United States Department of the Interior

FISH AND WILDLIFE SERVICE

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

JAN 20 2017

In Reply Refer To:
01EWFW00-2016-F-0565
X-Ref: 1-3-04-PI-0803
1-3-05-IC-0607
1-3-06-TA-0300
13410-2010-TA-0233

Michelle Walker
Department of the Army
Seattle District, Corps of Engineers
P.O. Box 3755
Seattle, Washington 98124-3755

Attention: Kristina Tong

Dear Ms. Walker:

This letter transmits the U. S. Fish and Wildlife Service's Biological Opinion on the proposed programmatic consultation for Regional General Permit 6 (RGP-6), Structures in Inland Marine Waters in Washington State, in Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca, and its effects on bull trout (*Salvelinus confluentus*), marbled murrelet (*Brachyramphus marmoratus*), and critical habitat for bull trout. Formal consultation on the proposed action was conducted in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your March 17, 2016, request for formal consultation was received on March 18, 2016.

The enclosed Biological Opinion (Opinion) is based on information provided in the 2016 National Marine Fisheries Services' Biological Opinion for RGP-6, the January 1, 2011 Biological Evaluation, telephone conversations, meetings, email correspondences, field investigations, and other sources of information cited in the Biological Opinion. The Opinion analyzes the effects of your proposal to permit the construction of new permanent structures in Puget Sound and the Strait of Juan de Fuca over the next five years. In this opinion, we conclude that the proposed action is not likely to jeopardize the continued existence of bull trout or marbled murrelets, and would not result in the destruction or adverse modification of designated bull trout critical habitat. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

If you have any questions regarding the enclosed Biological Opinion, our response to your concurrence request(s), or our shared responsibilities under the Endangered Species Act, please contact Lindsy Wright at 360-753-6037, or Martha Jensen at 360-753-9000.

Sincerely,

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

Enclosure(s)

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
01EWFW00-2016-F-0565

Regional General Permit 6
Structures in Inland Marine Waters in Washington State (RGP-6)

Clallam, Jefferson, Island, King, Kitsap, Mason, Pierce, San Juan, Skagit, Snohomish, Thurston, and Whatcom Counties, Washington

Federal Action Agency:

U.S. Army Corps of Engineers

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

Eric V. Rickerson, State Supervisor
Washington Fish and Wildlife Office

1/20/2017
Date

TABLE OF CONTENTS

APPENDICES

Appendix A:	Regional General Permit 6 (RGP-6): Structures in Inland Marine Waters of Washington State
Appendix B:	Bubble Curtain Specifications and Performance Standards
Appendix C:	Hydroacoustic Monitoring Protocol
Appendix D:	Marbled Murrelet Monitoring Protocol
Appendix E:	Status of the Species for Marbled Murrelet
Appendix F:	Status of the Species for Bull Trout
Appendix G:	Status of Critical Habitat for Bull Trout
Appendix H:	Nooksack River Core Area
Appendix I:	Lower Skagit Core Area
Appendix J:	Stillaguamish Core Area
Appendix K:	Snohomish and Skykomish Core Area
Appendix L:	Puyallup Core Area
Appendix M:	Skokomish Core Area
Appendix N:	Dungeness River Core Area
Appendix O:	Elwha River Core Area

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

ACZA	Ammoniacal Zinc Copper Arsenate
BMP	Best Management Practices
CFR	Code of Federal Regulations
CI	confidence interval
Corps	U.S. Army Corps of Engineers
dB	Decibel
DSAY	Discounted Service Acre Years
ESA	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)
FMO	Foraging, Migration and Overwintering
FR	Federal Register
ft	feet
ft^2	square feet
GHG	Greenhouse Gas
HEA	Habitat Equivalency Model
IPCC	Intergovernmental Panel on Climate Change
km	kilometer
km^2	square kilometers
m	meters
mg/L	Milligrams per Liter
NHV	Nearshore Habitat Values Model
NMFS	National Marine Fisheries Service
NWFP	Northwest Forest Plan
NWFPEM	Northwest Forest Plan Effectiveness Monitoring
OHWM	Ordinary High Water Mark
Opinion	Biological Opinion
OWS	Overwater Structures
PAH	Polycyclic Aromatic Hydrocarbons
PBF	Physical or Biological Features
PCE	Primary Constituent Element
PRF	Pier, Ramp, and Float
PSP	Puget Sound Partnership
PSU	Primary Sampling Units
RGP-6	Regional General Permit-6
RMS	Root Mean Squared
SAV	Submerged Aquatic Vegetation
SEL	Sound Exposure Level
SPIF	Specific Project Information Form
SPL	sound pressure levels
TS	Threshold Shift
TSS	total suspended solids
USFWS	United States Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife

(This page intentionally left blank)

INTRODUCTION

This document represents the U. S. Fish and Wildlife Service's (USFWS) Biological Opinion (Opinion) based on our review of the proposed Regional General Permit 6 (RGP-6), Structures in Inland Marine Waters in Washington State located in in Clallam, Jefferson, Island, King, Kitsap, Mason, Pierce, San Juan, Skagit, Snohomish, Thurston, and Whatcom Counties, and its effects on bull trout (*Salvelinus confluentus*), marbled murrelet (*Brachyramphus marmoratus*), and bull trout critical habitat, in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA). The U.S. Army Corps of Engineers' (Corps) March 17, 2016, request for formal consultation was received by the USFWS on March 18, 2016.

This Opinion is based on information provided in RGP-6 (Appendix A), 2011 Biological Evaluation, the Draft National Marine Fisheries Service (NMFS) Biological Opinion, telephone conversations, meetings, email correspondences, field investigations, and other sources of information as detailed below. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

CONSULTATION HISTORY

The following is a summary of important events associated with this consultation:

- On February, 8, 2010, the previous consultation on RGP-6 was due to expire and upon request from the Corps, it was extended through August 2010 (USFWS # 13410-2010-TA-0233).

- Between 2010 and 2016, the Corps, NMFS, and the USFWS to a lesser degree, worked jointly to update RGP-6. The NMFS met with industry practitioners and used the information provided to guide their recommendations to the Corps on structure size and placement in intertidal habitat.

- April 24, 2012, the NMFS received a Biological Evaluation and request for informal consultation from the Corps. The NMFS started the consultation and recognized that the proposed action was not finalized and that the information necessary to complete the consultation was not available. The NMFS notified the Corps on August 2, 2012, that they would initiate consultation as soon as the proposed action had been finalized.

- In 2013, the Corps started drafting a mitigation table based on the NMFS Habitat Equivalency Model (HEA) model.

- In July 2013, the Corps transferred staff responsibility to a different biologist and there was a delay necessary for the new staff biologist to become familiarized with the RGP-6.

- Between August 2013 and September 2015, the public notice for the proposed action was published and the NMFS and Corps coordinated to identify final elements that needed inclusion in the proposed action. These included adding a new category (stairs to facilitate beach access), maintenance actions, Corps monitoring of post-construction conditions, excluding mitigation for indirect effects from boats (the Corps doesn't regulate this), simplifying impacts and mitigation tables, revising duration from habitat impacts to 40 years rather than in perpetuity, and implementing Conservation Measures.

- After an April 30, 2014 meeting, there were major delays in progress because the Corps requested more details on mitigation and impacts to water quality and simplified other components (i.e., submerged aquatic vegetation scenarios).

- February 16, 2016, the Corps forwarded the USFWS a correspondence to NMFS related to RGP-6 content for marbled murrelets.

- February 18, 2016, the USFWS provided comments to the Corps on RGP-6, in which specific information related to limits on the number of impact-pile driving pile strikes were incorporated.

- On March 18, 2016, the Corps submitted an electronic request for consultation containing a final proposed action to the NMFS. Many of the items that the Corps and NMFS had coordinated on were not included in the information submitted in this request (i.e., Specific Project Information Form [SPIF]); however, the NMFS considers this the initiation date for the consultation.

- March 28, 2016, the NMFS and USFWS coordinated via phone regarding mitigation for new pier, ramp, and floats (PRF). On this same date, the NMFS forwarded the USFWS the formal consultation request the Corps had sent to the NMFS, including the final proposed RGP-6. The formal request by the Corps was issued March 17, 2016.

- Between March and September, 2016, the USFWS, NMFS, and the Corps had discussions on how mitigation would be calculated for project effects.

- September 8, 2016, the NMFS sent a final copy of their biological opinion for RGP-6 to the Corps.

- September 13, 2016, the Corps emailed the NMFS and USFWS that they had not reviewed the terms and conditions of the biological opinion, and were not certain yet whether they could implement them.

- September 14, 2016, the NMFS emailed the USFWS a final version of the biological opinion they had completed for RGP-6, which provided details regarding mitigation requirements under RGP-6 that were necessary for the USFWS to complete the consultation.

- September 16, 2016, the Corps emailed the USFWS requesting any terms and conditions of our biological opinion when they were available.

- October 5, 2016, the NMFS provided training on how to calculate mitigation for RGP-6 using the Habitat Equivalency Model (HEA). The NMFS also provided supporting information on how to calculate the mitigation requirements for RGP-6 implementation during the training.

