can happen anytime there is simultaneous occurrence of a biologically important sound and a masking sound. The duration of masking of acoustic stimuli between marbled murrelets which would result in a measurable effect to an individual is not known. However, we expect that the likelihood of effects from masking increases with increased duration of exposure. The Navy anticipates that there will be up to 400 days of impact and vibratory pile driving and an additional 11 days of impact pile driving of the upland abutment piles over the 3 year construction period. In-water pile driving may occur up to 6 days per week. All pile driving would occur during daylight hours. Due to implementation of the marbled murrelet monitoring plan, we do not anticipate that marbled murrelets within 55 m of impact pile driving will be exposed to high in-air sounds. However, there are no restrictions on discontinuing vibratory pile driving if a marbled murrelet is present.

We anticipate that marbled murrelets will be able to hear the sound levels generated by the vibratory and impact pile drivers during installation. These sound levels will exceed the disturbance thresholds of 92 dB and are assumed to contain the same frequencies as those reported in (Illingworth & Rodkin 2007, p. I.3-1, 3-3). As marbled murrelets are able to detect these frequencies, we have determined that marbled murrelets may be disturbed at distances from pile driving where sound levels have not attenuated to 92 dB. Thus, marbled murrelets may be exposed to in-air sounds greater than 0.6 kHz within 34 m of vibratory pile driving (assuming more than vibratory pile driver operating at one time) and 0.25 kHz from 55m[17] to 121 m (in-water vibratory and impact pile driving occurring concurrently) for up to 400 days over 3 years. In-air sounds associated with the 11 days of impact pile driving are expected to extend approximately 121 m from land, assuming vibratory pile driving.

For marbled murrelets in the marine environment, vocalization plays an important role in foraging, pairing (Strachan et al. 1995, p. 248), and courtship (Speckman et al. 2004, p. 269). As with other alcids, marbled murrelets are anticipated to form long-term pair bonds (DeSanto and Nelson 1995 in Dechesne 1998, p. 4), and thus, require pair recognition (Dechesne 1998, p. 4). Vocalization recognition between mates is common in birds (Falls 1982, Colgan 1983 both in Dechesne 1998, p. 4). Therefore, the proposed action could inhibit or disrupt foraging, pairing, or courtship if the acoustic events are of sufficient duration and/or frequency such that foraging efficiency or courtship/pairing are measurably affected. Based on observations of Entranco and Hamer Environmental (2005, p. 20) it is likely that marbled murrelets will continue foraging, even if masking occurs; therefore, we do not anticipate measureable effects to foraging due to potential masking effects.

All calls identified by Dechesne (1998, p. 46) were used by adult marbled murrelets both in the marine and forested environment. However, some calls, including the *ay, hey*, *keer*, *keheer*, *key*, and *quack* calls were more commonly recorded in the marine environment. Only the *key* call appeared to be restricted to the marine environment. Marbled murrelets while on water appear to

[17] No exposure to in-air sound pressures are anticipated at less than 55 m due to implementation of marbled murrelet monitoring protocol that precludes pile driving if a marbled murrelet is present within this zone.

make shorter calls (*eh* calls) sometimes during courtship activities (Gus van Vliet pers. comm. in Dechesne 1998, p. 33). The *keheer* call was the second most common call and is used by marbled murrelets in reunions at sea (Dechesne 1998, pp. 37, 46). However, the biological importance of each of the call types was not determined (Dechesne 1998, p. 42). If masking occurs due to high in-air sound pressures, pair recognition may be negatively affected. Courtship begins in late winter/early spring and continues through the summer (April 1 to September 15) (Nelson 1997, p. 13; Speckman 1996, p. 60). Therefore, courtship behavior may be affected during part of the construction season (July 16 through September 15).

Birds, including marbled murrelets, may adapt behaviors to improve their ability to hear when exposed to high in-air sound levels. Dooling and Popper (2007, p. 40, 53) report short-term behavioral changes in some bird species, including penguins, in response to sound, presumably to enhance communication among conspecifics. These short-term strategies, effective when ambient sound levels (received) are as high as 70 dBA, include scanning (head turning), raising vocal output, and changing singing location. The authors suggest that all birds likely employ all three strategies simultaneously to gain acoustic signal strength. However, these strategies may not be sufficient to receive the calls of their mates in all cases. Brackenbury (1979 in 2006, p. 640) and Brumm (1994b in Patricelli and Blickley 2006, p. 640) note that a bird's ability to increase the amplitude of their song sufficiently above background sound is likely limited by body size and energetic costs associated with creating the louder sounds. Due to the small size of the marbled murrelet, it is possible that they are limited in their ability to increase the amplitude of their calls above high background sounds sufficient enough to be heard by conspecifics. We expect marbled murrelets are likely to apply similar strategies as described above in response to high in-air sound levels.

Although marbled murrelets are currently exposed to sound levels at the project site as high as 104 dBA, the average in-air sound levels average 64 dBA. The higher existing sound levels at the site were produced by a combination of sound sources, including heavy trucks, forklifts, cranes, marine vessels, mechanized tools and equipment, and other sound-generating industrial/military activities. We anticipate that these sound conditions will occur during the proposed construction. However, the sound levels produced by the proposed action will exceed the background levels frequently and for extended durations during pile driving. Therefore, masking events may occur for extended periods during pile installation.

Marbled murrelets may respond with an increase in scanning (head turning), a raised vocal output, and changed singing location, but these strategies will not likely be successful in allowing communication to occur without interruption during all in-air acoustic events. Therefore, we anticipate that marbled murrelets exposed to in-air sound levels that result in masking in the marine habitat could experience effects to pair bonding and delays in reproduction due to the inability to communicate. However, it is likely that the effects of masking are associated with an unknown duration of exposure before the effects are biologically significant to marbled murrelets. We conclude that while marbled murrelets will be exposed to high sound frequencies for approximately 400 days over 3 years, available evidence is currently insufficient to establish a likelihood that such impacts will significantly disrupt or impair normal marbled murrelet behaviors.

Effects from Anthropogenic Presence (Surface Vessels and Personnel)

The proposed action may result in exposure of marbled murrelets to personnel, barges, and other aquatic vessels, including observer vessels, used during construction. We do not anticipate that the level of vessel use or personnel will increase measurably during operation of EHW-2.

Agness et al. (2008) investigated the potential effects of vessels on the near shore density and behavior of Kittlitz's murrelets (*Brachyramphus brevirostris*) in one summer (breeding) season at Glacier Bay, Alaska, with particular emphasis on the behavioral (response) differences between breeding and non-breeding adults and forage group size at three time scales: instantaneous, 30-minutes, and daily. In general, Kittlitz's murrelets were immediately displaced by vessel traffic, resulting in a 40 percent decrease in the nearshore density for up to 30 minutes. Kittlitz's murrelet density returned to or exceeded the pre-exposure density within the same day. The authors also noted that group size did not change at the 30-minute or daily time scales and inferred that group dynamics (possibly of importance to foraging success) was unaffected on days with high vessel traffic (Agness et al. 2008, p. 352).

Overall, however, the authors noted a three-fold increase in dive behavior on days with higher vessel traffic. However, this did not appear to be a direct response to an approaching vessel as no change in dive behavior was detected at the instantaneous and 30 minute time scales (Agness et al. 2008, p. 352). Rather, the increase in dive behavior (presumably foraging) was probably in response to the 30 percent increase in flight behavior that placed an increased energetic demand on individuals and led to the observed higher frequency in diving and foraging behavior.

Non-breeding Kittlitz's murrelets were much more likely to flush in response to vessel traffic, and breeding Kittlitz's murrelets (holding a fish for delivery to inland nestlings) were more likely to dive. Breeding adults seldom flew while holding a fish, probably because the combination of the added weight and effort of holding a fish made diving energetically more preferable (Agness et al. 2008, p. 352). Dive behavior of marbled murrelets with fish was also observed by (Speckman et al. 2004, p. 33) in response to research boats attempting to approach the birds. Fish-holding Kittlitz's murrelets will sometimes fly when the vessels are slow and approaching at greater distances (Agness et al. 2008, p. 351).

Bellefleur et al. (2007) studied the behavior of marbled murrelets in response to small vessels (4.9 m to 7.3 m in length) in the marine waters of the Pacific Rim National Park Reserve, Vancouver Island, British Columbia, Canada. They found that juveniles flushed more than adults (70.1 percent versus 51.7 percent), but flushed when boats were closer. Also, boats with speeds greater than 29 kph resulted in a greater proportion of the birds flushing and to greater distances versus speeds less than 12 kph. Based on a regression analysis, marbled murrelets tended to fly completely out of feeding areas at the approach of boats travelling more than 28.8 kph and later in the season (July and August) (Bellefleur et al. 2007, p. 1).

We assume the response of marbled murrelets to vessels will be similar to the closely related Kittlitz's murrelet, as described above. The visual stimuli associated with the vessels may induce either diving or flying behavior in affected marbled murrelets. We expect this will not affect the foraging success of marbled murrelets.

We expect that current Navy activities at NBKB expose marbled murrelets to Navy surface vessels, submarines, and personnel as the Navy performs routine training, security, and maintenance activities in the area. Marbled murrelets may avoid or be physically displaced from exposure to vessels currently using the project area. Responses to existing and proposed vessel operation by marbled murrelets could include diving, swimming away from a vessel, or abandoning a foraging area. However, our assumption is that marbled murrelets that use this area are accustomed to the daily activity levels that occur there. The effects associated with the surface vessels and personnel that marbled murrelets may be exposed to as a result of this proposed action are not anticipated to be measurable over existing conditions due to the current active use of the facilities by the Navy. Therefore, we anticipate that the effects to marbled murrelets associated with the presence of humans and surface vessels will not measurably affect normal marbled murrelet behaviors, such as loafing, breeding, and foraging.

Effect due to Changes in Water Quality

Contaminants may enter the action area due to stormwater runoff associated new pollution generating surfaces associated with the trestle and wharf, new upland road surfaces, and new upland structures and their associated parking and sidewalks. Contaminants may also enter the action area due to stormwater runoff associated with staging areas associated with the proposed action.

The proposed action may result in an increased risk of contaminants due to fuel and oil leaks from the use of boats and barges during construction. Although there is a risk of fuel and oil leaks from the surface water vessels, due to the relative light traffic on the wharf and proposed design for stormwater treatment, petroleum amounts are expected to be negligible. Therefore, the effects of contamination due to fuel and oil are anticipated to be insignificant.

Construction effects on water quality will be minimized with the implementation of BMPs, including use of filters to treat stormwater discharged from catch basins. During operation of the EHW-2 stormwater quality is expected to be similar to that discharged from the existing EHW and Bangor stormwater outfall OF-02.

The proposed action will result in an additional 0.8 acre of new impervious surfaces associated with the construction of new roads to access the wharf and for maintenance purposes. Flows will be direct to a new stormwater treatment facility and then discharged via a new outfall into Hood Canal. Due to the size of the receiving body (i.e., Hood Canal) and limited area of new impervious surface created, we do not anticipate measurable changes in hydrology. Stormwater from the main wharf, warping wharf, and trestle will be treated in catch basins that contain filter cartridges prior to discharge into Hood Canal. However, stormwater, even if treated to meet state water quality standards, may discharge contaminants (e.g., copper and zinc) that are at levels known to negatively impact fish. The amount of contaminants that may be discharged in the treated stormwater is unknown, but would result in some additional loading of contaminants in Hood Canal.

Although stormwater contaminants may be discharged into Hood Canal as part of the proposed action, we do not anticipate the effects to marbled murrelets to be measurable for the following reasons.

1. Upland sources of stormwater from new buildings and associated impervious surfaces will either be fully infiltrated or will result from very small increases in impervious surface and treatment will include at least partial infiltration (for the new pure water facility).

2. Upland sources from new paved roads will result from a small increase in impervious surface (0.8 acre) and will be treated with filters effective at removing solids, which will also remove most of the copper and zinc prior to discharge into Hood Canal.

3. Filters will also be used at each of the 11 outfalls along the trestle and wharf, thus removing most of the copper and zinc. Any dissolved copper and zinc remaining in the stormwater following filter treatment will be rapidly diluted as the stormwater is discharged into Hood Canal and a significant level of exposure to marbled murrelets is unlikely to occur.

Therefore, effects marbled murrelets from contaminants associated with stormwater will be insignificant.

Therefore, the risk of marbled murrelet exposure to contamination (ingestion or contact) at concentrations that would measurably affect marbled murrelets is considered insignificant due to the proposed action.

<u>Collision with Lightning Towers and Catenary Wires</u>

The placement of lightning towers and catenary wires surrounding to the EHW-2 pose a collision risk for marbled murrelets. There are no documented reports of marbled murrelet collisions with towers (including telecommunication towers) and only limited information on the potential for collisions with wires (specifically transmission wires) (Nelson 1997, p. 20). However, evidence regarding other birds colliding with structures and wires is well documented (Avatar Environmental et al. 2004) and guidance has been published to reduce these interactions (USFWS 2000). Other seabirds, such as the Hawaiian petrel (*Pterodroma sandwichensis*), are known fly into structures such as communication towers, power transmission lines and poles, and other structures (USFWS 2011, p. 50). Although petrels often fly at night and are attracted to lights (which increases potential risk of strikes), these structures and associated lines could pose a strike hazard to marbled murrelets.

The structure type, height, siting, lighting, season, species present, and weather conditions are thought to affect the potential risk for avian collisions and the magnitude of these effects (Avatar Environmental, et al.2004, p. 3-19). Towers taller than 500 ft tend to be implicated in more of the mass kills reported for communication tower sites (Avatar Environmental et al. 2004, p. 3-34). Gehring et al. (2011, p. 848) recently reported that unguyed medium towers (towers 116 to 146 m above ground level) resulted in significantly fewer mortalities than guyed medium towers.

Tall towers (towers greater than 305 m above ground level) were responsible for more mortalities of migratory songbirds than guyed medium height towers. Bird strikes often occur with the overhead static wire, which may be less visible than the other wires due to its smaller diameter (Avian Power Line Interaction Committee and USFWS 2005, p. 11).

Additionally, due to the height of the towers (230 ft above the wharf deck), aviation lights (red-blinking lights) will be required, which is recommended by the Service (2000), although we acknowledge that these guidelines are based on limited research (Avatar Environmental et al. 2004, p. 3-48). There are no conclusive data at this time regarding the effects of lighting color, duration, intensity, and type (e.g., incandescent, strobe, neon, or laser) on bird attraction, though some species appear to be more attracted to lights than others (Gauthreaux and Belser 2000 Avatar Environmental et al. 2004, pp. 3-30, 31).

Nocturnal migrants, such as songbirds, appear to be more susceptible to collisions with communication towers than diurnal species (Avatar Environmental et al. 2004, p. 3-20). Diurnal species that are fast flying, such as waterfowl and other waterbirds, may be more susceptible to collisions (Avatar Environmental et al. 2004, p. 5-8). Marbled murrelets fly at all times of day and may be most susceptible to collisions at dawn or dusk and/or during poor visibility (e.g., fog). Marbled murrelets are fast flying seabirds that may not be able to quickly maneuver around a wire once it comes into view. Mean ground speeds of 77 km per hour (56 km per hour to 105 km per hour) (Hamer et al. 1995, p. 73) have been recorded for marbled murrelets in flight. (Burger 1997, p. 215) recorded flight speeds ranging from 40 km per hour to 158 km per hour, with a mean incoming speed of 74 +/-12 km per hour and outgoing speeds of 136 +/-17 km per hour (mean 119 +/- 24 km per hour). Circling birds were recorded at 81 +/- 11 km per hr.

Marbled murrelets may fly at any time during day light hours, especially during the nesting season when young are being feed on the nest, with most feedings occurring during low light conditions around sunrise and sunset.

There have been few mortality studies and monitoring programs for the "shorter towers" (500 ft and less) (Avatar Environmental et al. 2004, p. 3-34). Bird strikes were determined for towers that approximate the height of the proposed lightning towers [90 m (295 ft)] (Crawford and Engstrom 2001, p. 383). Additionally, avian mortality has also been determined for an unlit 60-m tall, guyed meteorological tower (Nicholson et al. 2005, p. 37) and 38-m tall (125 ft) guyed meteorological tower (Young 2003, p. 9, 23).