- On October 21, 2016, the USFWS emailed the Corps with comments and edits to NMFS' September 13, 2016, final biological opinion on RGP-6.

- October 21, 2016, the USFWS received confirmation that the Corps had incorporated the USFWS edits into RGP-6.

- November 14, 2016, the NMFS sent correspondence to the South Sound Salmon Enhancement Group inquiring about projects that could fulfill the mitigation requirements for specific projects under RGP-6.

- November 17, 2016, the USFWS emailed the Corps requesting the final determination on the number of strikes per day that would occur when impact pile driving and providing recommendations to RGP-6.

- November 21, 2016, the USFWS received confirmation from the Corps that there would be no more than 300 impact pile strikes per day according to the requirements of RGP-6, which was necessary to complete the effects analysis for underwater sound pressure levels to bull trout and marbled murrelets and that recommendations provided on November 17, 2016, would be included.

- December 1, 2016, the USFWS notified the Corps that there were no terms and conditions in the draft biological opinion.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

A federal action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas (50 CFR 402.02). The Corps is proposing to authorize (permit) construction of new residential overwater structures under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Overwater structures include piers, ramps, and floats (PRFs), mooring buoys, marine rails, open-frame stairways, bluff-to-beach trams, and watercraft lifts in inland marine waters within Washington State for the purpose of private watercraft moorage and water-related recreational use. For the purposes of RGP-6, "new" overwater structures means those placed where there was previously none; this includes modifications to existing structures that expand the footprint. For example, if an existing pier is proposed to be extended 10 ft waterward, the proposed 10 ft must meet all applicable terms and conditions of RGP-6.

For the purposes of this RGP, inland marine waters are defined as tidally influenced waters within the state of Washington limited to the marine waters of Puget Sound, Hood Canal, the Strait of Juan de Fuca, and the Strait of Georgia. These waters include all of Hood Canal, Puget Sound from South Puget Sound near Olympia and Shelton to the Canadian border, including Port Susan, Saratoga Passage, and Skagit Bay on the east side of Whidbey Island, and the Washington State side of the Strait of Juan de Fuca to Cape Flattery. The RGP-6 does not include the urban waterfront of Elliott Bay or sites within 300 feet of an existing or previously designated Superfund Site.

The RGP-6 does not authorize the replacement, repair, modification, or construction of any commercial structures or marinas. It also does not authorize the repair or maintenance of existing residential structures. RGP-6 only applies to inland marine waters of Washington State (i.e., Puget Sound, Strait of Juan de Fuca, and San Juan Islands), and does not apply to any freshwater systems. The purpose of RGP-6 is to expedite authorization of recurring activities that are similar in nature, thereby reducing the amount of time, money, and paperwork involved in issuing individual permits.

The RGP-6 authorizes one new overwater structure per property; however, for a joint-use pier, which can be larger, there are exceptions and further limitations. An "overwater structure" includes piers, ramps, floats, and associated components, including support pilings, chains, anchors, ladders, hand rails, steps, watercraft lifts, mooring buoys, and swim steps. This RGP also authorizes any fill material placed for the purpose of fish habitat enhancement, as required by the Hydraulic Project Approval from the Washington Department of Fish and Wildlife (WDFW). The Corps proposes compensatory mitigation to offset habitat impacts resulting from the existence of the structures.

The Corps' SPIF includes terms and conditions that avoid and minimize impacts, including limits on the sizes and number of structures, limits to the number and sizes of the pilings, minimization of vegetation removal, and working only during approved in-water work windows applicable to the project area. The measures described below are incorporated into the Corps'

SPIF Terms and Conditions, and will reduce the impacts associated with overwater structures that shade submerged aquatic vegetation, reduce water quality, and affect sediment transport:

- Widths of the permanent structures are limited to:
  - 6 ft for joint-use piers and/or stair landings,
  - 4 ft for ramps, single-use piers, and/or stair landings, and
  - 8 ft for floats.
- Lengths of the floats are limited to 60 ft for joint-use floats and 30 ft for single-use PRFs.
- Surfaces must be entirely grated with either multi-directional grating with a minimum of 40 percent open space or square grating with a minimum of 60 percent open space, and have the appropriate orientation to facilitate the highest light transmission possible (e.g. oriented north/south, if possible).
  - Pier surfaces and stairway landings and steps must have 100 percent of their surface area grated with either multi-directional grating with 40 percent open space or square grating with 60 percent open space.
  - Ramps must have 100 percent of their surface area with 40 percent open area or square grating with 60 percent open space across the entire surface.
  - Floats must have a minimum of 50 percent of their surface area with grating that has 40 percent open space or square grating with 60 percent open space.
- Floats may not be installed in the upper shore zone (approximately landward of +5 ft mean lower low water) and float stops are required to suspend the float above the substrate at all tides.
- Stairs must be open-frame construction and not a solid structure (i.e., concrete).
- The only treated wood allowed will be wood treated with ammoniacal copper zinc arsenate (ACZA) according to the "Best Management Practices for the Use of Treated Wood in Aquatic and Wetland Environments," which will reduce leaching. Additionally, the resulting product is certified by an independent third party inspection agency for compliance with these best management practices (BMPs).
  - The proposed action allows for AZCA-treated wood piles to be installed only outside forage fish spawning habitat and/or state-owned aquatic lands.
- The quantities of new piles or embedded anchors for floats is limited to four piles or anchors for single-use floats and eight for joint-use floats (does not include stub piles, of which a maximum of four stub piles can be installed per structure). However, up to a maximum of 20 piles can be installed for a PRF.
- Vibratory pile driving will be the primary means of pile installation, and impact installation/proofing only if necessary.
  - When impact installation/proofing are necessary, a bubble curtain will be used that meets the specifications and performance standards described in Appendix B.

- If impact pile driving exceeds 300 strikes per day, a hydroacoustic monitoring plan (see Appendix C for Hydroacoustic Monitoring Protocol) and/or marbled murrelet monitoring plan (See Appendix D for Marbled Murrelet Monitoring Protocol) will be developed and submitted to the USFWS prior to permit issuance.

- In-water work will be conducted during the approved in-water work window as described by the Corps' website: http://www.nws.usace.army.mil/Missions/Civil-Works/Regulatory/Permit-Guidebook/. For bull trout in marine waters, the current work timing window is July 16 to February 15 of any given year, but any updated work timing window will be on the Corps' website. The presence of potentially suitable and/or documented forage fish spawning habitat truncates the work window depending on location.

Up to 150 new structures may be installed in the project areas over the duration of the programmatic (5 years). Based on the overall total, the USFWS estimates that up to 30 projects may be constructed per year, with a maximum of 20 piles per project. Steel piles will be 12 inches in diameter or less and the total number of impact pile strikes will not exceed 300 per day.

The expected overwater coverage for new PRFs will vary on the sizes of the pier, ramp, and floats. A float for a single-use PRF is limited to 240 ft^2 (8 ft by 30 ft); while a joint-use PRF will be 480 ft^2 (8 ft by 60 ft). The Corps permits many more single-use PRFs than joint-use PRFs. However, the Corps imposes no limits to the length of a pier and ramp because different locations will require them to vary in length depending on the grade of the substrate in the intertidal area. Additionally, county regulations limit piers to 150 to 200 ft in length. Based on the average length of commonly installed structures in Puget Sound, we assume that the average length of a pier and its ramp will be 100 ft. Therefore, the average total overwater coverage for a single-use PRF is 640 ft^2 (100 ft long pier, 4 ft wide is 400 ft^2 plus a 240 ft^2 float) and 980 ft^2 for a joint-use PRF (400 ft^2 ramp plus 580 ft^2 float).

Conservation Measures

Several conservation and mitigation measures of the RGP-6 will reduce impacts to aquatic vegetation and other components of habitat associated with the installation of permanent structures in the nearshore environment. Compensatory mitigation will be required by the Corps as part of the proposed action to reduce cumulative and individual impacts (See Appendix A, RGP-6 Application Form). Additionally, the Corps will ensure compliance with their terms and conditions by annually inspecting structures and the associated compensatory mitigation projects (unspecified quantity). The amount of mitigation needed to offset a particular project will be calculated only after all efforts to avoid and minimize impacts have been exhausted.

The terms and conditions of RGP-6 include calculating the necessary mitigation associated with a new PRF or other overwater structure. The amount of mitigation will be calculated only after it has been demonstrated that impacts have been avoided and minimized. An example of avoidance is situating a pier as far as possible from eelgrass, while fully grating an overwater structure is a minimization measure. The terms and conditions of RGP-6 require that photographs of the lower shore zone be taken of the project area at low tide, from June 1 through October 1 to most accurately reflect vegetation distribution. If the project area is located in dense submerged aquatic vegetation or if native eelgrass (*Zostera marina*) exists on the property where work is proposed, a survey may be required to demonstrate how the project will avoid and minimize impacts. The required process of documenting submerged aquatic vegetation will inform mitigation requirements.

Mitigation

The Corps proposes to require mitigation for direct habitat impacts to NMFS-listed Puget Sound Chinook (*Oncorhynchus tshawytscha*) salmon and Hood Canal summer-run chum salmon (*O. keta*) critical habitat for all applicants using RGP-6. Many of these areas overlap with bull trout critical habitat and/or areas providing prey for bull trout and marbled murrelets. Mitigation for project-related direct effects is a requirement for participation in the program and can occur off-site or on-site. Required mitigation will be proportional to structure size and amount of grating. The Corps did not propose mitigation for indirect effects of PRFs, such as the effects of boats using the PRFs for moorage because regulating boat use is outside of their statutory authority.

Mitigation includes on-site enhancements, including riparian plantings, placing spawning gravel, installing large woody material, removing pilings, removing existing overwater structures, removing bank stabilization, removing boat ramps, and removing rails. All on-site mitigation will occur within the recommended in-water work windows. Additionally, on-site mitigation in intertidal areas will occur in the dry, at low tide, and outside of forage fish spawning times. Proposed off-site mitigation includes removal of man-made groins as well as purchasing credits from third-party mitigation sources. The benefits of off-site mitigation can be used to offset habitat impacts from the actions proposed under RGP-6. Considering that impacts from new structures are expected to endure for at least 40 years, mitigation requirements are calculated using the NMFS Habitat Equivalency Model (HEA Model) and the Nearshore Habitat Values Model (NHV) (Ehinger 2016).

Major considerations and assumptions of calculating mitigation according to these two NMFS models include:

1. Habitat degradation can be offset by better mitigating for the residual functional deficits to habitat that remain after avoidance and minimization measures have been implemented.
    a. Mitigation options include riparian plantings, in-water structure removal, withdrawals from established fish conservation banks, contributions to in-lieu fee programs, withdrawals from Corps and U.S. Environmental Protection Agency-approved wetland mitigation banks, and contributions to fully designed projects sponsored by non-profit habitat restoration entities.

2. Using a repeatable methodology for calculating the quantity of habitat lift needed to offset habitat degradation will increase consistency and the ability to implement mitigation.
    a. The HEA model assumes the value and area of restored or enhanced habitat for mitigation purposed, the time required for the habitat to reach full function, and the time the subject habitat will exist in the state evaluated.
    b. Functional value of the altered habitat is assumed to differ depending on the role it serves in supporting the life history elements of the species using it.
    c. The HEA model is intended for use in determining habitat value over the long term, not for short-term impacts, such as those associated with short-term construction-related effects such as increased suspended sediment and elevated underwater sound from impact pile driving.

3. Habitat currency is described in terms of a dimensionless unit called a "Discounted Service Acre Years" (DSAY), in which a debt is a functional loss in ecosystem services that are withdrawn or made inaccessible when habitat is impacted. The number of DSAYs lost from impacts to habitat indicates the quantity of restoration of functional habitat would be needed to offset the lost habitat functions.

4. Common currency to express functional habitat loss and gain is known as ecological equivalency, which assumes that the ecological functions and services for a species or group of species that are gained from habitat at a restored site fully offset the functions and services lost at an impacted site, when full function at the restored site are incorporated into the analysis. There is not necessarily a one-to-one trade-off in terms of specific resources but rather in the services they provide for the species adversely impacted. For example, reductions in productivity from shading intertidal habitat can be offset with the productivity provided by riparian plantings (i.e., litter fall, large wood and insects).

5. The NHV model determines the functional value of nearshore habitat at site-specific scales. The NHV model considers the functions the habitat provides for foraging, refuge, water quality, and migration. NHV model outputs are used as input into the HEA model to determine the ecological gains and losses associated with impacts to habitat (calculate mitigation).

6. Habitat modifications that trigger the need for mitigation include adding or removing: riparian vegetation; impervious surface in riparian corridors; shoreline armoring; nearshore fill, including pilings; shading from overwater structures; and impacts to sediment quality, transport, and sorting associated with installation of permanent structures in nearshore areas.

For a complete description of the methodology and assumptions made in the HEA and NHV modeling, please refer to the final draft "Use of the Puget Sound Nearshore Habitat Values Model with Habitat Equivalency Analysis for Characterizing Impacts and Avoidance Measures for Projects that Adversely Affect Critical Habitat of ESA-listed Chinook and Chum Salmon" (Ehinger 2016).

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). Activities associated with RGP-6 will occur throughout Puget Sound, the San Juan Islands, Hood Canal and the Strait of Juan de Fuca. The limits of the action area would include all underwater areas that will be ensonified from the installation of piles that are installed to support the PRFs and other associated structures. The presence of boats, including jet skis, and the use of them are indirect effects of the action, as we are reasonably certain that the new structures will increase the abundance and use of boats in Puget Sound, Strait of Juan de Fuca, and the San Juan Islands. The express purpose of marine rails, boat lifts, and mooring buoys are to store and facilitate use of recreational watercraft in the nearshore and provide access to the water. Therefore, but for these structures, boat use in Puget Sound, Strait of Juan de Fuca, and the San Juan Islands would be more difficult, restricted to marinas or public access points, and a greater percentage of shoreline residents would likely not access the water, or they would access the water at a reduced frequency.

In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. The action area for this proposed federal action is based on the geographic extent of increased vessel traffic, which is expected to be the furthest-ranging effect. The action area encompasses all areas affected by the action, including all riparian areas, shoreline, and all waters, shallow and deep, of the Puget Sound, Strait of Juan de Fuca, and the San Juan Islands. Most stressors will concentrate in the vicinity of each structure (pier/ramp/float, marine rail, staircase, watercraft lift, or buoy), and/or extent of elevated underwater sound pressure levels (SPLs) from impact pile driving. However, other stressors may extend beyond the immediate vicinity. For example, reductions in forage base, increases in predator populations, increased depredation from non-lethal exposure (e.g., temporary threshold shift) and reduced ability to detect and evade predators), and effects from increased boating activity.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

The following analysis relies on the following four components: 1) the *Status of the Species*, which evaluates the rangewide condition of the listed species addressed, the factors responsible for that condition, and the species' survival and recovery needs; 2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species; 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 species; and 4) *Cumulative Effects*, which evaluates the effects of future, non-federal activities in the action area on the species.

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 species' 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 listed species in the wild.

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

Adverse Modification Determination

Section 7(a)(2) of the ESA requires that Federal agencies insure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. A final rule revising the regulatory definition of "destruction or adverse modification of critical habitat" was published on February 11, 2016 (USFWS and NMFS 2016). The final rule became effective on March 14, 2016. The revised definition states: "Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features."

Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), "physical or biological features" (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (79 FR 27066) discontinue use of the terms "PCEs" or "essential features," and rely exclusively on use of the term "PBFs" for that purpose because that term is contained in the statute. However, the shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features. For those reasons, in this biological opinion, references to PCEs or essential features should be viewed as synonymous with PBFs. All of these terms characterize the key components of critical habitat that provide for the conservation of the listed species.

Our analysis for destruction or adverse modification of critical habitat relies on the following four components: 1) the Status of Critical Habitat, which evaluates the range-wide condition of designated critical habitat for the Choose an item. in terms of essential features, PCEs, or PBFs, depending on which of these terms was relied upon in the designation, the factors responsible for that condition, and the intended recovery function of the critical habitat overall; 2) the Environmental Baseline, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; 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 essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units; and 4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on the essential features, PCEs, or PBFs and how those effects are likely to influence the recovery role of affected critical habitat units.

For purposes of making the destruction or adverse modification finding, the effects of the proposed federal action, together with any cumulative effects, are evaluated to determine if the critical habitat rangewide would remain functional (or retain the current ability for the PBFs to be functionally re-established in areas of currently unsuitable but capable habitat) to serve its intended conservation/recovery role for the bull trout.

STATUS OF THE SPECIES: Marbled Murrelet

Marbled murrelet populations have declined at an average rate of 1.2 percent per year since 2001. The most recent annual population estimate for the entire Northwest Forest Plan (NWFP) area ranged from about 16,600 to 22,800 marbled murrelets during the 14-year period, with a 2013 estimate of 19,700 marbled murrelets (95 percent confidence interval [CI]: 15,400 to 23,900 birds) (Falxa and Raphael 2015, p. 7). While the overall trend estimate was negative (-1.2 percent per year), this trend was not conclusive because the confidence intervals for the estimated trend overlap zero (95 percent CI:-2.9 to 0.5 percent), indicating the marbled murrelets population may be declining, stable, or increasing at the range-wide scale (Falxa and Raphael 2015, pp. 7-8). Annual reports with population estimates have been released since the 2015 report by Falxa and Raphael (2015); however, these reports did not also provide trend information. Therefore, some of the data cited in this Opinion was used to predict current abundance of marbled murrelets based on the most recent population abundance estimates, but the trend information comes from previous reports (Falxa and Raphael 2015).