The Navy proposes to install bird deflectors on the catenary wires every 15 ft. The proposed deflectors will be reflective to increase their visibility to some degree by facility lights at night. The towers will be equipped with red blinking aviation lights that are directed downward, which should help reduce the risk of bird collision with the tower and wires at night. Additionally, although some species of pelagic seabirds are known to be attracted to lights at night, there is currently no evidence that marbled murrelets are attracted to lights or fly inland to feed their chicks at night.

We do not anticipate marbled murrelets to frequently fly over or past the proposed lightning towers or lines. There is limited potential marbled murrelet nesting habitat close to the project

area (nesting has not been documented on the Kitsap Peninsula) and the project is not located in or near a potential flight corridor that may be used by this species to reach nesting habitat. Marbled murrelets may fly near or over the structures as they move between feeding areas. However, based on the measures to reduce the lighting attraction to the towers and enhanced visibility of the wires with deflectors, we do not anticipate that marbled murrelets will collide with these structures. Therefore, we anticipate that the effects of the lightning towers and catenary wires on marbled murrelets are discountable.

Indirect Effects to Marbled Murrelets via Effects to Prey

Indirect effects to marbled murrelets may occur due to impacts to forage fish and forage fish spawning habitat within the action area. Pacific herring, surf smelt, and Pacific sand lance occur within the area and are important prey species for marbled murrelet.

Effects to Forage Fish Habitat

Indirect effects to marbled murrelets may occur due to impacts to their forage fish and to forage fish spawning habitat within the action area. Pacific herring, surf smelt, and Pacific sand lance occur within the area and are important prey species for marbled murrelets.

The proposed action may result in temporary and permanent impacts to forage fish habitat, including spawning habitat. Although eelgrass beds occur on-site and may be used by Pacific herring for spawning, no spawning has been documented at the project site. No surf smelt spawning has been documented at the project site. Although Pacific sand lance spawning has been documented within the action area, the spawning area will not be impacted by the project.

Construction of the trestle and wharf will shade nearshore marine habitat and submerged aquatic vegetation in the immediate project vicinity of the proposed structure. Construction is expected to disturb 25.7 acres of benthic habitat and will shade 0.92 acre of eelgrass, algae, and kelp beds. Long-term shading will impact approximately 0.09 acre of eelgrass and 0.17 acre of macroalgae. The concrete abutment for the trestle will be constructed 4 to 9 ft above MHHW, and may also result in a temporary loss of upper intertidal potential forage fish spawning habitat during construction. Additionally, the abutment will block sediment supply to the beach. Under natural conditions, erosion provides sediments to the beach that are then redistributed along the beach by longshore drift. When the sediment supply is cut off, longshore drift will, over time, remove the finer materials, resulting in the loss of substrates that could be suitable for forage fish spawning in the future (Thom et al. 1994, p. 6-4; Williams and Thom 2001, p. 40).

Although the proposed action will result in short and long-term impacts to potential forage fish habitat, we do not anticipate the temporary and/or permanent loss of a small amount of forage fish habitat be of a magnitude as to measurably affect the marbled murrelets that may forage in this area. Therefore, effects to marbled murrelets via effects to forage fish habitat are considered to be insignificant.

Effects to Forage Fish from Underwater Sound Pressure

Impact pile driving will occur over a period of three in-water work seasons (July 16 through February 15, 2012, through 2014). Restricting in-water work to this time period will reduce, but not eliminate, the potential for exposure to individual forage fish that may be present in the water all year (Table 13).

Table 13. Underwater sound levels and threshold distance for fish based on assumed attenuated sound pressures[18] of 204 dB peak, 175 dB SEL, and 185 db_{rms} at 10 m for underwater sound pressures for 36 inch and 48 inch diameter steel piles. A 168 dB SEL attenuated underwater sound pressure is expected at 10 m for 24-inch piles.

			Distance to Onset Threshold with 10 dB Sound Attenuation(m)					
			24-inch pile			36/48-inch pile		
Species	Type of Effect	Onset of Effect	1,000 strikes (m)	2,000 strikes (m)	6,400 strikes (m)	1,000 strikes (m)	2,000 strikes (m)	6,400 strikes (m)
Fish ≥ 2 grams	Injury Threshold	187 dB SEL (cumulative)	54	86	158	158	252	464
Fish < 2 grams	Injury Threshold	183 dB SEL (cumulative)	100	158	158	293	464	464
Fish all sizes	Injury Threshold	206 dB peak	7	7	7	7	7	7
Fish all sizes	Guideline for Assessing Behavioral Response	150 dB_{rms}	3,361	3,361	3,361	3,361	3,361	3,361

Additionally, Pacific sand lance spawning occurs within the action area. Pacific sand lance spawn from November through mid-February, and therefore, spawners and spawning areas may be exposed to high sound pressure levels during pile installation. Therefore, we anticipate that there is a likelihood that spawning Pacific sand lance, including their eggs and fry, may be exposed to high levels of underwater sound during pile driving. However, due to the proposed sound attenuation measures implemented during pile driving (e.g., bubble curtain) that will limit the extent of the area of injury and loss of forage fish, we do not anticipate the temporary loss of individual forage fish to be of such a magnitude as to measurably affect the marbled murrelets that may forage in Hood Canal. Therefore, we anticipate that the effects to marbled murrelet via their prey associated with underwater sound pressure will be insignificant.

[18] Assumes a reduction of 10 dB due to sound attenuation device(s) used.

Effects to Forage Fish due to Changes in Water Quality

Contaminants in stormwater runoff from the new pollution-generating surfaces of the trestle and wharf, staging areas, new upland roads, structures, parking lots and sidewalks, may affect marbled murrelet forage species that are present in the area. As described above (Effect to Bull Trout due to Changes in Water Quality), we anticipate the water quality discharged into Hood Canal after treatment to be at levels that would not result in measurable effects to forage fish. Therefore, effects to marbled murrelets via their prey associated with project-related changes in water quality to be insignificant.

The proposed action may result in increased turbidity and sediment during construction due to the installation and removal[19] of piles, operation of the bubble curtain, construction of the bank stabilization, use of spuds and anchors, and boat scour. Additionally, if contaminants are present in the sediments where the piles are installed and removed, these may become available to marbled murrelets indirectly through their prey.

Sediment may be dispersed up to 130 ft from the piles (Kunz, in litt. 2011). Turbidity associated with the bubble curtain may occur higher in the water column compared to other actions due to the rising bubbles. Additionally, if any piling is removed, increased turbidity in the water column would also likely occur.

Surface sediments at the project site are coarse-grained, ranging from 82 to 100 percent sand and gravel in shallow areas (less than 40 ft below MLLW), 94 to 100 percent sand and gravel in mid-depth areas (40 ft to 60 ft below MLLW), and 65 to 100 percent sand and gravel in deeper areas (greater than 60 ft below MLLW) (Hammermeister and Hafner 2009 in BA). The BA further states that based on the size of sediment particles typical of the project site, the settling period for individual particles could be up to several hours depending on the water depth and distance above the bottom.

Increased levels in turbidity may result in negative effects to forage fish due to gill abrasion or decreased fitness or an inability to locate prey. Increased sediments could impact forage fish spawning habitat, including smothering eggs. However, due to the composition of the substrates (primarily sand and gravels), the extent of the area that may be affected due to increased sediments and turbidity, we anticipate that these effects will be limited. Although some injury and loss of individual forage fish and temporary impacts to their spawning habitat may occur due to increased sediment and turbidity associated with project construction, and we do not anticipate that project-related impacts to marbled murrelets prey will be at a magnitude as to measurably affect those individuals that may forage in this area. Therefore, we anticipate that the effects to marbled murrelets via their prey will be insignificant.

Compensatory Mitigation Measures

To mitigate for project-related impacts to the marine environment, the Navy is proposing mitigation in the form of an ILF program that is currently under development. The Navy has

[19] Temporary piles may be installed help with alignment of the design piles. The "template piles "would be vibrated in to provide a frame to set up the other piles and would be removed.

stated that they would implement permittee responsible mitigation if the ILF program is not be completed and approved at the time of permitting of the proposed action. Because the mitigation plan is still being developed, we are unable to evaluate the effectiveness of the proposed mitigation and/or its effects on marbled murrelets or their prey.

Similarly, because the Navy has not clearly defined the proposed program for acquiring property to compensate for aquatic and Tribal resource impacts, we are unable to evaluate the benefits or effectiveness of the proposed "recovery crediting" for marbled murrelets. As this proposal is better defined, the Service will consider what the benefits to marbled murrelets might be and whether it can be considered in reducing the marbled murrelet monitoring requirements within the harassment zone of potential effects.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Current and future stressors in the action area are expected to affect marbled murrelets. Urban development and climate change are two stressors that are most likely to affect conditions in the action area and the listed resources that occur there, including marbled murrelets.

Development is reasonably certain to occur in the action area and will likely result in increased discharges of stormwater and wastewater. Marbled murrelets and their prey species in the action area are likely to be negatively affected as a result of degraded water quality from these discharges. The severity of effects to marbled murrelets will depend on the amount and concentration of contaminants discharged, which is determined by many factors (e.g., implementation of stormwater BMPs and time between rain events), and is likely to be more severe in urbanized areas. The NBKB and action area is fairly rural compared to other naval facilities in Puget Sound. Therefore, we anticipate less contamination from stormwater and wastewater discharges than in more urban settings.

Climate change is anticipated to result in sea level rise, increased water temperatures, and decreases in the pH of marine waters in the action area. As sea levels rise, a greater amount of shoreline will likely be armored to protect public property and reduce threats to public safety (Penttila 2007, p.18). Current levels of shoreline armoring within Puget Sound have interfered with natural erosion of upland material (organic and inorganic debris) onto the beach and into the intertidal area, caused beach scouring, and resulted in changes in population structure of epibenthic and benthic organisms. A decrease in marine water pH is expected to affect marine organisms at the base of the food chain and those species that are temperature sensitive, such as forage fish species. Increased water temperatures will likely affect forage fish populations directly by negatively influencing survival and growth, and indirectly by changing the predator/prey ratio (DFO (Department of Fisheries and Ocean Canada) and DOE (Department of the Environment Canada) 1994, p. 13; US Global Change Research Program 2003, p. 4).

Increasing acidification of marine waters may have significant impacts on marine food-webs and is likely to adversely affect the forage fish food base. Calcifying species of plankton (i.e., pteropods, a free-swimming planktonic mollusk) are expected to suffer serious negative impacts from increased ocean acidification and (DFO (Department of Fisheries and Ocean Canada) and DOE (Department of the Environment Canada) 1994) dissolution of their exoskeleton (NOAA Magazine 2006, Issue 2606). The negative impacts of increased acidity on plankton may cause negative impacts to many other species which are important food sources for juvenile salmon, herring, and cod (Ruckelshaus and McClure 2007, p. 55). The anticipated future changes in water quality (pH and temperature) along with a loss or degradation of habitat from increased armoring and effects on prey are expected to add to the current stressors on marbled murrelets.

CONCLUSION

After reviewing the current status of the marbled murrelet, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's Biological Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the marbled murrelet, as summarized below. No critical habitat has been designated for this species in the action area; therefore, none will be affected.

- The poor breeding success of marbled murrelets inferred from juvenile ratios determined through at-sea monitoring in Conservation Zone 1 and an adult survival estimate of 0.83 to 0.93, led investigators to conclude the marbled murrelet population trend is negative (Cam et al. 2003, p. 1123; McShane et al. 2004, p. 3-29). Despite this, the population of marbled murrelets in Conservation Zone 1 (Washington Inland Marine Waters) is relatively large compared to other recovery zones, with an estimated population of 4,393 (2,689 to 6,367).
- The primary threats to marbled murrelets in Conservation Zone 1 are habitat loss, nest predation, and mortality in the marine environment from oil spills and commercial fisheries. The proposed action will not result in habitat loss or increased nest predation, and is not expected to cause mortality or physical injury of individuals.
- A number of conservation measures, including implementation of a marbled murrelet monitoring protocol within the area of potential injury and mortality, the use of a sound attenuation system during impact pile driving, diurnal timing restriction during the nesting season, and daily timing restrictions outside the nesting season are proposed as part of the project. Implementation of the proposed marbled murrelet monitoring protocol will eliminate the loss of individuals from the population. However, these measures will reduce, but not eliminate, the extent of adverse effects to marbled murrelets in the marine environment associated with non-injurious TTS and the associated behavioral impacts that may occur due to this temporary hearing loss (i.e., increased risk of predation and decreased foraging efficiency). However, we have not established that the effects to individuals will appreciably reduce survival and reproduction. We also do not anticipate that the proposed action will result in a missed feeding of a young still on the nest during the nesting season.
- Individuals may experience disruptions to their normal behaviors (including conspecific communication related to pair bonding, mating, and/or foraging efficiency) from elevated

in-air SPLs that result in masking of biologically relevant sounds. These disruptions will occur for up to 10 hours per day over a total of 400 days of impact and vibratory pile driving from July 16 through February 15 over the three construction seasons. However, we are unable to conclude that these effects will result in measurable effects to individuals.

- Therefore, while we anticipate that there were will be measurable effects to individuals, because the action is limited in duration (up to 385 days over 3 years) and the effects will not measurably affect reproduction and survival, we do not anticipate that the effects of the action, combined with the cumulative effects, will result in measurable adverse effects at the scale of the conservation zone in terms of reducing numbers, reproduction, and distribution of marbled murrelets.
- We do not anticipate that the effects to marbled murrelets will result in measurable reductions in numbers (abundance), reproduction (productivity), or distribution at the scale of the Conservation Zone and will not preclude marbled murrelets from foraging, mating, or pair bonding. Therefore, we do not anticipate that the proposed action will appreciably reduce the likelihood of survival and recovery of the marbled murrelet rangewide.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. *Harm* is defined by the Service as an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). *Harass* is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Navy so that they become binding conditions of any grant or permit issued to the (applicant), as appropriate, for the exemption in section 7(o)(2) to apply. The Navy has a continuing duty to regulate the activity covered by this incidental take statement. If the Navy 1) fails to assume and implement the terms and conditions or 2) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the (agency or applicant) must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE of Marbled Murrelets

The Service anticipates that the incidental take of marbled murrelets will be difficult to detect or quantify as any incidental take will be limited to those marbled murrelets foraging under water at the time of impact pile driving, making detection difficult. The level of take of this species can be approximated by using the area that will be ensonified by the impact pile driving that is not surveyed to protocol. Using this area as a surrogate for estimating the amount and extent of take, the Service anticipates the following incidental take associated with the proposed action:

The Service anticipates that all adult, sub-adult, and juvenile marbled murrelets occurring within a cumulative total area of 0.48 km^2 of marine habitat in Hood Canal will be taken in the form of harassment as a result of non-injurious TTS. We anticipate that the incidental take from the proposed action will occur between July 16 and February 15 in the years 2012, 2013, and 2014. The effects may occur for up to 385 days (187 between July 16 and September 30; 198 days between October 1 and February 15) during this time period.

The Service will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-712), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

In the accompanying Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat as no critical habitat within the marine environment has been designated for marbled murrelets.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures (RPM) are necessary and appropriate to minimize take of marbled murrelets.

1. RPM 1: Minimize incidental take resulting in non-injurious TTS caused by exposure to underwater sound pressure associated with impact pile driving.

2. RPM 2: Monitor incidental take caused by exposure to underwater sound pressure associated with impact pile driving and by in-air sound pressure associated with vibratory and impact pile driving.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Navy must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

The following terms and conditions are required for the implementation of RPM 1:

1. The Navy shall implement monitoring of marbled murrelets during impact pile driving to reduce impacts associated with non-injurious TTS. The Navy must monitor marbled murrelets, implementing the Service's marbled murrelet survey protocol, out to a distance of 293 m. This distance may be adjusted based on the number of pile strikes. If a marbled murrelet is observed, impact pile driving must be stopped until the marbled murrelet leaves the monitoring area under its own volition, but pile driving does not need to be stopped for longer than 1 hour per marbled murrelet encounter. Impact pile driving does not need to be curtailed for more than 2 hours total time per day, regardless of the number of marbled murrelets encountered. The Navy will prepare a marbled murrelet monitoring plan that meets Service protocol and provide this to the Service at least 90 days prior to the proposed in-water work window of July 16, 2012. Impact pile driving shall not occur until the Navy is notified that the Service has approved the monitoring plan.

2. The Navy will document the duration and frequency of shut downs of impact pile driving due to the presence of marbled murrelets and/or sea-state conditions exceeding a Beaufort Sea State 2 within the area of non-injurious temporary threshold shift (i.e., between cumulative 183 dB SEL and 202 dB SEL to a distance of up to 293 m depending on the number of pile strikes). Should shutdowns occur at a frequency that is significantly affecting the project's schedule for completion, then the Navy may convene an adaptive management group consisting of representatives of the Navy and the Service to address the issue. The Navy would work with the Service to develop and implement an adaptive strategy. The adaptive management group would identify and agree to criteria and timelines for implementation of the strategy.

The following terms and conditions are required for the implementation of RPM 2:

1. The Navy shall provide a copy of the marbled murrelet monitoring report to the Service's consulting biologist (Nancy Brennan-Dubbs, 360-753-5835) within 90 days of completion of in-water work during each year of construction.

2. The Navy shall implement hydroacoustic monitoring during impact pile driving. The Navy shall prepare a hydroacoustic monitoring plan and provide this to the Service at least 90 days prior to the proposed in-water work window of July 16, 2012. Impact pile driving shall not occur until the Navy is notified that the Service has approved the monitoring plan.

3. The Navy shall provide a copy of hydroacoustic monitoring report to the Service's consulting biologist (Nancy Brennan-Dubbs, 360-753-5835) within 90 days of completion of in-water work during each year of hydroacoustic monitoring is performed.

The Service believes that marbled murrelets occurring within no more than 0.48 km^2 cumulative total area of marine habitat within Hood Canal will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and

conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

The Service is to be notified within three working days upon locating a dead, injured, or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the Service's Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. The Navy should convene, in coordination with the Service, an expert panel comprised of researchers, biologists, and acousticians to review the Service's current approach and to propose refinements, as appropriate, to the use of our interim underwater sound pressures of between 183 dB SEL and 202 dB SEL for non-injurious TTS effects to marbled murrelets.

2. The Navy should ensure that mitigation for the proposed action occurs within close proximity of the impacts. Mitigation should be in-kind and result in the full compensation of the functions and values impacted. Loss of nearshore habitat due to shading, temporary and long-term loss of eelgrass and macroalgae, and loss of forage fish due to effects associated with lethal and sublethal sound pressures should be mitigated as these resources are important for providing forage for marbled murrelets and other marine species.

3. The Navy should implement measures to reduce threats to marbled murrelets associated with the marine environment that would assist in the recovery of this species. This may include the removal of derelict gill nets from the marine environment.

4. The Navy should perform marbled murrelet surveys to determine their specific occurrence and timing of their use within the areas affected by Navy actions anticipated in the future. These surveys would provide more site-specific information regarding the abundance and timing of use of these areas.

5. The Navy should survey for all dead and/or distressed fish during the proposed action, especially during impact pile driving. Fish that are found dead should be collected and necropsied to determine cause of death. The Service should be notified of any dead and/or distressed fish that are observed due to the proposed action.

6. The Navy should monitor the roof of the wharf to determine if bird strikes are occurring. Monitoring on a monthly basis is recommended. Should dead birds be found, the Navy will notify the Service.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the (request/reinitiation request). As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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APPENDIX 1 – Marbled Murrelet Monitoring Plan

U.S. Fish and Wildlife Service – Washington Fish and Wildlife Office

Protocol for Marbled Murrelet Monitoring During Impact Pile Driving (Revised 4/4/2011)

TRIDENT Support Facilities
Explosives Handling Wharf Project
Naval Base Kitsap Bangor

November 7, 2011

1.0 Objective

The intent of the monitoring protocol is to:

1. Comply with the requirements of the Endangered Species Act Section 7 consultation for the United States Department of the Navy TRIDENT Support Facilities Explosives Handling Wharf, NBK Bangor.
2. Detect all marbled murrelets (murrelets) within 55 meters during impact pile driving.
3. To avoid injury of murrelets from exposure to elevated underwater sound pressure associated with pile driving by communicating immediately with the pile driver operator.
4. Track incidental take exempted through the Incidental Take Statement found in the final Biological Opinion for the project so that the Department of the Navy will know when take occurs and/or when take exemptions might be exceeded.

2.0 Adaptive Approach

The individuals that implement this protocol will assess its effectiveness during implementation. They will use their best professional judgment throughout implementation and will seek improvements to these methods when deemed appropriate. Any modifications to this protocol will be coordinated between the Department of the Navy and the Washington Fish and Wildlife Office.

3.0 Monitoring

3.1 Activities to be Monitored

This protocol applies to monitoring associated with in-water impact pile driving. It does not apply to monitoring that may be necessary for vibratory pile driving, pile removal, or out-of-water pile driving.

3.2 Equipment

- Binoculars - quality 8 or 10 power (2);
- Two-way radios with earpieces (2);
- Log books (2);
- Range finder
- Seabird identification guide;
- Life vests or other personal flotation devices for observers in the boat;
- Cellular phone to contact the Department of the Navy, the Construction Contractor, or WFWO.

3.3 Locations

Proposed monitoring locations are shown on the *Seabird Monitoring Site/Transect Identification Form* (Figure 1). Due to limitations that could result from construction activity and/or other site specific variables, the monitoring locations may be refined in the field. In that case, final monitoring locations will be noted on an aerial photo or plan sheet, and documented in the final monitoring report.

3.4 Monitoring Techniques

One qualified biologist shall be identified as the Lead Biologist. The Lead Biologist has the authority to stop impact pile driving when murrelets are detected in the monitoring area or when visibility impairs monitoring. The Lead Biologist is responsible for:

- Ensuring consistency with the criteria in the consultation
- Communicating with monitoring crew(s), the pile driver operator, and the WFWO, and
- Determining the monitoring start and end times.

An appropriate number of qualified observers will be positioned in the boat to provide adequate coverage of the 55 meter radius monitoring area to ensure no murrelets are within the monitoring area. Monitoring will begin at least 30 minutes prior to commencement of impact pile driving. Each qualified observer will conduct a boat transect that is no more than 50 meters wide. During EHW-2 trestle pile driving, an additional observer (small boat/rowboat/canoe) will be placed within the EHW-1 for better monitoring visibility to the full 55 meter monitoring zone. If operations are occurring simultaneously at EHW-1, there will be some restrictions regarding the placement of a boat within this area. Although there will be security restrictions, monitoring will be conducted per the USFWS protocol. Therefore, another monitoring location would be selected to allow visibility into the EHW-1 or no impact pile driving can occur. All observers are responsible for:

- Understanding the requirements in the consultation and monitoring plan;

- Knowing the lines and method of communicating with the Lead Biologist and boat operator (if an observer on the boat);
- Evaluating the sea conditions and visibility;
- Calibrating their ability to determine a 50-meter distance at the beginning of each day. Calibration should be done using a range finder on a stationary object on the water; and
- Determining when conditions for monitoring are not met.

Monitoring will only occur when the sea state is at a Beaufort scale of 2 or less. The Beaufort scale is presented in Table 1 below. Observers should scan without a scope or binoculars; scopes and binoculars should only be used to verify species. Observers will be positioned at the best practicable vantage point, taking into consideration security, safety, and space limitations at the NBK waterfront, in order to properly monitor these zones. Security restrictions inside the water restricted area (WRA) have precluded the placement of boat/personnel at certain locations within the port security barrier (PSB) fence line. For instance, security concerns regarding the number of vessels within the WRA have resulted in the Navy limiting the number of monitoring vessels for the acoustic, marine mammal, and marbled murrelet monitoring plans to no more than three boats, in addition to the construction related vessels (i.e. barges, tugs, etc.). Additionally, security requires that all vessels maintain a minimum standoff distance of 25 feet from the PSB fence at all times. Due to ongoing operations that may occur at the EHW-1 facility and Marginal Wharf, monitoring personnel are also precluded from being stationed on these structures. Lastly, marbled murrelet observers were not placed on the barge(s) due to safety concerns from the construction contractor.

Two representative pile driving locations are depicted in Figure 1, *Seabird Monitoring Site/Transect Identification Form*, but it should be understood that piles will be driven around the entire perimeter of the proposed trestle and wharf and only one impact pile driver will be in use at a time. Associated boat monitoring transects are depicted for two pile driving scenarios, as described in Section 3.6.

Observers in the boat will conduct at least 2 full sweeps of the monitoring zone prior to pile driving to ensure that no murrelets are in the monitoring zone. Each observer is responsible for scanning from 0° (straight ahead of bow) to 90° left or right, depending upon which side of the boat they occupy. Observers should occasionally scan past 90°, looking for murrelets that may have surfaced behind the boat. Boat speed should be no less than 5 knots and no greater than 10 knots. Observer coverage should not be compromised; therefore, observer's ability to scan dictates the speed of the boat. Boat operators will not function as murrelet monitors while operating the boat.

If no murrelets are within the monitoring zone, the observers will notify the Lead Biologist who will communicate to the pile driver operator that pile driving may commence. The observers in the boat will patrol and scan the monitoring area. All observers will have two-way radios with earpieces to allow for effective communication during pile driving. If murrelets are seen within the monitoring zone during pile driving,

the observers will immediately notify the Lead Biologist who will communicate to the pile driver operator that he/she is to cease pile driving. Pile driving will not resume until the murrelets have left the monitoring area and at least 2 full sweeps of the monitoring area have confirmed murrelets are not present.

When a murrelet is detected within the monitoring area, it will be continuously observed until it leaves the monitoring area. If observers lose sight of the murrelet, searches for the murrelet will continue for at least 5 minutes. If the murrelet is still not found, then at least 2 full sweeps of the monitoring area to confirm no murrelets are present will be conducted prior to resumption of pile driving.

It is the observers' responsibility to determine if he/she is not able to see murrelets and inform the Lead Biologist that the monitoring needs to be terminated until conditions allow for accurate monitoring.

Murrelets are especially vulnerable to disturbance when they are molting and flightless. Molting occurs after nesting in late summer, typically July through October in Puget Sound populations. Extra precaution should be exercised during this period.

Table 1 – Beaufort Wind Scale develop in 1805 by Sir Francis Beaufort of England (0=calm to 12=hurricane)

Force	Wind (knots)	Classification	Appearance of wind effects on the water	Appearance of wind effects on land	Notes specific to on-water seabird observations
0	<1	Calm	Sea surface smooth and mirror like	Calm, smoke rises vertically	Excellent conditions, no wind, small or very smooth swell. You have the impression you could see anything.
1	1-3	Light air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes	Very good conditions, surface could be glassy (Beaufort 0), but with some lumpy swell or reflection from forests, glare, etc.
2	4-6	Light breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move	Good conditions, no whitecaps, texture/lighting contrast of water make murrelets hard to see. Surface could also be glassy or have small ripples, but with a short, lumpy swell, thick fog, etc.
3	7-10	Gentle breeze	Large wavelets, crests beginning to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended	Surveys cease, scattered whitecaps present, detection of murrelets definitely compromised, a hit-or-miss chance of seeing them owing to water choppiness and high contrast. This could also occur at lesser wind with a very short wavelength, choppy swell.

Force	Wind (knots)	Classification	Appearance of wind effects on the water	Appearance of wind effects on land	Notes specific to on-water seabird observations
4	11-16	Moderate breeze	Small waves 0.3 to 1.1m becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move	
5	17-21	Fresh breeze	Moderate waves 1.1 to 2.0 m taking longer form, many whitecaps, some spray	Small trees begin to sway	

3.5 Limitations

No monitoring will be conducted during inclement weather that creates potentially hazardous conditions as determined by the Lead Biologist. Observers must have visibility to at least 50 meters. No monitoring will be conducted when visibility is significantly limited such as during heavy rain, fog, glare or in a Beaufort sea state greater than 2.

Glare can significantly limit an observer's ability to detect birds. Boat orientation may be adjusted to reduce glare (e.g. change direction or reduce width of transects to 50 meters with observers on only one side of boat). However, if visibility cannot be adjusted, monitoring and pile driving must cease until effective monitoring can be conducted.

Monitoring will not start until 2 hours after sunrise and will cease prior to 2 hours before sunset during the period July 16 to September 15. Between September 16 and February 15, pile driving can occur during daylight hours.

3.6 Documentation

The observers will document the number and general location of all murrelets in the monitoring area determined by the injury threshold of 202 dB SEL. Additional information on other seabirds and behaviors will be collected during documentation to improve general data knowledge on seabird presence and distribution as well as project impacts on various seabirds. Each observer will record information using the *Seabird Monitoring Data Collection Form* (Figure 2) and reference the completed *Seabird Monitoring Site/Transects Identification Form* (Figure 1) and *Seabird Land-Based Monitoring Site Form*s (Figure 3). Forms are included in the Appendix.

Office Pre-Monitoring Set-Up

The monitoring transects needed to appropriately cover the monitoring area during the course of the pile driving activity are indicated in Figure 1. Each observer will be limited to 50 meters. The monitoring areas and transects shown in the *Seabird Monitoring Site/Transects Identification Form* indicate how monitoring will occur for all impact pile driving up to 6400 pile strikes (Figure 1). The location of the one marbled murrelet survey boat in operation at a given time will depend on the location of the pile being impact driven.

All monitoring will be conducted by observers based on a boat traveling along the monitoring transects. No monitoring is planned from land-based stations or wharves in the project area due to security concerns, and no monitoring is planned from construction barges due to safety concerns.

Data Collection

All murrelets within transects or monitoring sites will be continuously documented during impacting activities. On the *Seabird Monitoring Data Collection Form* (Figure 2), time, number of birds, location, and observed behavior will be documented. The documentation will be updated when a murrelet changes behavior, changes location, or leaves the area. To the extent possible, the observers will also record each murrelet "take" incident that is observed, as defined in the final Biological Opinion. This may include obvious disturbance responses from pile driving or other construction activities, and injury or mortality that can be attributed to project-related activities.

Observers will also note all seabirds within the area that appear to be acting abnormally during any project activities. For example, if a seabird is listing, paddling in circles, shaking its head, or suddenly flushing at the onset of activity, the information will be noted on the *Seabird Monitoring Data Collection Form* (Figure 2).

General information on other seabird behavior and distribution within the monitoring area will be collected. Every two hours at a minimum during pile driving activities, the observers will document other seabird presence, behavior, and distribution in the monitoring area. This information can be collected more frequently. Many seabirds may linger in an area for several hours. If this is the case, the time and species will be noted, and in the comments section it will be noted if this is the same group from earlier. Any notable changes in behavior will be recorded.

Locations of seabirds will be documented in the boat observer columns of the form including the distance in meters from the boat to the seabird and whether the bird is toward the pile driving activity, relative to the boat's location, or away from the pile driving activity.

3.7 Timing and Duration

Monitoring will commence at least 30 minutes before the initiation of pile driving (but not before daylight) and will continue until pile driving is completed each day (but not after nightfall). Monitoring will not start until 2 hours after sunrise and will cease 2 hours before sunset during the period July 16 to September 15. Between September 16 and February 15, pile driving can occur during daylight hours.

3.8 Contingency

In the unlikely event that a murrelet is perceived to be injured by pile driving, all pile driving will cease and WFWO will be contacted as soon as possible.

The Department of the Navy will work with WFWO to make necessary changes to the monitoring plan as described in section 2.0 above. Pile driving cannot resume until the plan has been amended, unless WFWO cannot be reached, then the Lead Biologist determines the course of action and continues to ensure consistency with the consultation.