Marbled murrelet population size and marine distribution during the summer breeding season is strongly correlated with the amount and pattern (large contiguous patches) of suitable nesting habitat in adjacent terrestrial landscapes (Falxa and Raphael 2015, p. 156). Monitoring of marbled murrelet nesting habitat within the NWFP area indicates nesting habitat has declined from an estimated 2.53 million acres in 1993 to an estimated 2.23 million acres in 2012, a total decline of about 12.1 percent (Falxa and Raphael 2015, p. 89). The largest and most stable marbled murrelet subpopulations now occur off the coast of Oregon and northern California, while subpopulations in Washington have experienced the greatest rates of decline (-5.1 percent per year; 95 percent CI: -7.7 to -2.5 percent) (Falxa and Raphael 2015, p. 8-11). Rates of nesting habitat loss have also been highest in Washington, primarily due to timber harvest on non-federal lands (Falxa and Raphael 2015, p. 124), which suggests that the loss of nesting habitat continues to be an important limiting factor for the recovery of marbled murrelets.

Factors affecting marbled murrelet fitness and survival in the marine environment include: reductions in the quality and abundance of marbled murrelet forage fish species through overfishing and marine habitat degradation; by-catch in gillnet fisheries; marbled murrelet entanglement in derelict fishing gear; oil spills; and high levels of underwater SPLs generated by pile-driving and underwater detonations (USFWS 2009, pp. 27-67). While all of these factors are recognized as stressors to marbled murrelets in the marine environment, the extent that these stressors affect marbled murrelet populations is unknown (USFWS 2012). As with nesting habitat loss, marine habitat degradation is most prevalent in the Puget Sound area where anthropogenic activities (e.g., shipping lanes, boat traffic, and shoreline development) are an important factor influencing the marine distribution and abundance of marbled murrelets in Conservation Zone 1 (Falxa and Raphael 2015, p. 163).

For a detailed account of marbled murrelet biology, life history, threats, demography, and conservation needs, refer to Appendix E: Status of the Species for the Marbled Murrelet.

STATUS OF THE SPECIES: Bull Trout

The bull trout was listed as a threatened species in the coterminous United States in 1999. Throughout its range, bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, incidental angler harvest; entrainment and introduced non-native species (64 FR 58910 [Nov. 1, 1999]). Since the listing of bull trout, there has been very little change in the general distribution of bull trout in the coterminous United States, and we are not aware that any known, occupied bull trout core areas have been extirpated (USFWS 2014, p. iv).

Five segments of the coterminous population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2002, pp. iv, 2, 7, 98; 2004a, Vol. 1 & 2, p. 1; 2004b, p. 1). Each of these interim recovery units is necessary to maintain the bull trout's distribution and its genetic and phenotypic diversity. Each of the interim recovery units are further organized into multiple bull trout core areas, which are mapped as non-overlapping watershed-based polygons, and each core area includes one or more local populations. On September 4, 2014, the USFWS announced the availability of a revised draft recovery plan for the coterminous U.S. population of bull trout (79 FR: 52741). This revised plan focuses on the identification and management of known threat factors in core areas in six proposed recovery units. The revised draft recovery plan updated the recovery criteria. The plan was finalized September 28, 2015 (U.S. Fish and Wildlife Service 2015).

The USFWS has also identified a number of marine or mainstem riverine habitat areas outside of bull trout core areas that provide foraging, migration, and overwintering (FMO) habitat that may be shared by bull trout originating from multiple core areas. These shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas.

For a detailed account of bull trout biology, life history, threats, demography, and conservation needs, refer to the Rangewide Status of the Species for Bull Trout in Appendix F.

STATUS OF CRITICAL HABITAT: Bull Trout

The USFWS published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (70 FR 63898); the rule became effective on November 17, 2010. The scope of the designation involved the species' coterminous range. Rangewide, the USFWS designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat. Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering.

The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63898:63943 [October 18, 2010]). Critical habitat units generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

The final rule excludes some critical habitat segments. Critical habitat does not include: 1) waters adjacent to non-federal lands covered by legally operative incidental take permits for habitat conservation plans issued under section 10(a)(1)(B) of the ESA, in which bull trout is a covered species on or before the publication of this final rule; 2) waters within or adjacent to tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the tribes indicated that inclusion would impair their relationship with the USFWS; or 3) waters where impacts to national security have been identified (75 FR 63898).

Within the designated critical habitat areas, nine primary constituent elements (PCEs) have been identified for bull trout. These PCEs are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering.

Factors that contribute to degrade the PCEs and are appear to be particularly in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to dams and water diversions; 2) degradation of spawning and rearing habitat from forest and rangeland practices and intensive development of roads; 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout; 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

For a detailed account of bull trout critical habitat, refer to Appendix G: Status of Critical Habitat for Bull Trout.

ENVIRONMENTAL BASELINE:

Regulations implementing the ESA (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 action area includes all riparian shoreline areas and waters of Puget Sound, Hood Canal, the Strait of Juan de Fuca, and the San Juan Islands. Shoreline habitat in these areas has been continuously developed for residential, commercial, recreational, and municipal purposes. Different indicators of ecosystem health have been researched by the Puget Sound Partnership (PSP), described in detail in the State of the Sound biannual report (Puget Sound Ecological Fire Partnership 2015). Their research tracks a variety of metrics used to assess and measure progress toward enhancement goals. Conclusions the PSP have made are that development pressure continues to impact habitat in the marine and freshwater portion of the range, improvements in human use patterns are slow at best, and few of the 2020 improvement targets identified by the PSP will be reached. This most recent report points out the following unresolved issues:

- Declining Pacific herring (*Clupea pallasii*) stocks.
- Continuing loss of non-federal forested land cover to developed land cover.
- Shoreline armoring was stable between 2011 and 2014, there was no recent net increase, and restoration actions are balancing out the increase from private shoreline armoring. However, the data is insufficient to determine this, and declines in private shoreline armoring could be related to poor economic conditions.
- Accelerated conversion/loss of vegetation cover on ecologically important lands for 2006-2011 was over double (0.36 percent) the conservative 2020 target of less than 0.15 percent of the total 2011 baseline land area over a 5-year period.
- Marine water quality trends have been getting worse with closures of beaches and shellfish harvest in some bays. While there has been some increase between 2011 and 2014 in the amount of shellfish beds open to harvest, about 19 percent are still closed and PCB levels in fish are still high.
- Native Eelgrass (*Zostera marina*) abundance seems stable comparing 2011 to 2013 data to baseline from 2000 to 2008. However, this does not account for losses that occurred prior to 2000.
- Human behaviors have not changed, indicating that an increase in population is likely to continue to degrade habitat quality because human use practices that likely affect habitat and water quality and quantity. These practices include the use of non-native vegetation in riparian areas, introducing wastewater into marine areas, using herbicides and pesticides, keeping livestock near riparian areas, and many other activities.

- Overwater structures (OWS) were not assessed; however, the current percent of nearshore coverage is 0.63 percent for all of Puget Sound, as detailed below (Table 1). OWS include large industrial/commercial docks, family residence docks, floating docks, fixed piers, bridges, floating breakwaters, moored vessels, but not marinas, which are listed separately.

Table 1. Area and quantity of overwater structures in Puget Sound

Puget Sound Sub-basins (Figure 1)	**Number of Overwater Structures *(and Marinas)***	**Number of Structures Per Kilometer of Shoreline**	**Area of Overwater Structures *(Marinas)* (km^2)**	**Total Area of OWS including marinas (km^2)**	**Nearshore Area (km^2)**	**Percent of Nearshore Area Coverage for OWS & Marinas combined**
Strait of Juan de Fuca	213 *(4)*	0.8	0.2 *(0.2)*	0.43	181.4	0.2
San Juan Islands/Strait of Georgia	1,180 *(40)*	1.2	1.2 *(2.0)*	3.26	580.3	0.6
Hood Canal	911 *(8)*	2.8	0.3 *(0.1)*	0.48	154.5	0.3
Whidbey	654 *(28)*	1.2	0.8 (1.0)	1.81	549.5	0.3
North Central Puget Sound	374 *(6)*	1.8	0.2 *(0.2)*	0.6	112.8	0.5
South Central Puget Sound	2,040 *(67)*	4.1	3.7 (*3.1)*	6.78	262.9	2.6
South Puget Sound	1,781 *(26)*	3.2	0.5 *(0.3)*	0.85	287.3	0.3
***Puget Sound Basin*[11]**	**6,927** *(171)*	**2.3**	**6.45 *(6.3)***	12.78	**2,035.8**	**0.63**

Schlenger et al. (2011) & Simenstad et al. (2011)

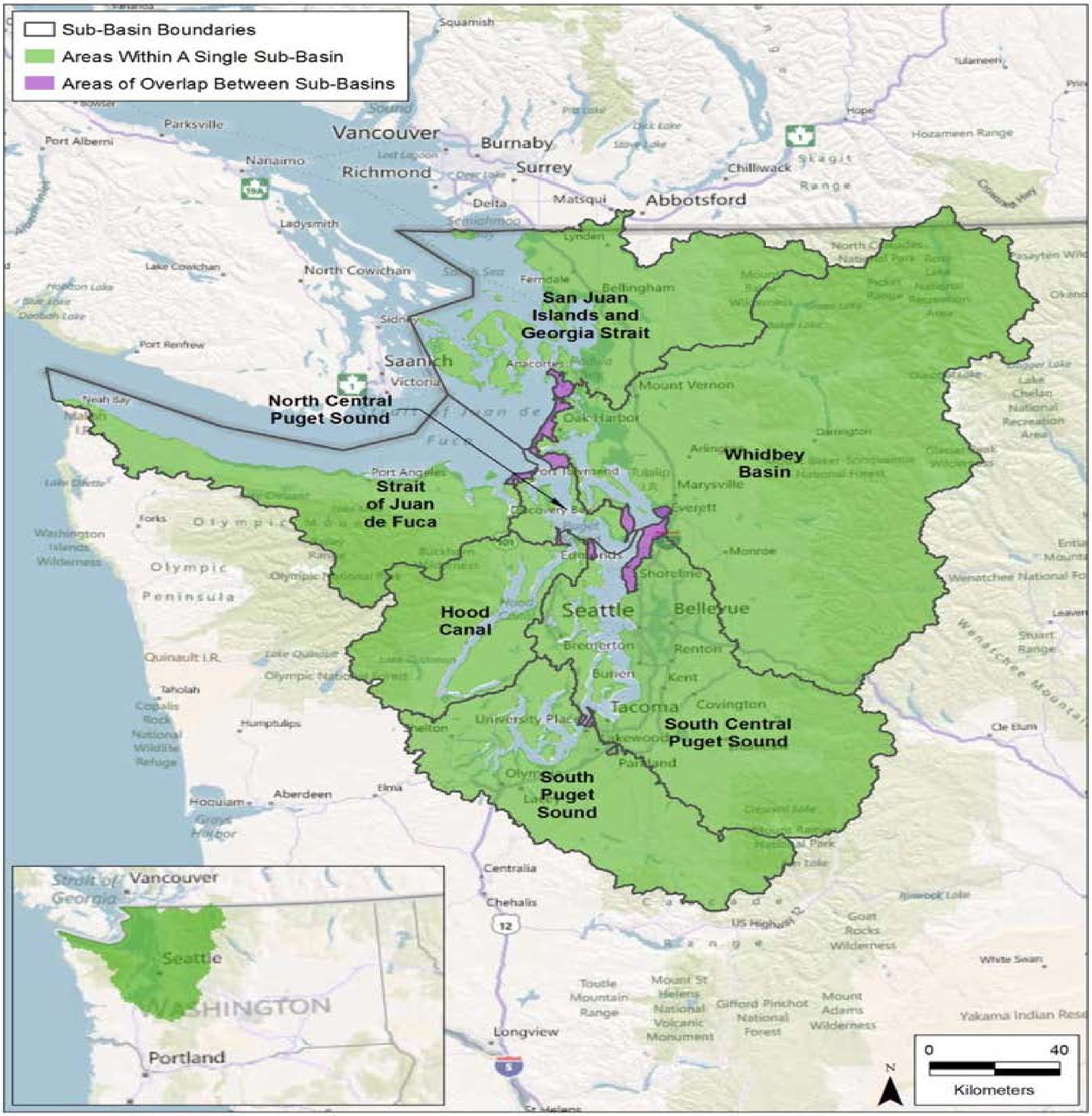

Figure 1. Puget Sound sub-basin boundaries

Habitat conditions and the abundance of native species continue to decline from development and climate change (Puget Sound Ecological Fire Partnership 2015). Over the last 150 years 4.5 million people have settled in the Puget Sound region. The condition of nearshore areas demonstrate the significant alteration that has occurred from installing the infrastructure associated with this population increase. Major physical changes include the simplification of river deltas, the elimination of small coastal bays, the reduction in sediment supplies to the foreshore due to beach armoring, and the loss of tidally influenced wetlands and salt marsh (Fresh et al., 2011).

Shoreline armoring often results in increased beach erosion waterward of the armoring, which, in turn, leads to beach lowering, coarsening of substrates, increases in sediment temperature, and reductions in invertebrate density (Dethier et al. 2016). New shoreline armoring continues to reduce the suitable habitat for Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*), spawning and may reduce their numbers. Fresh et al. (2011) write “We can only surmise how much forage fish spawning habitat we have lost because we lack comprehensive historical data on spawning areas.” Considering that these forage fish are an essential food source for bull trout and marbled murrelets, the beach armoring has multiple negative effects, including reductions in prey and access to shallow water rearing habitat and refuge for forage fish.

Habitat quality is reduced by beach armoring, overwater structures, marinas, roads, and railroads. The amount of these changes varies, but is generally correlated with development and overall is staggering (Simenstad et al., 2011). The simplification of the largest river deltas has caused a 27 percent decline in shoreline length compared to historical conditions. Of 884 historic small embayments, 308 have been eliminated. Approximately 27 percent of Puget Sound shorelines are armored and only 112 of 828 shoreline segments remain in properly functioning condition. The loss of tidal wetlands in the largest deltas averages 26 percent (Fresh et al., 2011). Each of these habitat changes is related to development and overall reduces the quality and quantity of habitat for bull trout, marbled murrelets, and their prey resources.

Status of the Species and Critical Habitat in the Action Area

Marbled Murrelet

The action area encompasses the marine environment of the Strait of Juan de Fuca, San Juan Islands, Hood Canal, and Puget Sound, which is entirely encompassed by Conservation Zone 1 of Northwest Forest Plan Effectiveness Monitoring (NWFPEM) (Figure 2). For a discussion of the range-wide status of the marbled murrelet, see Appendix E. The environmental baseline analysis for the marbled murrelet also addresses the relationship of the current condition and conservation role of the action area to marbled murrelet recovery units. The *Recovery Plan for the Marbled Murrelet* identifies 6 broad “Marbled Murrelet Conservation Zones” across its range. These Conservation Zones were assigned recovery goals and objectives (USFWS 1997, p. 114) and, on that basis, they functions as recovery units. Their assigned conservation role is to support persistent populations of the marbled murrelet across its range.

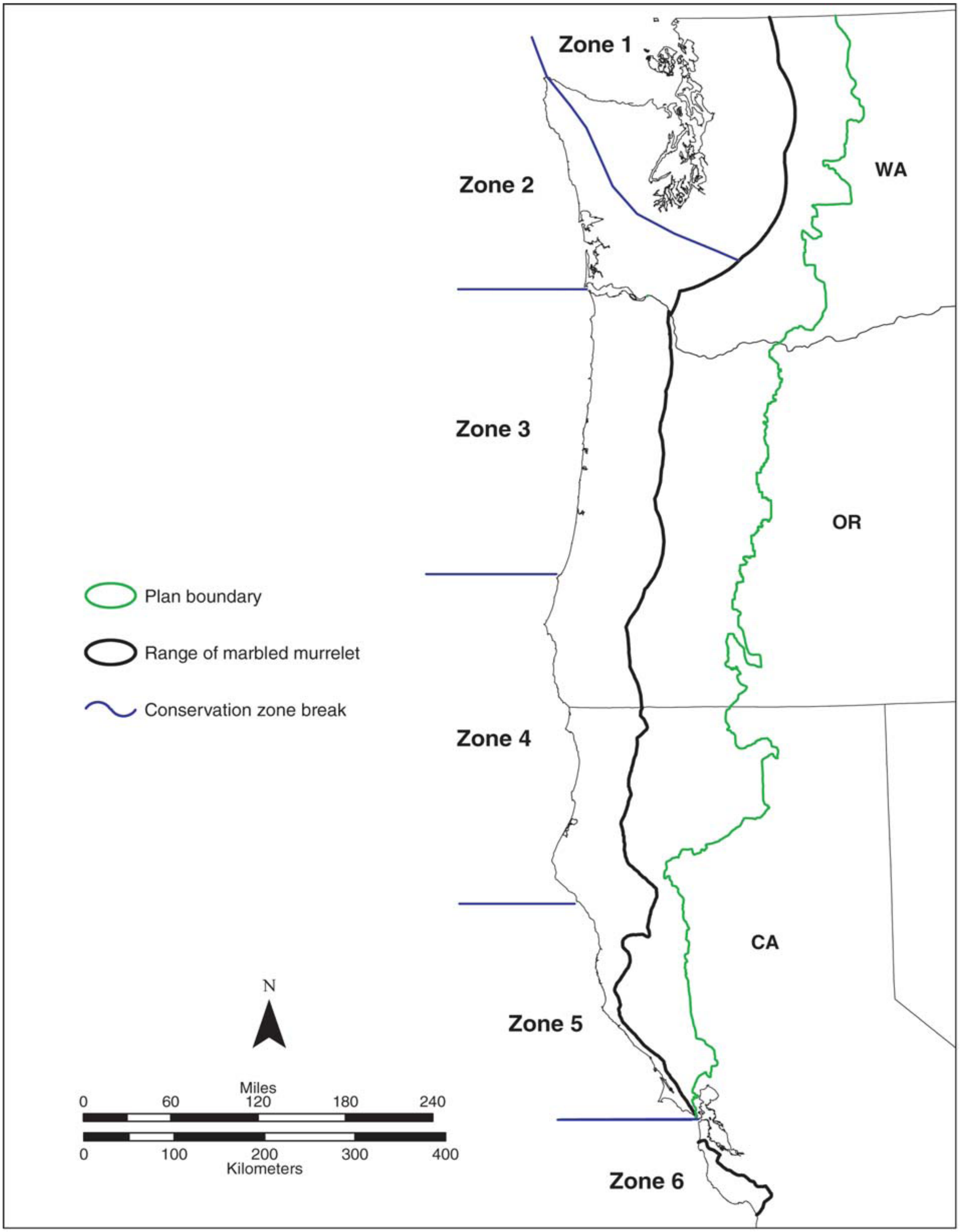

Figure 2. Marbled murrelet conservation zones in the NWFP
(USFWS 1997)

Declining abundance of marbled murrelets is primarily due to loss of nesting habitat and degraded marine habitat conditions, which has lowered reproductive success. The action area includes marine areas that provides year-round foraging habitat and is considered essential to marbled murrelet survival and recovery. The information we considered in our exposure analysis is summarized below and it specifically relates to marbled murrelet occurrence and use of the marine environment in the action area. Bird density is typically reported in birds per km^2 and our exposure analysis describes area in marine waters as km^2 to allow easier synthesis of effects regarding number of birds exposed and the area of effect.