4.0 Beach Surveys

Searches for diving seabird carcasses along nearby beaches will be conducted following pile driving activities. The biologist will walk accessible beaches within 0.5 miles of the pile driving location. Beach surveys will be conducted during low or receding tides, if possible, to maximize the chances of finding beached carcasses. Beach surveys will be conducted each day following in-water impact pile driving (as is practical based on the timing of tide events and pile driving activities.) Beach surveys are of secondary priority and will not be conducted if such activities would interfere with the implementation of murrelet monitoring or if the timing of low/receding tides imposes unreasonable schedule demands on the biologist.

Any dead murrelets or other diving seabirds found during the beach surveys (or during monitoring activities will be collected by monitoring staff and delivered, as soon as possible, to the WFWO in Lacey, Washington for examination. Collected carcasses will be put in plastic bags, and kept cool (but not frozen) until delivery to the WFWO.

5.0 FWS Communication

Prior to the initiation of monitoring the Department of the Navy and a representative from the WFWO will meet to review the proposed monitoring location and logistics concerns that may have developed during monitoring preparation. The Department of the Navy will keep the WFWO informed of the progress and effectiveness of the monitoring activities and of the number and disposition of murrelet take that is documented throughout the duration of the project.

The Department of the Navy will notify the WFWO of any problems and/or necessary modification to the monitoring protocol. The Department of the Navy will coordinate

with the WFWO in the development of a modified approach and will obtainWFWO approval for such modifications.

Primary points of contact at the WFWO are:

1. Nancy Brennan-Dubbs – phone: (360) 753-5835
2. Emily Teachout – phone: (360) 753-9583
3. Deanna Lynch – phone: (360) 753-9545

Primary points of contact at the Department of the Navy are:

1. Cindi Kunz – phone: (360) 396-1860
2. Andrea Balla-Holden – phone: (360) 396-0002

6.0 Personnel Qualifications and Training

All observers must be certified by USFWS to perform the Marbled Murrelet Marine Protocol. Observers will have appropriate qualifications, including education or work experience in biology, ornithology, or a closely related field; at least one season (2-3 months) of work with bird identification being the primary objective (i.e. not incidental to other work). Observers must have experience identifying marine birds in the Pacific Northwest; as well as understanding and documenting bird behavior.

All observers will attend the marbled murrelet marine monitoring protocol training and pass the written and photo examination with 90% proficiency. Upon successful comnpletion, observers will be certified. Certification is valid for one year. Recertification is required annually, unless the observer can document that he/she implemented the monitoring protocol for at least 25 monitoring days in the previous year. Recertification can then be delayed for one year; however, recertification can only be delayed for one year.

All observers will be provided a copy of the consultation documents for the project. Monitoring personnel must read and understand the contents of the consultation documents related to identifying, minimizing, and reporting “incidental take” of murrelets.

7.0 Reporting

At the completion of each in-water work window for which there has been impact pile driving, the Department of the Navy will forward a monitoring report to the WFWO within 30 days. Reports shall be sent to the attention of the WFWO Branch Manager. The report shall include:

- Observation dates, times, and conditions
- Description of the any “take” (as described in the final Biological Opinion) identified by the biologist
- Copies of field data sheets or logs

Note: Questions and comments regarding this protocol should be directed to Emily Teachout at the USFWS, Washington Fish and Wildlife Office (360-753-9583); emily_teachout@fws.gov

Appendix

Figure 1. Seabird Monitoring Site/Transect Identification Form (up to maximum 6400 strike scenario)

Project Name

Monitoring Dates

Number of Monitoring Sites/Transects

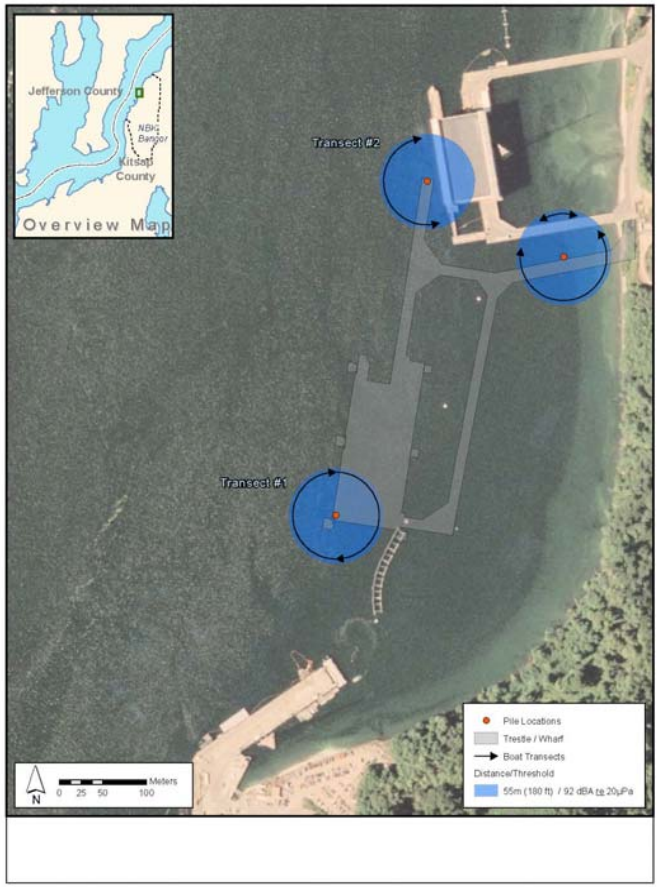


Figure 2. Seabird Monitoring Data Collection Form

Date_____

Project Name _____ **Monitoring Site/Transect ID**_____

Observers_____

Activity _____ **Time and Duration**_____

Time	**Species**	**# of birds**	**Wind speed** (Beaufort Marine scale)	**Land Observer**	**Boat Observer**		**Observed Behavior***	**Comments**
				Grid Location	Distance	Land/ Seaward		

*R=resting, F=feeding/diving, P=preening, Y= flushing, T=transiting, N=nesting, O=other

Figure 3. Seabird Land-Based Monitoring Site form

Project Name _____

Date_____

Land Based Monitoring Site

ID_____

Additional site details

	1	2	3	4	5	6	7	8	9	10
A										
B										
C										
D										
E										
F										
G										
H										
I										
J										

APPENDIX 2 – Marbled Murrelet Status of the Species

APPENDIX 2 - STATUS OF THE SPECIES: Marbled Murrelet

Legal Status

The marbled murrelet (murrelet) was listed as a threatened species[20] on September 28, 1992, in Washington, Oregon, and northern California (57 FR 45328 [October 1, 1992]). Since the species' listing, the U.S. Fish and Wildlife Service (FWS) has completed two 5-yr status reviews of the species: September 1, 2004 (USFWS 2004) and June 12, 2009 (USFWS 2009). The legal status of the murrelet remains unchanged from the original designation.

Threats to Murrelet Survival and Recovery

Murrelets are long-lived seabirds that spend most of their life in the marine environment, with breeding adult birds annually nesting in the forest canopy of mature and old-growth forests from April 1 through September 15. Murrelets have a naturally low reproductive rate. Breeding adults lay just one egg and renesting, in the event of nest failure, is thought to be an extremely rare event.

Several threats to murrelets, present in both the marine and terrestrial environments, have been identified. These threats collectively comprise a suite of environmental stressors that, individually or through interaction, have significantly disrupted or impaired behaviors which are essential to the reproduction or survival of individuals. When combined with the species naturally low reproductive rate, these stressors have led to declines in murrelet abundance, distribution, and reproduction at the population scale within the listed-range.

When the murrelet was listed under the Endangered Species Act (57 FR 45333-45336 [October 1, 1992]) and summarized in the Recovery Plan (USFWS 1997a, pp. 43-76), several anthropogenic threats were identified as having caused the dramatic decline in the species.

- habitat destruction and modification in the terrestrial environment from timber harvest and human development caused a severe reduction in the amount of nesting habitat
- unnaturally high levels of predation resulting from forest "edge effects" ;
- the existing regulatory mechanisms, such as land management plans (in 1992), were considered inadequate to ensure protection of the remaining nesting habitat and reestablishment of future nesting habitat; and
- manmade factors such as mortality from oil spills and entanglement in fishing nets used in gill-net fisheries.

[20] The Act defines a threatened species as a species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

There have been changes in the levels of these threats since the 1992 listing (USFWS 2004, pp. 11-12; USFWS 2009, pp. 27-67). The regulatory mechanisms implemented since 1992 that affect land management in Washington, Oregon, and California (for example, the Northwest Forest Plan (NWFP)) and new gill-netting regulations in northern California and Washington have reduced the threats to murrelets (USFWS 2004, pp. 11-12). The threat levels for the other threats identified in 1992 listing (57 FR 45333-45336 [October 1, 1992]) including the loss of nesting habitat, predation rates, and mortality risks from oil spills and gill net fisheries (despite the regulatory changes) remained unchanged following the FWS's 2004, 5-year, range-wide status review for the murrelet (USFWS 2004, pp. 11-12).

However, new threats were identified in the FWS's 2009, 5-year review for the murrelet (USFWS 2009, pp. 27-67). These new stressors are due to several environmental factors affecting murrelets in the marine environment. These new stressors include:

- Habitat destruction, modification, or curtailment of the marine environmental conditions necessary to support murrelets due to:
    - elevated levels of polychlorinated biphenyls in murrelet prey species;
    - changes in prey abundance and availability;
    - changes in prey quality;
    - harmful algal blooms that produce biotoxins leading to domoic acid and paralytic shellfish poisoning that have caused murrelet mortality; and
    - climate change in the Pacific Northwest.

- Manmade factors that affect the continued existence of the species include:
    - derelict fishing gear leading to mortality from entanglement;
    - energy development projects (wave, tidal, and on-shore wind energy projects) leading to mortality; and
    - disturbance in the marine environment (from exposures to lethal and sub-lethal levels of high underwater sound pressures caused by pile-driving, underwater detonations, and potential disturbance from high vessel traffic).

Detailed discussions of the above-mentioned threats, life-history, biology, and status of the murrelet are presented in the Federal Register, listing the murrelet as a threatened species (57 FR 45328 [October 1, 1992]); the Recovery Plan, Ecology and Conservation of the Marbled Murrelet (Ralph et al. 1995); the final rule designating murrelet critical habitat (61 FR 26256 [May 24, 1996]); the Evaluation Report in the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004); and the 2004 and 2009, 5-year Reviews for the Marbled Murrelet (USFWS 2004; USFWS 2009).

Nesting Habitat Abundance

The destruction, modification, or curtailment of nesting habitat from logging, urbanization, and land use conversion has generally been regarded as the most influential environmental stressor that led to the 1992 Federal listing of the species under the Act. The FWS estimates that over 80 percent of the historic nesting habitat has been rendered unsuitable for nesting (57 FR 45328 [October 1, 1992]). Because of the important role nesting habitat plays in the survival and recovery of the species, significant attention has been given to describing the quality, quantity, and location of the remaining nesting habitat and planning for the restoration of nesting habitat in California, Oregon, and Washington.

Loss of Nesting Habitat Since 1992

The FWS has determined that the rate of habitat loss has declined since listing, particularly on Federal lands due to implementation of the NWFP (USFWS 2004, pp. 11 and 13). Between 1992 and 2003, the estimated loss of suitable murrelet habitat totaled 22,398 acres in Washington, Oregon, and California combined, of which 5,364 acres resulted from timber harvest and 17,034 acres resulted from natural events (McShane et al. 2004, pp. 4-64). Those data primarily represented losses on Federal lands, and did not include data for most private or State lands within the murrelets' range.

More recently, (Raphael et al. 2006 in Huff et al. 2006) used habitat models to estimate losses of potential murrelet habitat for the period from 1994-1996 to 2002-2003 on both Federal and non-Federal lands within the five Conservation Zones in the NWFP area. Results indicate that losses of potential nesting habitat may be greater than previously estimated, with losses ranging from 61,000 to 279,000 acres (depending on the model, see discussion below) in the 5-Conservation Zone area, with 10 to 28 percent of habitat loss occurring on Federal lands and 72 to 90 percent on non-Federal lands.

Current Amount of Nesting Habitat

McShane et al. (2004, p. 4-2), reviewed and summarized habitat estimates from 16 sources and estimated the amount of murrelet nesting habitat at 2,223,048 acres distributed throughout Washington, Oregon, and California (McShane et al. 2004, p. 4-5). Washington State contains almost half of all remaining nesting habitat with an estimated 1,022,695 acres or 48 percent of the total. Approximately 93 percent (2,000,000 acres) are reported to occur on Federal lands (McShane et al. 2004, p. 4-10).

In another effort, (Raphael et al 2006 in Huff et al. 2006) produced two spatial models for the NWFP Effectiveness Monitoring (EM) program to predict the amount, location, and distribution of murrelet nesting habitat. Combining vegetation-based maps derived from satellite imagery and prior estimates of habitat on State and private lands from 1994 to 2003, (Raphael et al. 2006, p. 109 in Huff et al. 2006) used a panel of experts to reclassify 22 old-growth forest classes into four classes of murrelet habitat based upon nesting suitability. Referred to as the Expert Judgment Model, the model classifies existing forest structure, based upon percent conifer cover, canopy structure, quadratic mean diameter, and forest patch size, into four classes of suitability

for nesting murrelets. (Raphael et al. 2006, p. 116-123 in Huff et al. 2006) found that across the murrelet range, most habitat-capable land (52 percent) is unsuitable nesting habitat (Class 1) and 18 percent is classified as Class 4 habitat (highest suitability), with an estimated 41 percent of the Class 4 habitat (1,620,800 acres) occurring on non-Federal lands.

The second habitat model developed by (Raphael et al. 2006 in Huff et al. 2006) used the Biomapper Ecological Niche-Factor Analysis methodology developed by Hirzel et al. (2002). The resulting murrelet habitat suitability maps are based on both the physical and vegetative attributes adjacent to known murrelet occupied polygons or nest locations for each NWFP province. The maps provide a range of habitat suitability values, each with acreage estimates. In Washington, 2.1 million acres of habitat were rated with a habitat suitability (HS) greater than 60 and captured 82 percent of the stands documented as occupied, while 440,700 acres of habitat were rated as HS >80 habitat and captured 36 percent of the known occupied stands.

The FWS believes the Expert Judgment and Ecological Niche Factor Analysis models, which relate known (occupied) murrelet nest stands to habitat abundance, distribution, and quality, represent the best available information on the subject. While not necessarily the best means to describe suitable habitat at the site scale, the FWS expects these models have higher reliability for provincial-scale analysis compared to previous efforts.

Population Status

The initial at-sea surveys for murrelets that began during the 1990s in the marine waters of Washington, Oregon, and California were generally independent and sporadic efforts to assess murrelet population status (abundance, trends, distribution, and fecundity). Through a more coordinated effort, researchers developed the EM Program for the NWFP (Bentivoglio et al. 2002) in 2000 that unified the various at-sea monitoring efforts within terrestrial portions of the five Conservation Zones contained within the planning area of the NWFP. At-sea surveys in Conservation Zone 6, are independent of the EM Program, but are conducted using similar survey methods. The at-sea survey data collected prior to the EM Program are generally not suitable for statistical comparisons or trend analyses due to differences in survey methods, (McShane et al. 2004).

<u>Abundance and Distribution</u>

Murrelet abundance during the early 1990s in Washington, Oregon, and California was estimated at 18,550 to 32,000 birds (Ralph et al. 1995). Through the efforts of the EM program, the 2010 murrelet abundance in the listed range of the species (Table 1) is estimated at 16,691 birds (13,075 – 20,307, 95 percent confidence interval (CI); (Falxa 2011). Conservation Zones 3 and 4 support approximately 65 percent (10,981/6,691) of the murrelet population within the U.S., have the highest reported densities and generally the lowest within-zone statistical variation in population size (Falxa 2011). Murrelets occur in the lowest abundance in Conservation Zones 5 and 6.