Telemetry studies indicate that some mixing of marbled murrelet subpopulations occurs between Conservation Zones 1 and 2 (Bloxton and Raphael 2006). However, it is impossible to know whether a marbled murrelet observed in Conservation Zone 1 originated from another Conservation Zone. With the possible exception of Zone 6, the Conservation Zones are not necessarily occupied by discrete subpopulations of the marbled murrelet; however, for management and consultation purposes, the USFWS uses the Conservation Zones as a way to divide and describe marbled murrelet populations into discrete segments that are recognized as Recovery Units for purposes of the jeopardy analyses under section 7(a)(2) of the ESA. We expect there is some movement of individual marbled murrelets between zones, although there is insufficient telemetry data to quantify the frequency or extent of that movement. For the purposes of our analysis, we assume that marbled murrelets in Conservation Zone 1 do not mix with the other Conservation Zones to a degree that would influence population abundances.

Much of what we know about marbled murrelet use of the marine environment comes from long-term population trend sampling for the NWFP effectiveness monitoring program (NWFPEM). To monitor population trends, the Forest Service conducts an annual census of marbled murrelets at-sea, along the coasts of Washington, Oregon, and California, and in inland waters including the Strait of Juan de Fuca, Hood Canal, the San Juan Islands, and Puget Sound. The sampling plan divides each conservation zone into strata and then each stratum is further refined into smaller primary sampling units (PSUs; Figure 3); the strata are surveyed at the scale of the PSU. Marbled murrelet densities can then be estimated, but only at the stratum level, not at the smaller PSU scale. The PSU sampling scheme was carefully designed to provide information about densities only at the larger stratum level. Marbled murrelet occurrence in the marine environment is highly variable and the density information is only intended to inform a long-term trend analysis.

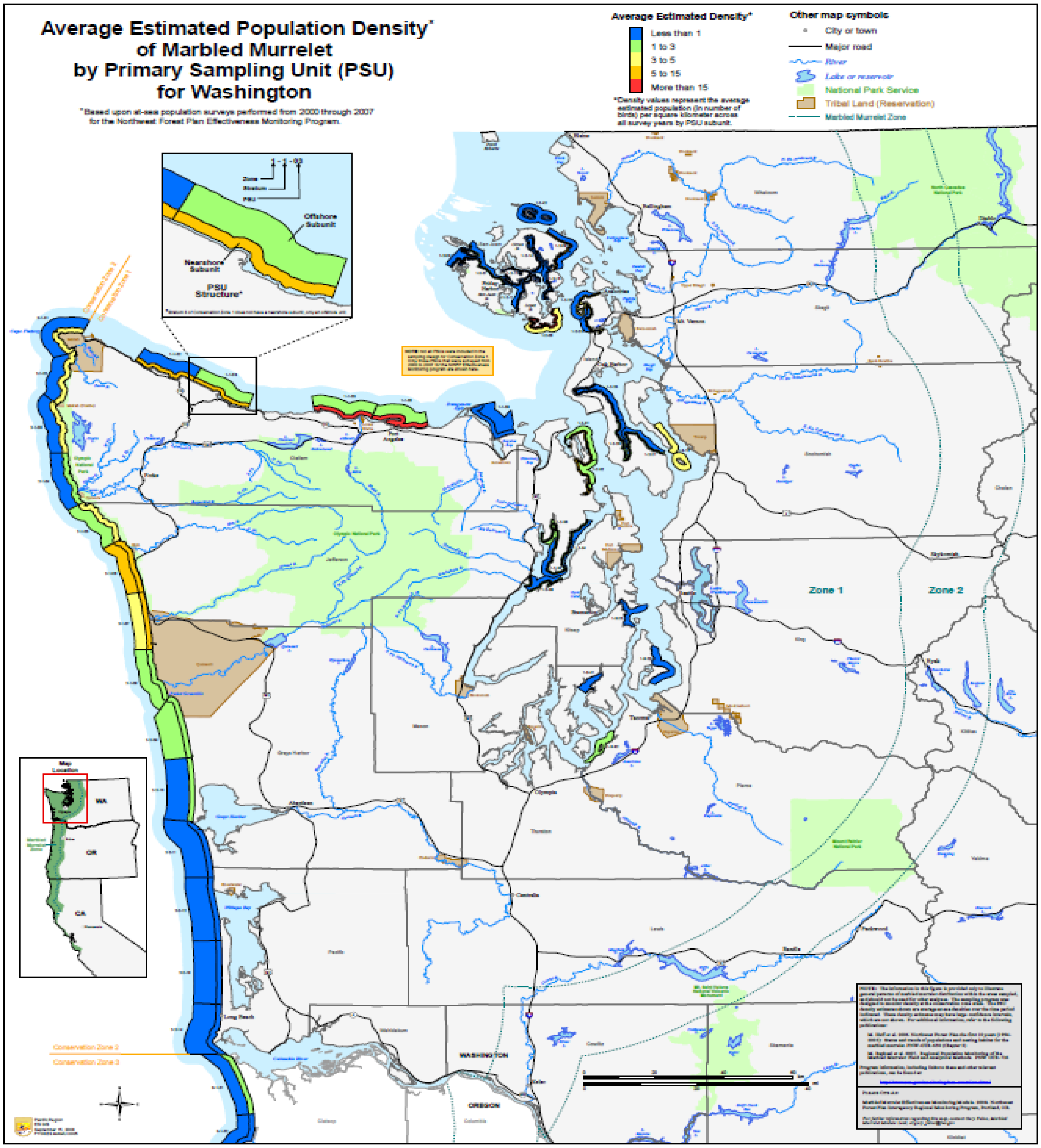

Figure 3. PSUs for at-sea survey of marbled murrelets in Washington
(Falxa et al. 2009)

Using density information at the scale of the PSU introduces error and uncertainty when used to predict probability of exposure. The sampling protocol for the NWFPEM was only designed to determine long-term marbled murrelet population trends, not to estimate marbled murrelet density. Each PSU is typically sampled only once or twice in a given year, which is inadequate to determine a density estimate at the individual PSU scale unless several years of data are averaged. More appropriate use of the data is to average several years at the stratum level or Conservation Zone level to reduce the amount of error. We average the most recent 5 years of data to calculate probability of exposure, which results in more accurate estimates of marbled murrelet density. We use density data at the scale of the stratum or Conservation Zone (whichever is most appropriate) to describe the baseline conditions for the marbled murrelet within an action area.

We assume the primary driver of marbled murrelet presence in the marine environment is prey availability. Prey availability varies depending on a variety of factors, but especially upwelling conditions created by seawater temperature changes and seafloor topography. The foraging habits of marbled murrelets change depending on whether they are nesting and provisioning young or just feeding themselves. When breeding, they tend to forage closer to shore, primarily on small pelagic fish. This allows them to efficiently provision young. During the non-breeding season, they disperse and can be found much farther offshore foraging on both small fish and crustaceans.

Marbled murrelets are known to consume prey from at least 27 taxa; however, the diet is much less diverse at the small (local) scale (McShane et al. 2004, p. 5-7). Marbled murrelet diet north of Washington State is thought to be dominated by sand lance, Pacific herring, and capelin (*Mallotus villosus*), while in the southern portions of the range it is dominated by northern anchovy (*Engraulis mordax*), surf smelt, night smelt (*Spirinchus starksi*), and herring (McShane et al. 2004, p. 5-9). Marbled murrelets incidentally salvaged from gill nets in Washington State (mainly the Strait of Juan de Fuca) had diets that were approximately 86 percent sand lance and 14 percent Pacific herring (Grettenberger et al. 1998).

Conservation Zone 1 encompasses all of Puget Sound, Hood Canal, the San Juan Islands, and the Strait of Juan de Fuca. During the breeding season, marbled murrelets tend to forage in well-defined areas close to suitable nesting habitat. They are found in the highest densities in the nearshore waters of the San Juan Islands, Rosario Strait, the Strait of Juan de Fuca, Admiralty Inlet, and Hood Canal. They are more sparsely distributed elsewhere in Puget Sound, with smaller numbers observed during different seasons within the Nisqually Reach, Possession Sound, Skagit Bay, Bellingham Bay, and along the eastern shores of the Strait of Georgia. In the most southern end of Puget Sound, they occur in extremely low numbers. During the non-breeding season, they typically disperse and are found farther from shore (Strachan et al. 1995).