At the time of listing, the distribution of active nests in nesting habitat was described as non-continuous (USFWS 1997a, p. 14). The at-sea extent of the species currently encompasses an area similar in size to the species historic distribution, but with the extremely low density of murrelets in Conservation Zones 5 and 6, the southern end of the murrelet distribution is sparsely populated compared to Conservation Zones 1-4.

Table 1. Estimates of murrelet density and population size (95 percent confidence interval (CI)) in Conservation Zones 1 through 5 during the 2010 breeding season (Falxa 2011) and in Conservation Zone 6 during the 2009 breeding season (Peery and Henry 2010).

Conservation Zone	**Density** (birds/km^2)	**Coefficient of Variation** (% Density)	**Population Size Estimates with 95% CI**			**Survey Area** (km^2)
			Number of Birds	Lower	Upper	
1	1.26	20.4	4393	2,689	6,367	3,497
2	0.18	25.7	1,286	650	1946	1,650
3	4.53	16.9	7,223	4,605	9,520	1,595
4	3.16	27.3	3,668	2,196	6,140	1,159
5	Not Surveyed	-	-	-	-	-
6	-	-	631	449	885	-
Zones 1-6	-	-	17,322	13,524	21,192	-

The at-sea distribution also exhibits discontinuity within Conservation Zones 1, 2, 5, and 6, where five areas of discontinuity are noted: a segment of the border region between British Columbia, Canada and Washington, southern Puget Sound, WA, Destruction Island, WA to Tillamook Head, OR, Humboldt County, CA to Half Moon Bay, CA, and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

Trend

There are two general approaches that researchers use to assess murrelet population trend: at-sea surveys and population modeling based on demographic data. In general, the FWS assigns greater weight to population trend and status information derived from at-sea surveys than estimates derived from population models because survey information generally provides more reliable estimates of trend and abundance.

Marine Surveys

Researchers from the EM Program detected a statistically significant decline ($p \leq 0.05$) in the abundance of the surveyed populations in Conservation Zones 1 through 5 for the 2000-2010 sample period (Falxa 2011). The annual rate of decline was 3.7 percent during the 2001-2010 survey period.

While the 2008 population estimate for Conservation Zone 6 indicated a decline of about 55 percent from the 2007 estimate and a 75 percent decline from the 2003 estimate (Peery et al. 2008), the 2009 estimate was similar to estimates from 1999-2003. Peery and Henry (2010) speculated that their 2009 results may have indicated murrelets in central California moved out of the survey area in 2007 and 2008, then returned in 2009, or the increase may have been due to immigration from larger populations to the north.

At the scale of individual conservation zones, the murrelet population is declining at an estimated rate of 7.4 percent per year in Conservation Zone 1. No statistically significant, zone-specific trends were detected for any of the other four conservation zones (Falxa 2011). With a *p value* estimate of 0.06, it appears the change in murrelet abundance during the 2000-2010 sample period is approaching significance in Conservation Zone 2 (Falxa 2011). For Washington State (Conservation Zones 1 and 2 combined) there was a 7.31 percent (standard error = 1.31 percent) annual rate of decline in murrelet density for the 2001-2010 period (Pearson et al. 2011, p. 10), which equates to a loss of approximately 47 percent of the murrelet population since 2001.

Population Models

Prior to the use of survey data to estimate trend, demographic models were more heavily relied upon to generate predictions of trends and extinction probabilities for the murrelet population (Beissinger 1995; Cam et al. 2003; McShane et al. 2004; USFWS 1997c). However, murrelet population models remain useful because they provide insights into the demographic parameters and environmental factors that govern population stability and future extinction risk, including stochastic factors that may alter survival, reproductive, and immigration/emigration rates.

In a report developed for the 5-year Status Review of the Marbled Murrelet in Washington, Oregon, and California (McShane et al. 2004, p. 3-27 to 3-60), computer models were used to forecast 40-year murrelet population trends. A series of female-only, multi-aged, discrete-time stochastic Leslie Matrix population models were developed for each conservation zone to forecast decadal population trends over a 40-year period with extinction probabilities beyond 40 years (to 2100). The authors incorporated available demographic parameters (Table 2) for each conservation zone to describe population trends and evaluate extinction probabilities (McShane et al. 2004, p. 3-49).

McShane et al. (2004) used mark-recapture studies conducted in British Columbia by Cam et al. (2003) and Bradley et al. (2004) to estimate annual adult survival and telemetry studies or at-sea survey data to estimate fecundity. Model outputs predicted -3.1 to -4.6 percent mean annual rates of population change (decline) per decade the first 20 years of model simulations in murrelet Conservation Zones 1 through 5 (McShane et al. 2004, p. 3-52). Simulations for all zone populations predicted declines during the 20 to 40-year forecast, with mean annual rates of -2.1 to -6.2 percent per decade (McShane et al. 2004, p. 3-52). These reported rates of decline are similar to the estimates of -4 to -7 percent per year reported in the Recovery Plan (USFWS 1997c, p. 5).

Table 2. Rangewide murrelet demographic parameter values based on four studies all using Leslie Matrix models.

Demographic Parameter	Beissinger 1995	Beissinger and Nur 1997*	Beissinger and Peery (2007)	McShane et al. 2004
Juvenile Ratio (Ŕ)	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	-
Nest Success	-	-	0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5
Estimated Adult Survivorship	85 % – 90%	85 % – 88 %	82 % - 90 %	83 % – 92 %

*In U.S. Fish and Wildlife FWS (1997b).

McShane et al. (2004, pp. 3-54 to 3-60) modeled population extinction probabilities beyond 40 years under different scenarios for immigration and mortality risk from oil spills and gill nets. Modeled results forecast different times and probabilities for local extirpations, with an extinction risk[21] of 16 percent and mean population size of 45 individuals in 100 years in the listed range of the species (McShane et al. 2004, pp. 3-58).

Reproduction

Generally, estimates of murrelet fecundity are directed at measures of breeding success, either from direct assessments of nest success in the terrestrial environment, marine counts of hatch-year birds, or computer models. Telemetry estimates are typically preferred over marine counts for estimating breeding success due to fewer biases (McShane et al. 2004, p. 3-2). However, because of the challenges of conducting telemetry studies, estimating murrelet reproductive rates with an index of reproduction, referred to as the juvenile ratio (Ŕ),[22] continues to be important, despite the debate over use of this index (see discussion in Beissinger and Peery 2007, p. 296).

Although difficult to obtain, nest success rates[23] are available from telemetry studies conducted in California (Hebert and Golightly 2006; Peery et al. 2004) and Washington (Bloxton and Raphael 2006). In northwest Washington, Bloxton and Raphael (2005, p. 5) documented a nest success rate of 0.20 (2 chicks fledging from 10 nest starts). In central California, murrelet nest success is 0.16 (Peery et al. 2004, p. 1098) and in northern California it is 0.31 to 0.56 (Hebert and Golightly 2006, p. 95). No studies or published reports from Oregon are available.

[21] Extinction was defined by McShane et al. (2004, p. 3-58) as any murrelet conservation zone containing less than 30 birds.

[22] The juvenile ratio (**Ŕ**) for murrelets is derived from the relative abundance of hatch-year (HY; 0-1 yr-old) to after-hatch-year (AHY; 1+ yr-old) birds (Beissinger and Peery 2007, p. 297) and is calculated from marine survey data.

[23] Nest success here is defined by the annual number of known hatchlings departing from the nest (fledging) divided by the number of nest starts.

Unadjusted and adjusted values for estimates of murrelet juvenile ratios suggest extremely low breeding success in northern California (0.003 to 0.008 - Long et al. 2008, pp. 18-19), central California (0.035 and 0.032 - Beissinger and Peery 2007, pp. 299, 302), and in Oregon (0.0254 - 0.0598 - Crescent Coastal Research 2008, p. 13). Estimates for **Ŕ** (adjusted) in the San Juan Islands in Washington have been below 0.15 every year since surveys began in 1995, with three of those years below 0.05 (Raphael et al. 2007b, p. 16).

These current estimates of **Ŕ** are assumed to be below the level necessary to maintain or increase the murrelet population. Demographic modeling suggests murrelet population stability requires a minimum reproductive rate of 0.18 to 0.28 (95 % CI) chicks per pair per year (Beissinger and Peery 2007, p. 302; USFWS 1997c). Even the lower level of the 95 percent confidence interval from USFWS (1997c) Beissinger and Peery (2007, p. 302) is greater than the current range of estimates for Ŕ (0.02 to 0.13 chicks per pair) for any of the Conservation Zones (Table 2).

The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline. Beissinger and Peery (2007, p. 298) performed a comparative analysis using historic data from 29 bird species to predict the historic **Ŕ** for murrelets in central California, resulting in an estimate of 0.27 (95% CI: 0.15 - 0.65). Therefore, the best available scientific information of murrelet fecundity from model predictions and trend analyses of survey-derived population data appear to align well. Both indicate that the murrelet reproductive rate is generally insufficient to maintain stable population numbers throughout all or portions of the species' listed range.

<u>Summary: Murrelet Abundance, Distribution, Trend, and Reproduction</u>

The 2010 estimated abundance for murrelets within Conservation Zones 1-5 was the lowest recorded since inception of the EM program (Falxa 2011)(Falxa et al. 2009, p. 9), with the current population size within the listed range of the species estimated at 17,322 birds (95 percent CI: 13,524 – 21,192) (Table 1). Although murrelets are distributed throughout their historical range, the area of occupancy within their historic range appears to be reduced from historic levels. The distribution of the species also exhibits five areas of discontinuity: a segment of the border region between British Columbia, Canada and Washington; southern Puget Sound, WA; Destruction Island, WA to Tillamook Head, OR; Humboldt County, CA to Half Moon Bay, CA; and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

A statistically significant decline was detected in Conservation Zone 1 for the 2001-2010 period and the decline in Conservation Zone 2 is approaching significance ($\boldsymbol{p}$ = 0.0106) for the 2001-2010 period (Falxa 2011). The overall population trend from the combined 2001-2010 population estimates (Conservation Zones 1 - 5) indicate a statistically significant, rangewide annual rate of decline of 3.7 percent (Falxa 2011).

The current range of estimates for **Ŕ**, the juvenile to adult ratio, is assumed to be below the level necessary to maintain or increase the murrelet population. Whether derived from marine surveys or from population modeling (**Ŕ** = 0.02 to 0.13, Table 2), the available information is in general agreement that the current ratio of hatch year birds to after-hatch year birds is insufficient to

maintain stable numbers of murrelets throughout the listed range. The current estimates for **Ŕ** also appear to be well below what may have occurred prior to the murrelet population decline (Beissinger and Peery 2007, p. 298) and model predictions forecast an extinction risk of 16 percent, with a 3-state mean population size of 45 individuals in 100 years in the listed portion of the species' range (McShane et al. 2004, p. 3-58).

Thus, considering the best available data on abundance, distribution, population trend, and the low reproductive success of the species, the FWS concludes the murrelet population within the portion of its listed range currently has little or no capability to self-regulate, as indicated by the significant, annual decline in abundance the species is currently undergoing throughout the listed range. The FWS expects the species to continue to exhibit further reductions in the distribution and abundance into the foreseeable future, due largely to the expectation that the variety of environmental stressors present in the marine and terrestrial environments (discussed in the *Threats to Murrelet Survival and Recovery* section) will continue into the foreseeable future.

Recovery Plan

The Marbled Murrelet Recovery Plan outlines the conservation strategy with both short- and long-term objectives. The Plan places special emphasis on the terrestrial environment for habitat-based recovery actions due to nesting occurring in inland forests.

In the short-term, specific actions identified as necessary to stabilize the population include protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (USFWS 1997c, p. 119). Specific actions include maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance. The designation of critical habitat also contributes towards the initial objective of stabilizing the population size through the maintenance and protection of occupied habitat and minimizing the loss of unoccupied but suitable habitat.

Long-term conservation needs identified in the Plan include:

- increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size;
- increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat;
- protecting and improving the quality of the marine environment; and
- reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea.

<u>Recovery Zones</u>

The Plan identified six Conservation Zones (Figure 1) throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4),

Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6). Recovery zones are the functional equivalent of recovery units as defined by FWS policy (USFWS 1997c, p. 115).

Recovery Zones in Washington

Conservation Zones 1 and 2 extend inland 50 miles from marine waters. Conservation Zone 1 includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border and the Puget Sound, including the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Conservation Zone 2 includes marine waters within 1.2 miles (2 km) off the Pacific Ocean shoreline, with the northern terminus immediately south of the U.S.-Canadian border near Cape Flattery along the midpoint of the Olympic Peninsula and extending to the southern border of Washington (the Columbia River) (USFWS 1997c, pg. 126).

Lands considered essential for the recovery of the murrelet within Conservation Zones 1 and 2 are 1) any suitable habitat in a Late Successional Reserve (LSR), 2) all suitable habitat located in the Olympic Adaptive Management Area, 3) large areas of suitable nesting habitat outside of LSRs on Federal lands, such as habitat located in the Olympic National Park, 4) suitable habitat on State lands within 40 miles off the coast, and 5) habitat within occupied murrelet sites on private lands (USFWS 1997c).

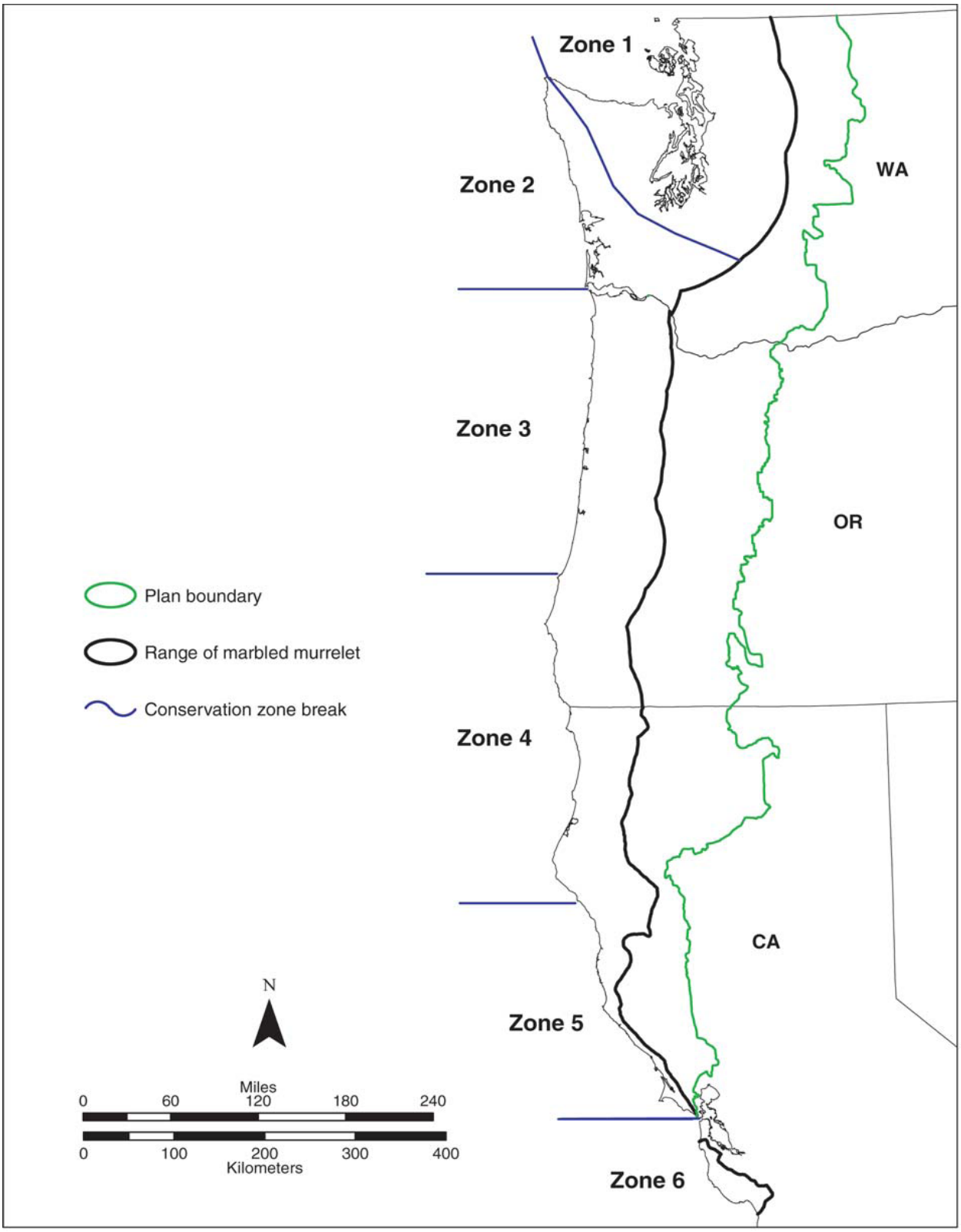


Figure 1. The six geographic areas identified as Conservation Zones in the recovery plan for the marbled murrelet (USFWS 1997c). Note: "Plan boundary" refers to the Northwest Forest Plan. Figure adapted from Huff et al. (2006, p. 6).