It appears that marbled murrelets from Vancouver Island, British Columbia move south into the more sheltered waters of Puget Sound and the Strait of Georgia, which contributes to the increased numbers of marbled murrelets observed in northern Puget Sound in the fall and winter (Burger 1995). Surveys along the southern shore of the Strait of Juan de Fuca conducted by the WDFW from 1996-1997 (Thompson 1997) showed an increase in the number and group size of marbled murrelets in August in the eastern Strait of Juan de Fuca, although numbers declined in the western portion of the Strait of Juan de Fuca. Surveys of near-shore waters in the San Juan Islands (Evans and Assoc. Inc. 1999; Ralph et al. 1995) showed a similar increase in abundance in August and September (end of the breeding season when both adults and fledglings are on the water). Increases in abundance have been detected as well in September and October during surveys in Admiralty Inlet, Hood Canal, Saratoga Passage, and Possession Sound (Merizon et al. 1997). A breeding marbled murrelet, banded in Desolation Sound in summer, was recovered near Orcas Island in September, and then detected in Desolation Sound the following year (Beauchamp et al. 1999).

Since 2000, the estimated population size for Conservation Zone 1 has ranged from a low of 2,822 marbled murrelets in 2014 to a high of 9,758 in 2002 (Lynch et al. 2016, p. 13). The most recent (2015) estimated population for Conservation Zone 1 is 4,290 marbled murrelets. For the estimated population of 4,290 marbled murrelets, 2,783-6,492 are the upper and lower 95 percent CIs, see (Lynch et al. 2016) for the data (Lance and Pearson 2016, p. 4; Lynch et al. 2016, p. 13). Since 2001, the estimated marbled murrelet density in Conservation Zone 1 has ranged from 0.81 to 2.79 marbled murrelets per km^2, with the most recent (2015) density of 1.23 birds per km^2 (Lynch et al. 2016, p. 13).

Additional data on marbled murrelet abundance and distribution come from multiple sources that employ a variety of survey methods to answer various research questions. The estimated post-fledging juvenile-to-adult ratios were derived from a comprehensive survey in the month of August (Stein and Nysewander 1999). Merizon et al. (1997) focused on marbled murrelet numbers and distributions in areas where fall tribal fisheries occurred. Estimates of marbled murrelet densities was derived from summer boat (1992-1999) and winter aerial (1993-2005) sampling of seabird populations undertaken by the WDFW under the Puget Sound Ambient Monitoring Program.

We expect marbled murrelet density to be higher during the winter months in the nearshore waters of northern and eastern Puget Sound. Marbled murrelet density is anticipated to be the lowest near the most southern end of Puget Sound. The most recent estimate of the population in inland waters (Conservation Zone 1, all Stratums) is 4,290 marbled murrelets, with a density of 1.23 marbled murrelets per km^2.

Summary of Marbled Murrelet Marine Distribution in the Action Area

Based on the above discussion and referenced information on marbled murrelet use of marine habitats, and the discussion in the *Status of the Species* section for the marbled murrelet, the USFWS has made the following findings regarding the distribution of the marbled murrelet population in the action area:

1. During the breeding season, marbled murrelets are located primarily in nearshore areas, typically within 5 km (2.7 nm) of landscapes that provide large areas of nesting habitat. Approximately 95 percent of the population occurs in this nearshore zone during the breeding season, while the remaining 5 percent are assumed to be dispersed in offshore areas farther than 5 km (2.7 nm), but not beyond the continental shelf (Bentivoglio et al. 2002, pp. 22, 29, 34, 40; Menza et al. 2015, p. 49).

2. Seasonal movements and redistribution of marbled murrelets occurs during the fall and winter months. In Puget Sound, there is evidence that marbled murrelet densities increase as marbled murrelets from the outer coasts of Washington and British Columbia move into the protected, inland waters of Puget Sound (Speich and Wahl 1995). For the purpose of this analysis, the USFWS assumes the density of marbled murrelets in Conservation Zone 1 increases by a factor of 1.83 during the non-breeding season.

3. For this analysis, the USFWS assumes that birds present in Conservation Zone 1 are isolated from Zones 2, 3, 4, and 5. We know birds within Conservation Zone 1 exhibit seasonal movements as well, but for the quantitative analysis, we assume the Zone 1 subpopulation remains within Zone 1 year-round.

Bull Trout

Anadromous adult and subadult bull trout may utilize all marine waters of the action area for foraging, migrating, and overwintering. The extent of this utilization is poorly understood; however, Kraemer (1994) speculated that bull trout distribution in marine waters depends on the distribution of forage fish and their spawning beaches. Anadromous bull trout prey on surf smelt, Pacific herring, sand lance, juvenile salmonids, and other small schooling fish while in the marine environment (Kraemer 1994; WDFW 1997). These prey species are present within the action area. Although foraging bull trout may tend to seasonally concentrate in forage fish spawning areas, they can be found throughout accessible estuarine and nearshore habitats.

Anadromous bull trout may seek and find more abundant forage in marine waters than in rivers (Kraemer 1994). As bull trout populations increase in abundance and competition for prey increases, individual bull trout may also forage more extensively and over greater distances in the marine environment (Chan, in litt. 2013). Kraemer (1994) also found bull trout in the marine environment as far as 40 kilometers (25 miles) from their natal stream. McPhail and Baxter (1996) documented a char traveling as far as 150 kilometers (93 miles) through marine waters from the Squamish River in British Columbia to the Skagit River in Washington.

We expect that some level of mixing or interaction within marine waters occurs among anadromous individuals from various core areas. Although studies have documented bull trout moving into non-natal rivers via marine waters (WDFW 1997; Goetz in litt. 2003), we do not understand the full extent of this behavior. On October 31, 2006, a 607 mm tagged bull trout was observed in the Snohomish River; by November 25, it migrated into the lower Duwamish River (approximately 35 mi [55 km]) where it stayed until the end of December (Goetz et al. 2012). The bull trout then migrated back to the Snohomish River by the end of January. The bull trout left the Duwamish River on December 27 and stayed within the action area until January 7, where it was located offshore of West Point, just north of Elliott Bay.

Based on these studies, anadromous bull trout from several different core areas may be present within the action area simultaneously. Bull trout in the Strait of Juan de Fuca and Puget Sound may come from multiple watersheds of western Washington that flow into these marine waters. The status of bull trout and habitat at the scale of each core area, where bull trout may come from, is described in the Appendices listed below:

- Appendix H: Nooksack River Core Area
- Appendix I: Lower Skagit River Core Area
- Appendix J: Stillaguamish River Core Area
- Appendix K: Snohomish and Skykomish Rivers Core Area

- Appendix L: Puyallup River Core Area
- Appendix M: Skokomish River Core Area
- Appendix N: Dungeness River Core Area
- Appendix O: Elwha River Core Area

Strait of Juan de Fuca

Distribution

The Strait of Juan de Fuca includes nearshore waters between the northwestern tip of the Olympic Peninsula (Cape Flattery) east to Point Wilson at Port Townsend. It is located in the northern region of the Coastal Recovery Unit.

The Dungeness and Elwha watersheds are the only bull trout core areas connected to the Strait of Juan de Fuca. Coastal and marine tributaries to the Strait of Juan de Fuca used by adult and subadult bull trout, but where habitat is likely unsuitable for spawning or early rearing, include Morse, Ennis, and Siebert Creeks. Bell (Freudenthal 2001) and Valley Creeks may also be used occasionally by bull trout (Ogg, in litt. 2006).

There are a number of small independent drainages to the strait, some of which originate in the Olympic National Park. The frequency of bull trout use of these tributaries is poorly understood. Bull trout have been documented in the Strait of Juan de Fuca drainages of Bell, Siebert, Morse, and Ennis Creeks (Cooper et al. 2003; Freudenthal 2001; Mongillo and Hallock 1993; WDFW 1998). Based on current or historical habitat conditions, and the experience and professional judgment of members of the bull trout recovery team, most of these rivers and streams located between Bell and Ennis Creeks on the Strait of Juan de Fuca are unlikely to support spawning populations, but do provide important foraging and overwintering opportunities for bull trout (Olympic Peninsula Recovery Team, in litt. 2003a; Olympic Peninsula Recovery Team, in litt. 2003b).

Numerous forage fish spawning sites are found throughout the Strait of Juan de Fuca (Shaffer et al. 2003; WDFW 2000). Thus, the Strait of Juan de Fuca provides essential and biologically important foraging and migration habitats for bull trout. No studies on the abundance of bull trout in the Strait of Juan de Fuca have been conducted to date. However, with the removal of the dams on the Elwha River, it is anticipated that more bull trout may use these nearshore waters as a result of the improved downstream access for the anadromous life history form.