Conservation Needs of the Species

Reestablishing an abundant supply of high quality murrelet nesting habitat is a vital conservation need given the extensive removal during the 20th century. However, there are other conservation imperatives. Foremost among the conservation needs are those in the marine and terrestrial environments to increase murrelet fecundity by increasing the number of breeding adults, improving murrelet nest success (due to low nestling survival and low fledging rates), and reducing anthropogenic stressors that reduce individual fitness[24] or lead to mortality.

The overall reproductive success (fecundity) of murrelets is directly influenced by nest predation rates (reducing nestling survival rates) in the terrestrial environment and an abundant supply of high quality prey in the marine environment during the breeding season (improving potential nestling survival and fledging rates). Anthropogenic stressors affecting murrelet fitness and survival in the marine environment are associated with commercial and tribal gillnets, derelict fishing gear, oil spills, and high underwater sound pressure (energy) levels generated by pile-driving and underwater detonations (that can be lethal or reduce individual fitness).

General criteria for murrelet recovery (delisting) were established at the inception of the Plan and they have not been met. More specific delisting criteria are expected in the future to address population, demographic, and habitat based recovery criteria (USFWS 1997c, p. 114-115). The general criteria include:

- documenting stable or increasing population trends in population size, density, and productivity in four of the six Conservation Zones for a 10-year period and
- implementing management and monitoring strategies in the marine and terrestrial environments to ensure protection of murrelets for at least 50 years.

Thus, increasing murrelet reproductive success and reducing the frequency, magnitude, or duration of any anthropogenic stressor that directly or indirectly affects murrelet fitness or survival in the marine and terrestrial environments are the priority conservation needs of the species. The FWS estimates recovery of the murrelet will require at least 50 years (USFWS 1997c).

Summary

The level of risk posed by some threats to the murrelet population may have been reduced as a result of the species' listing under the Act, such as the passage of the Oil Pollution Act and implementation of the NWFP. However, the FWS is not aware that any threats have been removed since listing and in some portions of the listed range, new threats (identified above) have been identified which affect the species at the local population or listed-entity scales. Currently, the FWS expects these threats to continue into the foreseeable future and those that cause direct mortality or reduce individual fitness are likely to contribute to murrelet population declines.

[24] Fitness is measure of the relative capability of individuals within a species to reproduce and pass its' genotype to the next generation.

Considering the life history characteristics of the murrelet, the species' capability to recover from the mortality or reduced-fitness stressors is extremely low. The low observed reproductive rate causes the murrelet population to be highly sensitive to mortality and fitness-reducing stressors, particularly when they occur at a frequency which exceeds the species' loss-replacement rate. Despite the relatively long life span of murrelets and a reasonably high adult survival rate, the annual replacement rates needed for long-term population maintenance and stability is currently well below the annual rate of individuals being removed from each Conservation Zone.

Therefore, given the interactive effect of an extremely low fecundity and the current threats facing the species, it is reasonable to predict that the murrelet populations (in each Conservation Zone) throughout the listed range are likely to continue to decline. The decline is expected to continue until murrelet fecundity is significantly improved and the anthropogenic stressors affecting fitness, survivorship, and nest success are eliminated or sufficiently reduced.

APPENDIX 3 – Marbled Murrelet Winter Range Diversity

Appendix 3. Marbled murrelet winter density based on Puget Sound Ambient Monitoring Program (1993-2005 data).

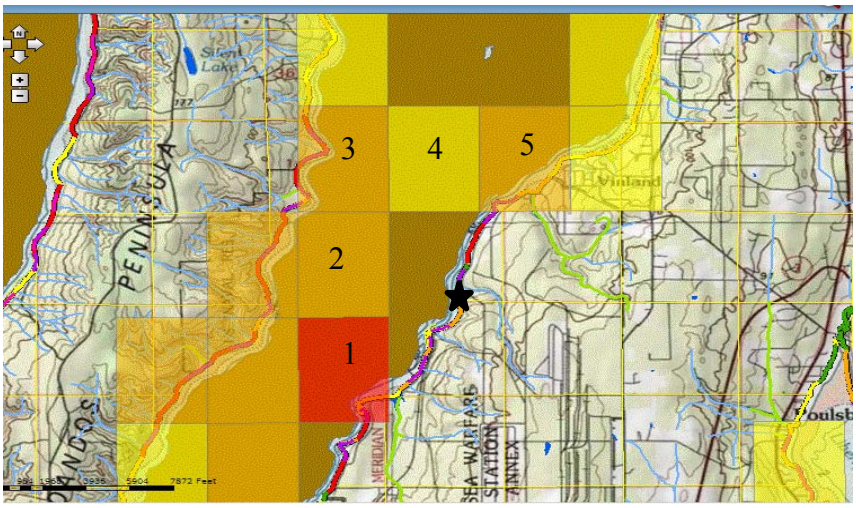


Figure 1. PSAMP density near proposed project. Survey areas (1 through 5) used to determine mean density of marbled murrelets for determining confidence interval to use in section 7(a)2 analysis.

★ Project location

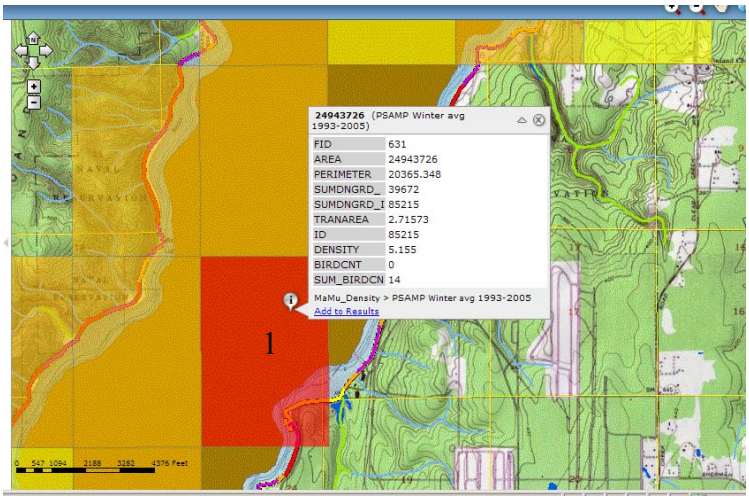


Figure 2. Average marbled murrelet density (5.155 marbled murrelets/km^2) southwest of proposed project.

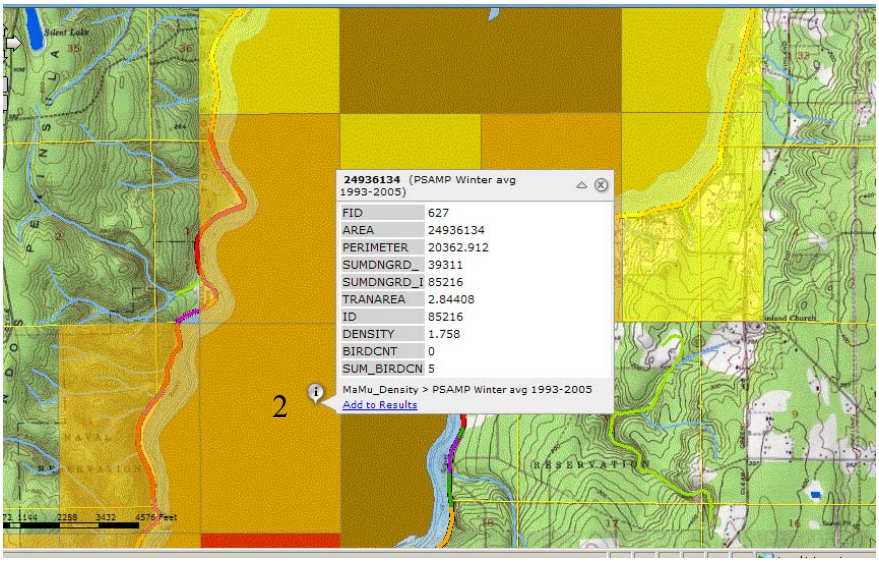


Figure 3. Average marbled murrelet density (1.758 marbled murrelets/km^2) west of proposed project.

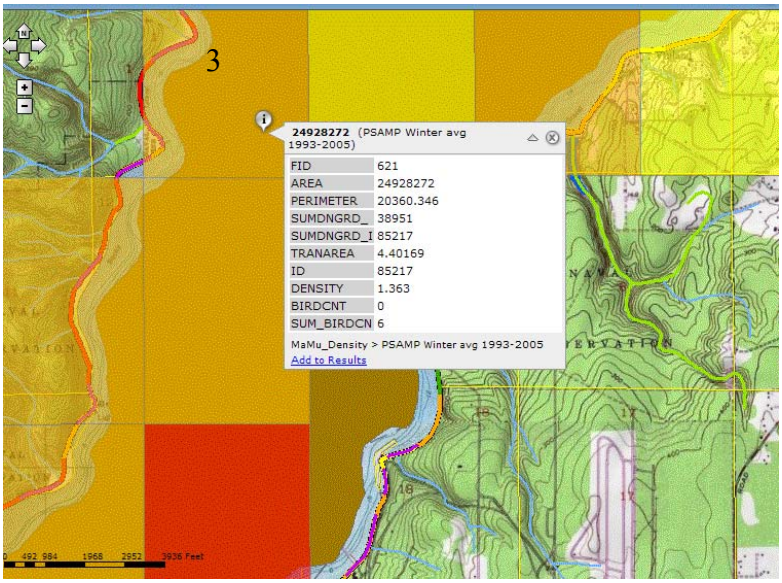


Figure 4. Average marbled murrelet density (1.363 marbled murrelets/km^2) northwest of proposed project.

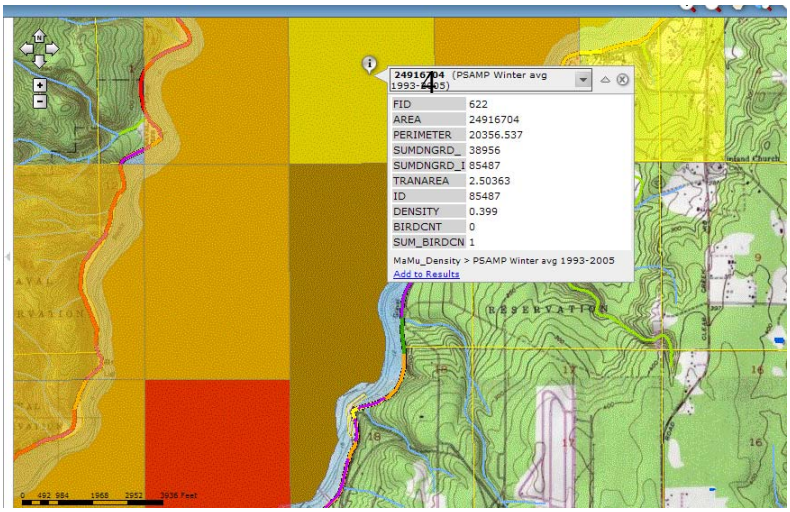


Figure 5. Average marbled murrelet density (0.399 marbled murrelets/km^2) north of proposed project.

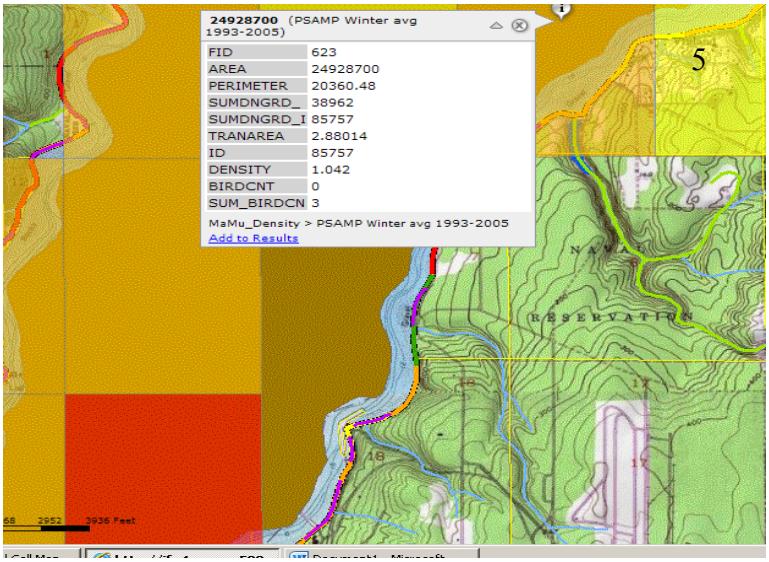
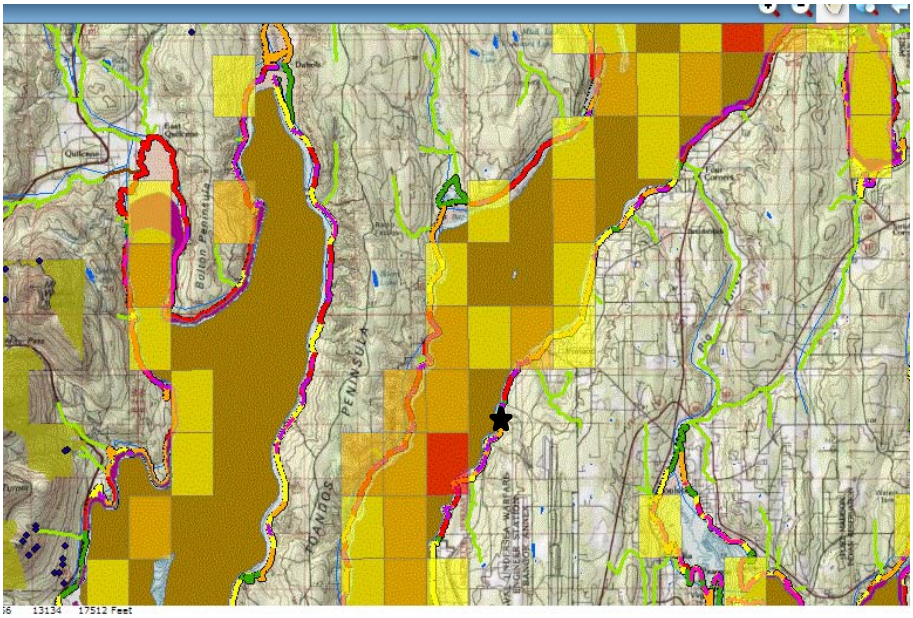
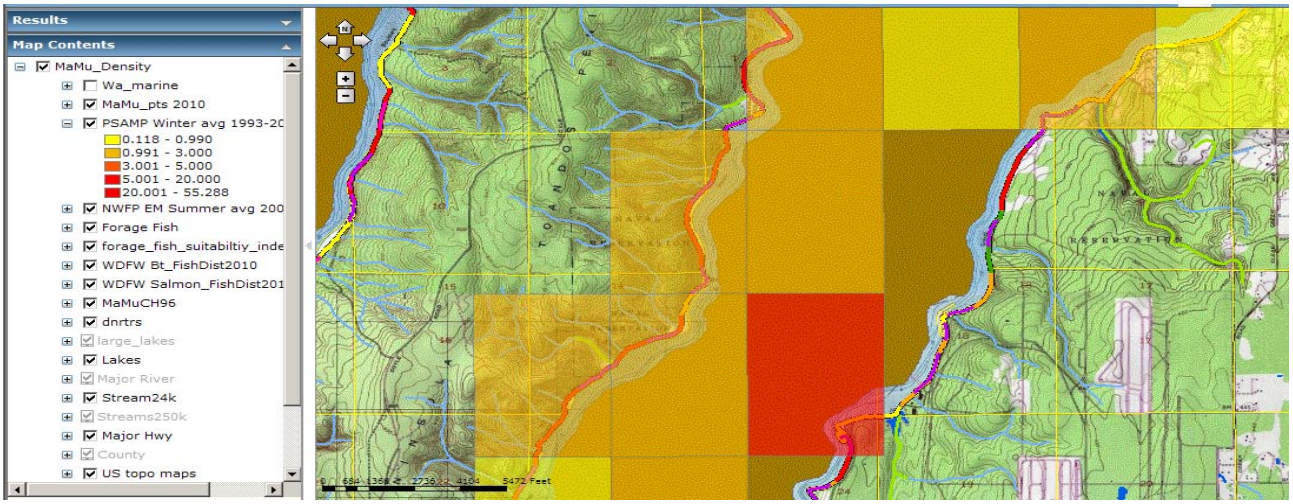


Figure 6. Average marbled murrelet density (1.042 marbled murrelets/km^2) north of proposed project.



Overall densities in area north and south of project



APPENDIX 4 – Proposal to Modify Current Method for Evaluating the Effects of Underwater Sound from Pile Driving on the Marbled Murrelet

Proposal to Modify Current Method for Evaluating the Effects of Underwater Sound from Pile Driving on the Marbled Murrelet *(Brachyramphus marmoratus)*

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Proposal to Modify Current Method for Evaluating the Effects of Underwater Sound from Pile Driving on the Marbled Murrelet *(Brachyramphus marmoratus)*

Background

As previously described (Teachout 2010), there is a paucity of relevant data on the effects of underwater sound on the marbled murrelet. Data specific to seabirds are primarily limited to evaluations of the effects of underwater blasting and seismic testing (Yelverton and Richmond 1981, p. 3; Cooper 1982; Stemp 1985; Flint et al. 2003; Lacroix et al. 2003). However, during the Endangered Species Act, Section 7 consultations, the US Fish and Wildlife Service (USFWS) must evaluate potential effects to individuals of a listed species. The USFWS is tasked with using the best available information, even when data are limited. In addition, when data are limited, we are obligated to apply a precautionary approach to avoid underestimating potential effects.

For the purposes of our analyses, the USFWS considers onset of "injury" as the level that is expected to cause auditory damage as indicated by a temporary threshold shift (TTS). TTS is a temporary reduction in hearing sensitivity. The basis for considering TTS an injury is that acoustic overexposure in birds has been shown to result in hair cell loss in the inner ear. The USFWS recognizes the loss and/or physical damage of hair cells within the ear of an organism as injury. The basis for this position is described more fully in the section titled: "Temporary Threshold Shift (TTS) as an Indicator of Onset of Injury", below.

Ideally, an analysis of the effects of sound on animals would utilize empirical data gathered from the species of interest, using similar sound types, and durations of exposure matching those that the animal will encounter in the real world. Further, when evaluating effects to auditory tissues in particular, the exposures should be with sounds at frequencies that are weighted based on the best hearing sensitivity of the species of interest. However, given the lack of data on underwater sound effects on seabirds in general, and on murrelets specifically, extrapolations across species and sound types are necessary. We acknowledge that this approach presents numerous challenges, and as a result, these estimations are likely conservative. We have attempted to clearly state our assumptions in the following rationale. The need for extrapolation and precautionary assumptions highlights the need for research on the hearing sensitivity and vulnerability of marbled murrelets to underwater sound. These proposed criteria are interim, and we expect that they will continue to be refined as new information becomes available.

Why Modify the Current Approach?

Until now, this office used a peak sound pressure level (SPL) of 180 dB (re: 1μPa)[25] as a threshold for estimating the onset of injury to marbled murrelets exposed to the underwater sounds from pile driving. This threshold was originally established by the National Marine Fisheries Service (NMFS) to assess the risk of injury to ESA-listed salmon, and was later adopted by the USFWS for bull trout. In adopting this threshold for murrelets, the USFWS assumed that a sound level that was protective of fishes would also be protective of murrelets because murrelets are larger, are not underwater 100 percent of the time, and coarse-scale effects

[25] Throughout this document, reference value for peak SPL is 1 μPa

appeared similar across all vertebrate taxa for which there are data. The rationale for this approach is described in Teachout (2010) and in numerous biological opinions that have been issued by this office.

However, both the USFWS and NMFS now recognize peak pressure alone is not a reliable threshold for injury because peak pressure does not correlate well with injury to non-auditory tissue. Hubbs and Reichnitzer (1952) found that black powder charges resulted in lower injury rates than a dynamite charge even when the peak pressure was much higher. They attributed the higher rate of injury from the dynamite charges to the more rapid rise in pressure, when compared to the black powder charges. Yelverton et al. (1973, 1975) studied the effects of underwater blasts on fishes, birds, and mammals, and found that the blast impulse (the time-integrated sound pressure) was a far better predictor of injury than peak pressure.

In 2004, the California Department of Transportation (Caltrans) and Federal Highway Administration (FHWA) established the inter-agency Fisheries Hydroacoustic Working Group (FHWG) to develop a better understanding of the issue of pile driving and its potential effects to listed fishes. The FHWG used the available literature on the effects from underwater explosions and seismic airguns to both identify the important metrics, and to establish and adopt a set of interim criteria. Through that effort, Carlson et al. (2007) proposed that the optimum metric for non-auditory tissue damage was a cumulative SEL summed over all strikes to which the animal is exposed. SEL is a measure of energy and can be extremely useful for assessing cumulative exposure because it enables sounds of differing duration, and multiple exposures, to be compared in terms of total energy (Southall et al. 2007, p 418). Further, a dual criterion approach was proposed because while cumulative SEL is the optimum metric for non-auditory injury, both peak and SEL could apply to auditory injuries.

The resulting interim criteria established by the FHWG use two sound metrics, peak SPL and cumulative sound exposure level (SEL), as proposed by Carlson et al. (2007) for assessing the risk of direct injury (including some TTS), and that account for the repeated hammer strikes required to drive a pile. Using these criteria for evaluating effects to fishes, injury is expected if either: 1) the peak SPL (defined as the maximum absolute value of the instantaneous pressure) of any strike exceeds 206 dB; or 2) SEL, accumulated over all pile strikes, exceeds 187 dB (re: 1 μPa2•sec)[26] for fishes 2 grams or larger and 183 dB for fishes smaller than 2 grams. It should be noted that these thresholds represent the initial onset of injury, not the levels at which fishes will be severely injured or killed. These thresholds are based on recent studies by Govoni et al. (2003) (for fishes smaller than 2 g), Popper et al (2005), and Song et al. (2008). The thresholds for the larger fishes are the highest cumulative SEL to which larger fishes have been exposed with no observable injury, and are thus, considered to be conservative. Some low-level temporary threshold shift was observed in some species at a cumulative SEL of 187 dB.

Because marbled murrelets, when underwater, are exposed to the same sound events as fish, we believe that the logic path for applying the dual criteria using an SEL value for fishes also applies to determining what metric is appropriate for conducting evaluations on diving birds. Relying solely on peak pressure ignores the accumulation of sound energy in an organism from exposure to the multiple pile strikes that occur during actual construction projects, and, as

[26] Throughout this document, SEL dB are referenced to 1 $\mu Pa^2 \cdot sec$.

observed in other vertebrates, that it does not correlate with injury to non-auditory tissues. As such, we propose adopting a new approach that incorporates the dual criteria of peak pressure and cumulative SEL.
One of the difficulties in applying the peak pressure component of the dual criteria to birds is that there are no data on birds to establish the peak pressure criteria. The Services' current 206 $_{peak}$ threshold is based entirely on the literature from fishes (Carlson et al., 2007; p. 2). There are no data, at this time, to help us understand how the auditory system of murrelets would compare to that of fishes. However, given the lack of other data, we are proposing that the 206 $_{peak}$ threshold be applied to murrelets as an interim approach, until new data is available that indicates otherwise. This will have the additional benefit of simplifying measurements in the field and during analyses by making them consistent with fishes.

As research in this field remains limited, there is a need for extrapolation and application of precautionary assumptions, and this leads us to the body of information on other vertebrate species.

Obviously, there are many physiological and morphological differences between birds, mammals, and fishes. Among vertebrates, birds have unique respiratory systems that include lungs and air sacs that create an efficient one-way, flow-through, system and a thin blood-gas barrier (West et. al., 2006, p. 382; and Proctor and Lynch 1993 p. 206). The pulmonary capillaries of birds are rigid and resistant to expansion and compression (West et al., 2006 p. 388). Baerwald et al. (2008) (p. 2) noted that these morphological features may make birds somewhat resistant to barotrauma from wind turbines. However, while it is possible that there may be effects unique to birds, due to their thin blood-gas barrier and/or the presence of air sacs in their respiratory system, these are not understood at this time.

Temporary Threshold Shift (TTS) as an Indicator of Onset of Injury

To determine the appropriate threshold for application of these dual criteria we must define the point at which the USFWS considers onset of "injury" to occur. It is this exposure that the criteria would strive to identify in our analyses. We define the onset of injury as the level expected to cause TTS.

Exposure to intense underwater sound can cause TTS lasting from hours to days (Gisiner et al. 1998, p. 26). Ryals et al. (1999) exposed four species of birds (quail, budgerigars, canaries, and zebra finches) to pure tone and bandpass noise. All four species experienced hair cell loss in varying degrees as well as some recovery of threshold sensitivity and hair cell number over time. In the canaries and zebra finches hearing and hair cell number recovered to within normal limits. The auditory effects to canaries and finches in this study would typically be categorized as TTS, though with the use of scanning electron photomicrographs the authors showed hair cell loss and damage on the surface of the papillae (p. 80).

Although TTS is considered by many to be a short-term fatiguing of the auditory system rather than an "injury" (Popper et al. 2006), the USFWS recognizes the loss and/or physical damage of hair cells within the ear of an organism as injury. Limited data from marine mammals suggest that onset of TTS occurs at levels below those required for non-auditory trauma (Southall et al. 2007, p. 424).

There are few documented auditory ranges for seabirds. Woehler (2002) presented data from Jouventin (1982) on six species of penguins and concluded that their vocalizations range from 400 Hz to 8 kHz (p. 97). Nelson (1997, p.9) recorded adult and nestling marbled murrelet vocalizations and found that adult calls ranged from approximately 4 to 7 kHz and nestling begging calls ranged from 2 to 11 kHz. More recently, Sanborn (pers. comm. 2005) analyzed recorded marbled murrelet calls and found a frequency range of 480 Hz to 4.9 kHz. There are no reliable data on the frequency ranges of underwater vocalizations. Based on this information and in the absence of direct hearing studies for murrelets, we estimate that murrelets can detect, at a minimum, sounds between 480 Hz and 11 kHz, both in-air and in-water. However, without an audiogram for murrelets, or at least a closely related species, it is not possible to predict the upper and lower extent of frequency detection capabilities, nor the species' hearing sensitivity.

Currently, there are no data regarding TTS specific to marbled murrelets, nor any alcid, or even another diving bird. To estimate the onset of TTS in murrelets from underwater sound, we relied on analyses done on marine mammals as summarized in Southall (2007). From the analyses done on marine mammals, we looked specifically at the available information on pinnipeds since they are adapted to hearing both above and below water. While there are few morphological similarities between pinnipeds and seabirds, both groups are amphibious, spend a significant amount of time foraging at sea, and dive to pursue prey. Both pinnipeds (Popper and Ketten 2008, p. 232) and seabirds (Ketten 2008) have evolved ear structures that are specially adapted to hearing in air and in water. Further, after examining underwater sound auditory mechanisms in dolphins, seals, turtles, and seabirds (species not defined) Ketten et al. (1999) note that both seals and seabirds share external auditory canals that are sheathed with fatty tissues.

Greatest hearing sensitivity in pinnipeds is between 700 Hz and 20 kHz (76 FR 4300 [January 25, 2011]), so some overlap in the hearing range occurs between pinnipeds and seabirds. Based upon life history requirements (i.e., habitat utilization above and below water), expected similarities in auditory mechanisms (i.e., based on preliminary work by Ketten et al., as noted above), and expected overlap in auditory range, we propose that the data on pinnipeds (though limited), represents the best available information for estimating the onset on TTS in murrelets until new information becomes available.

Kastak et al. (2005), examined the interactions of amplitude and duration in inducing TTS from non-pulsed sound exposure upon three pinnipeds - a California sea lion (*Zalophus californianus*), a harbor seal (*Phoca vitulina*), and a northern elephant seal (*Mirounga angustirostris*). The animals were exposed to pure tone sounds (frequency weighted to match the hearing sensitivities of each species) for durations of up to 50 minutes. The authors found that there was a significant linear relationship between cumulative SEL and the magnitude of observed TTS (p. 3161). The data indicated that harbor seals were the most sensitive of the species tested. Onset of TTS in harbor seals occurred at approximately 183 dB SEL (p. 3162) with a 25-minute exposure to 2.5 kHz octave-band-noise.

We know of only one study using pulsed sound to determine TTS in pinnipeds. Finneran et al. (2003) exposed two California sea lions to single pulses and found no measureable TTS with exposures up to 183 dB (peak to peak) and 163 dB SEL. As this study did not identify a level at which onset of TTS did occur, its applicability in this context is limited.

There are several challenges with applying these data to an analysis for marbled murrelets, which we acknowledge:

- The study used octave-band sounds centered at 2,500 Hz rather than broadband sounds found in impact pile driving. Kastak et al. (2005) found that TTS occurred at certain frequencies. It is possible that the broadband sounds of pile driving may not have sufficient energy at any one frequency to cause TTS.
- The intensity of the sounds used by Kastak et al. (2005) were adjusted to achieve a consistent dB above threshold levels at 2,500 Hz for of each species tested. There are no data on the hearing sensitivities of a marbled murrelet so we do not know if the sound levels used by Kastak et al. (2005) would have similar effects on murrelets. We assume that any one murrelet can detect sounds within the frequency range of their calls, and that their best hearing sensitivity would also be within that range (480 Hz to 11 kHz). Kastak et al. (2005) found TTS in harbor seals from sounds that were centered at 2,500 Hz.
- Kastak et al. (2005, p. 3161) note that their study suggests that moderate levels of long duration sounds may have a greater impact on hearing than equal-energy sounds of greater amplitude but shorter duration. If this is true, because their exposures were up to 50 minutes, it is possible that they might have seen less impact if the exposure durations were shorter.

Applying Dual Criteria for Injury to Marbled Murrelets

To account for all of the potentially injurious aspects of exposure, we propose interim dual criteria of 206 dB $_{peak}$ and 183 dB cumulative SEL for estimating the onset of injury from underwater sound in marbled murrelets.

The proposed criteria incorporate the cumulative SEL, summed over all the pile strikes to which the murrelet is exposed. In doing so, the USFWS assumes, as we do for fishes, that the equal energy hypothesis holds for injury to non-auditory tissues. There are no data on the occurrence of TTS, nor on an organism's ability to recover, for complex exposures and variable inter-strike intervals. We expect that this approach is probably most appropriate if the strikes occur close together (*i.e*. within seconds) and is increasingly conservative if exposures are widely spaced. A similar method was recently used for correlating potential cumulative impacts to marine mammals exposed to sonar ([71 FR 20986] April 24, 2006). Cumulative SEL, at a given distance from the pile driver, is calculated according to the method described in Stadler and Woodbury (2009), as follows:

Cumulative SEL = Single Strike SEL + 10*Log(number of strikes)
The single strike SEL can be estimated from either the mean SEL or the maximum single-strike SEL recorded when similar size piles were driven. This relationship means that a 10-fold increase in the number of pile strikes will result in a 10 dB increase in cumulative SEL at a given distance from the pile driver.

Conclusion

Based on the best information currently available, we propose using dual criteria of 206 dB $_{peak}$ and 183 dB cumulative SEL for onset of physical injury to marbled murrelets from underwater sound related to impact pile driving. Recognizing the dearth of direct information, but also the clear importance of accounting for energy from multiple, successive strikes, we propose an analysis method that allows for the accumulation of the sound energy over all pile strikes to which a murrelet is exposed. We will use the simple summation procedure of 10*log(number of strikes) to assess cumulative impacts. The single strike peak SPL of 206 $_{peak}$ is expected to account for the apparent lack of applicability of the equal energy hypothesis to auditory effects.

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APPENDIX 5 – Method for Determining the Likelihood of Occurrence of Marbled Murrelets

Appendix 5. Method for determining the likelihood of occurrence of marbled murrelets within area of potential negative effects from underwater impact pile driving

To approximate the density of marbled murrelets in the winter, we developed an index using the results of winter surveys reported by Nysewander et al. (2005) for the Puget Sound Ambient Monitoring Program (1992 to1999). Although Nysewander et al. (2005) did not report summer marbled murrelet density, we developed an index based on a close examination of the changes in seasonal abundance of marbled murrelets in Puget Sound reported from summer and winter surveys.

In summer surveys conducted by Nysewander et al. (2005), alcids comprised 5.9 percent to 14.6 percent (mean of 10.3 percent) of the summer marine bird populations over the eight summers in the core survey area covered every year. Marbled murrelets were one of the least abundant alcids observed during the surveys, comprising just 1.5 percent of all alcids in the summer observations.

An 8-year average density of 87.05 marine birds/km^2 was calculated from summer density information reported by Nysewander et al. (2005, p. 10) for the northern two-thirds of the study area, an area encompassing the action area of this proposed project. We then multiplied the 8-year average by the maximum marbled murrelet occurrence rate of 0.219 percent [(0.00219 is the product of 14.6 percent (0.146) maximum alcid occurrence rate x 1.5 percent (0.015), the proportion of the alcids that were marbled murrelets]. The result was an average maximum marbled murrelet summer density of 0.190 marbled murrelets/km^2 (87.05 birds/km^2 x 0.00219) for the 1992 to 1998 survey period. We then compared the maximum summer density (0.190 marbled murrelets/km^2) to the maximum winter density (0.35 marbled murrelets/ km^2) (Nysewander et al. 2005, p. 65) and calculated a 1.84-fold increase (0.35/0.19) in winter density over the summer density. This density increase is then applied to the summer survey values reported by Falxa (2011) to determine winter density values. The significant increase in the winter is likely due to marbled murrelets from coastal areas of British Columbia (outside the listed range of the species) and Conservation Zone 2. Recent radio-telemetry data indicates murrelets move between Conservation Zones 1 and 2 to forage (Bloxton and Raphael 2008).

To ensure we best capture the spatial variability in marbled murrelet abundance within our action area, we identified the primary sample units associated with winter (Nysewander et al. 2005) (Appendix 3 of this Opinion) and summer (Falxa 2011) (Conservation Zone 1, Stratum 2, Primary Sampling Unit 34) marbled murrelet surveys to determine if surveys have been conducted at or immediately adjacent to the action area. Based on the density values provided by these studies, we selected our computed summer and winter abundance estimates based on a comparison of our computed density values with these reported sampling values and selected the value that best approximated the long-term sample data. For example, the survey data for summer density (less than 1 to 3 marbled murrelets per km^2) was most closely associated with our mean density value (1.5 marbled murrelets per km^2) versus the upper 95 percent confidence interval (2.2 marbled murrelets per km^2). Therefore, we selected the mean density value estimate in our calculations.

Marbled Murrelet Group Size and Number of Groups

Marbled murrelet summer foraging groups occur most often in a flock size of two, with other flock sizes (singles and flocks of three or more birds) less common (Merizon et al. 1997). To assess marbled murrelet risk of exposure to underwater sound pressure, we elected to estimate of the size and number (density) of marbled murrelet groups in Conservation Zone 1. The mean group size of marbled murrelets is computed each year for Conservation Zones 1 as part of the at-sea surveys for the NWFPEM (Falxa 2011). To estimate the number of flocks at the Conservation Zone scale, we computed the overall mean group size (Se) from the 2001 through 2010 annual group size mean reported by Falxa (2011). This resulted in an overall mean group size of 1.73 (n = 10) in Conservation Zone 1, with an upper 95 percent confidence interval of 1.79 and lower 95 percent interval of 1.67. The observed range of average group size was 1.59 (2001) to 1.82 (2003).

Due to the low variation in mean group size between years, we estimated the number of marbled murrelet groups at the Conservation Zone 1 scale (i.e., from the population size reported in Falxa 2011) and within Strata 2 (i.e., from the reported strata densities in Falxa 2011) based upon a 1.73 mean group size. We estimate that 660 marbled murrelet groups (1,142 marbled murrelets/1.73 marbled murrelets per group) occur in Stratum 2 for the 2010 breeding cycle. A six-month summer season was established to generally correspond to the breeding season that begins in April and ends in September.

Although marbled murrelet group size probably increases during the winter (i.e., greater than 1.73 individuals per group), we decided to use the summer mean group size for the winter (defined as October to March), because we could not find adequate information to generate a group size estimate. We also were unable to compute winter group density estimates at the scale of the survey strata in Conservation Zone 1 because marbled murrelet winter distribution differs significantly from summer distribution. Thus, using a winter abundance of 8,084 marbled murrelets (4,393 marbled murrelets x 1.84), we estimate that 4,673 groups (8,084 marbled murrelets/1.73 marbled murrelets/group) occur in Conservation Zone 1 during the winter. Using this information, we then computed the summer and winter flock density (flocks/km^2) from Equation 1.

Equation 1: dflock = [(nt)/(fx)] / (as)

Where **dflock** is the group density (marbled murrelet flocks/km^2); **nt** is the annual population size (number of marbled murrelets) during year **t** in the stratum of interest; **f** is mean group size in season x; and **a** is the area of stratum **s** (km^2). Summer flock density was calculated as 0.55 groups/km^2 and winter flock density is 1.3 groups/km^2[27].

[27] We determined that our use of an overall winter abundance of 8,084 marbled murrelets for Conservation Zone 1 (2.3 marbled murrelets/km2) ([8,084 marbled murrelets/3,497 km^2) in the vicinity of the proposed EHW-2 facility is a reasonable approximation of the actual winter density. Winter marbled murrelet density information from Nysewander et al. (2005) suggests winter density is typically within the range of 1.0 to 5.5 marbled murrelets/km^2.

Likelihood of Occurrence within Area of Potential Negative Effects from Underwater Impact Pile Driving

We used a Poisson probability model based upon marbled murrelet group density in the stratum 2 (summer) and Conservation Zone 1 (winter) to evaluate the likelihood of one or more marbled murrelet flocks occurring within a given critical field. The Poisson probability model depends upon a (Poisson) process that operates continually over some time or space where determining the likelihood of a "success," referred to as an encounter, is the output of interest (for a more thorough discussion, see (Ewart and Ford 1974, pp. 175-193). The model is ideal for rare events that occur randomly over time or space when all that is known is the average number of occurrences of some event of interest during some specified time period.

In this analysis, marbled murrelet foraging groups were viewed as a Poisson process with an average group density (groups/km^2, represented by λ) of birds foraging in Puget Sound. Different values for λ were used for the winter (1.3 marbled murrelet flocks/km^2) and summer (0.55 marbled murrelet flock/km^2) periods as defined above. The sizes of the potential area of injury associated with the various pile driving event (i.e., based on the pile size and duration of impact pile driving per day) were treated as independent events, each event having a probability of an "encounter" (i.e., containing 0, 1, or more marbled murrelet groups foraging within some predefined area at the time of pile driving). We defined exposure to underwater underwater sound of at least 202 dB SEL as a "marbled murrelet encounter."

Equation 2 was used to estimate the seasonal probabilities of 0, 1, 2,…x groups occurring within an area of interest in marbled murrelet survey strata 2 and Conservation Zone 1.

Equation 2: $\boldsymbol{fp\ (x|\lambda, t) = [(\lambda t)x\ e\text{-}\ \lambda t\ ] / x\ !}$

where $\boldsymbol{fp}$ is the probability of x = 0, 1, 2 .. x marbled murrelet flock encounters; **e** is the natural logarithm base approximately equal to 2.7183; $\boldsymbol{\lambda}$ = the mean number of flock encounters within a critical field; and **t** = the number of time units under consideration (Ewart et al. 1974, p. 189,190).

Defined in this manner, $\boldsymbol{\lambda t}$ is the mean number of marbled murrelet flock encounters within a given critical field for t units of time representing the duration exposure to the high SPL.

The sizes of the various energy fields that marbled murrelets may be exposed to were determined by Equation 3, using radii associated with the attenuation distances to 202 dB SEL and183 dB SEL. Although the Navy does not propose to monitor out to 183 dB SEL, this information is needed to determine the area marbled murrelets may be exposed to non-injurious auditory sounds.

Applying these assumptions, we constructed a conceptual spatial frame upon which we could simulate a marbled murrelet encounter for the purposes of quantifying the number of individuals that might be exposed to injurious underwater sound pressures. The simulation was based upon computing the likelihood (probability) of a marbled murrelet encounter while foraging based upon the species foraging behavior, implementation of the Navy's proposed pre-impact pile

driving surveys within the zone of potential injury for marbled murrelets (≥ 202 dB SEL or a minimum of 55 m from the steel pile), and duration and extent of sound pressures associated with impact pile driving.

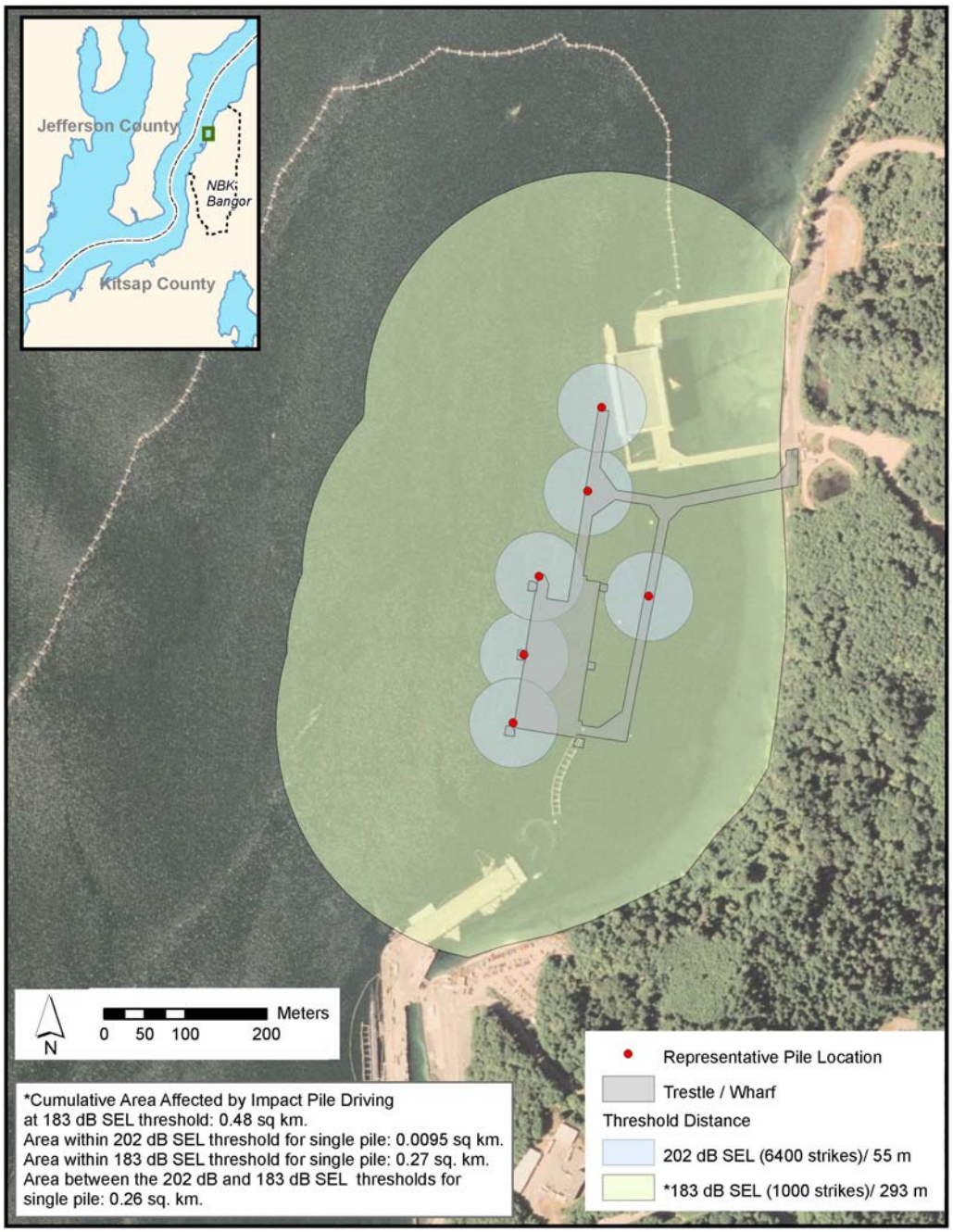
Based on these calculations, the following values resulted (Tables 1 and 2).

Table 1. Likelihood of encounter of at least one marbled murrelet flock within area of ensonification equal to or greater than 202 dB SEL. Values less than 0.1 are assumed to result in no exposure/encounter of a marbled murrelet.

24 inch Piles		likelihood of encounter at least 1 marbled murrelet flock			**36/48 inch Piles**		likelihood of encounter at least 1 marbled murrelet flock		
Season	Pile Strikes	L95	Mean	U95	Season	Pile Strikes	L95	Mean	U95
summer	1000	0.0000	0.0000	0.0000	summer	1000	0.0001	0.0001	0.0001
winter	1000	0.0000	0.0001	0.0001	winter	1000	0.0001	0.0002	0.0003
summer	2000	0.0000	0.0001	0.0001	summer	2000	0.0003	0.0005	0.0007
winter	2000	0.0001	0.0001	0.0002	winter	2000	0.0007	0.0012	0.0017
summer	6400	0.0004	0.0007	0.0010	summer	6400	0.0035	0.0058	0.0084
winter	6400	0.0010	0.0017	0.0024	winter	6400	0.0086	0.0140	0.0202

Table 2. Likelihood of encounter of at least one marbled murrelet flock within area of ensonification between 183 dB SEL and 202 dB SEL. Values less than 0.1 are assumed to result in no exposure/encounter of a marbled murrelet. Highlighted numbers are greater than 0.1. Mean values are used for future calculations.

24 inch Piles		likelihood of encounter at least 1 marbled murrelet flock			**36/48 inch Piles**		likelihood of encounter at least 1 marbled murrelet flock		
Season	Pile Strikes	L95	Mean	U95	Season	Pile Strikes	L95	Mean	U95
summer	1000	0	0	0	summer	1000	0.0766	0.122	0.172
winter	1000	0	0	0.	winter	1000	0.1773	0.273	0.370
summer	2000	0.0316	0.0513	0.074	summer	2000	0.3313	0.5118	0.696
winter	2000	0.0756	0.1219	0.174	winter	2000	0.7097	1.0224	1.291
summer	6400	0.0789	0.1282	0.185	summer	6400	0.8282	1.2794	1.741
winter	6400	0.1889	0.3049	0.436	winter	6400	1.7742	2.556	3.228

APPENDIX 6 – Estimated Area where Cumulative Underwater Sound Levels Exceed 183 dB SEL

Appendix 6. Estimated area where cumulative underwater sound levels exceed 183 dB SEL