The Strait of Juan de Fuca connects Puget Sound and Hood Canal to the Pacific Ocean. Currently, a portion of the migratory bull trout on the Olympic Peninsula appears to migrate into the Straits of Juan de Fuca. The Straits of Juan de Fuca provides the only accessible marine habitat for the anadromous life history form in the Dungeness and Elwha core areas.

Results of acoustic telemetry work in the Puget Sound (F. Goetz, pers. comm. 2002) and the Hoh River (Brenkman and Corbett 2003; Brenkman and Corbett, pers comm 2003) indicate that bull trout from more than one river intermingle in nearshore marine and estuarine waters. Recent radio telemetry studies have demonstrated that anadromous bull trout spend significant time outside of their natal core areas (Brenkman and Corbett 2005; Olympic Peninsula Recovery Team, in litt. 2003a; Olympic Peninsula Recovery Team, in litt. 2003b).

Morse, Ennis, and Siebert Creeks are identified in the recovery plan as providing an important contribution to foraging habitat for anadromous bull trout. These streams represent the few freshwater streams outside of the Elwha River and Dungeness River core areas known to be used by bull trout. This habitat is identified in the recovery plan as providing an important contribution to the forage base and connectivity of anadromous bull trout in the Strait of Juan de Fuca. Morse, Ennis, and Siebert Creeks are considered essential for maintaining overall distribution and abundance of anadromous bull trout in the Dungeness and Elwha core areas.

Bull trout use of Valley Creek has been identified using radio telemetry. Subadult bull trout were observed using the stream in May 2006 (Ogg, in litt. 2006). Valley Creek is identified in the recovery plan as providing an important contribution to foraging habitat for anadromous bull trout. The lower reach of this stream and its associated riparian area has been severely degraded as a result of residential and urban development so there is some uncertainty regarding the level of use by anadromous bull trout and degree of importance for recovery.

Factors Affecting the Bull Trout in the Strait of Juan de Fuca

Development impacts in tributaries to the Strait of Juan de Fuca have resulted in significant habitat loss for anadromous salmonids, including bull trout. Morse Creek was a significant producer of several species of salmon, which provide an important seasonal prey base for bull trout. The Morse Creek channel has been altered by development, channelization, and forest practices. Floodplain function has been severely altered by constrictions resulting from diking, development encroachment, and transportation corridors. Historical estuary conditions, thought to be largely responsible for Morse Creek's productivity, have been basically eliminated by development; however, habitat within the Olympic National Park boundary is in excellent condition (Haring 1999) while conditions outside of Olympic National Park have been significantly impacted by suburban development.

Siebert and Ennis Creeks drain directly to the Strait of Juan de Fuca. The lower reaches of these creeks are relatively intact, but habitat in the upper stream reaches is severely degraded by rural development, agricultural practices, and forest practices.

Streams that have their headwaters in the foothills, such as Bell and Siebert Creeks (and other streams draining into the Strait of Juan de Fuca) are subject to hydrologic/stormwater effects as a result of the permanent loss of forest cover due to conversion to residential development and from forestry activities. During severe rain storms or rain-on-snow events these forest cover changes have resulted in increased erosion in the small headwater streams as well as increased stream power to transport sediment and erode streambanks lower in the system (Haring 1999).

The nearshore marine environment provides important habitat for bull trout prey species, including spawning surf smelt, Pacific herring, and salmon smolts. Significant portions of nearshore habitat in the Strait of Juan de Fuca have been altered by bulkheads installed to protect various developments. The marine shoreline is armored from the mouth of Morse Creek west through Port Angeles to the end of Ediz Hook at the mouth of the Elwha River. This armoring effectively eliminates most, if not all, natural nearshore habitat functions (Haring 1999).

Stormwater runoff from residential development and agricultural lands contributes to nonpoint source water pollution from the transport of toxic metals and organic contaminants, such as petroleum hydrocarbons. Other sources of toxic contaminants are discharges of municipal and industrial wastewater, pesticide runoff from agricultural and residential lands, and leaching contaminants from shoreline structures. The Port Angeles Rayonier pulp mill is part of a clean-up action for contaminants (including dioxins and polychlorinated biphenyls) associated with the former mill.

Anadromous bull trout enter marine waters seasonally to prey on surf smelt, sand lance or Pacific herring where they school or spawn (Kraemer 1994). These forage fish species depend on the nearshore marine environment and spawn in the intertidal or shallow subtidal waters at specific locations (WDFW 2000). These locations are very vulnerable to destruction or modification through human activities, especially urban and rural development.

Forage fish, bottom fish, and wild salmon have declined in the Puget Sound (PSWQAT 2000). Part of this decline has been attributed to human encroachment and development of the nearshore areas throughout the Strait of Juan de Fuca that has resulted in the loss of nearshore habitat. It is likely that anadromous bull trout have been impacted by the decline in forage base and loss of habitat in this marine environment.

Threats

Threats to bull trout in the Strait of Juan de Fuca include:

- Ongoing habitat degradation from development and shoreline protection measures.
- Climate change is anticipated to modify the ocean chemistry.
- Bull trout are susceptible to incidental mortality associated with fisheries that target commercially desirable species.

Puget Sound

Anadromous bull trout forage, migrate, and overwinter along the nearshore (generally in water less than 10 meters deep) and are opportunistic foragers, often traveling to access and take advantage of seasonally abundant food resources. Anadromous bull trout feed primarily on marine forage fish and juvenile salmonids when in the marine environment. Eelgrass meadows and other complex nearshore marine and estuarine habitats are a focal point for their foraging activities and provide essential prey resources. Bull trout occur regularly and in significant numbers throughout the nearshore marine areas of the north Puget Sound.

The action area provides nearshore marine habitat for adult and subadult bull trout originating from several core areas (e.g., the Nooksack, Skagit, Stillaguamish, and Snohomish-Skykomish River bull trout core areas), and numerous local populations. These bull trout core areas support large and moderately sized local bull trout populations, including the largest anadromous bull trout populations found anywhere in Washington State (and the entire range of the species). Most of these local populations appear to be relatively stable, with some year-to-year variation in the measured indices for abundance and reproduction.

South Puget Sound: Bull trout use of Puget Sound south of the Tacoma Narrows and along the western shore (e.g., Vashon and Bainbridge Islands), is expected to be rare or extremely unlikely. The Puyallup River bull trout core area is believed to support the Puget Sound's southernmost anadromous bull trout populations. Tributaries to Puget Sound located south of Tacoma (including the Nisqually River) do not support bull trout spawning and rearing, or local populations.

Observations made at the Clear Creek Hatchery (on a tributary to the lower Nisqually River), indicate that bull trout still occasionally migrate south in marine waters to at least the Nisqually River (USFWS 2004a). It is unknown on the extent of individuals from Puget Sound populations migrating to the Kitsap Peninsula, the Strait of Juan de Fuca, or up to British Columbia.

Within the Puget geographic region of the Coastal Recovery Unit, anadromous bull trout require access to marine waters, estuaries, and lower reaches of rivers and lakes to forage and overwinter. Although recent and past studies have documented bull trout from one major Puget Sound river basin moving into the downstream portions of other rivers via marine waters (Goetz 2003; WDFW 1997), there is currently insufficient information to understand the full extent bull trout express this behavior. Goetz (2004, pp. 55, 60) noted that bull trout migrations may use nearshore marine shorelines as pathways, sometimes traveling over 250 kilometers from their natal stream. They may also choose an entirely different route during their return migrations.

Anadromous juvenile, sub-adult, and adult bull trout utilize marine waters of the action area for foraging, migration, and overwintering. There are ongoing studies of bull trout use of the Puget Sound nearshore by the Corps (Goetz et al. 2004). In two telemetry studies documenting the extent of anadromy in bull trout within portions of the Coastal Recovery Unit, approximately 55 percent of the fish tagged in freshwater emigrated to saltwater (Brenkman and Corbett 2005; Goetz et al. 2007). Over 160 bull trout have been radio tagged in north Puget Sound, including the Lower Snohomish River and Skagit Bay, with results demonstrating that anadromous bull trout inhabit a diverse range of estuarine, freshwater, and marine habitats. The residency period varied slightly for the two years data are available. In 2002, 98 percent of the tagged bull trout left the marine areas by late July. A single bull trout remained until August 12 in brackish water. In 2003, over 95 percent of the tagged bull trout left marine areas by early July.

Marine waters provide important habitat for anadromous bull trout for extended periods of time. Data for bull trout from Puget Sound indicate that the majority of anadromous bull trout tend to migrate into marine waters in the spring and return to rivers in the summer and fall period. Although much less frequent, tagged fish have been detected in Puget Sound nearshore marine waters during December and January, which indicates that some fish remain in marine waters during the winter (Goetz et al. 2007; Goetz et al. 2007; USGS 2008). It is thought that warmer water temperatures in the summer may be an environmental cue that stimulates bull trout to return to freshwater. Other factors that may influence marine residency for bull trout include prey availability, predation risks, or spawn timing.

Bull trout use of the marine environment is considered to be similar to other species, such as anadromous Dolly Varden (*Salvelinus malma*) and cutthroat trout. Thorpe's (1994) review of salmonid estuarine use found that anadromous Dolly Varden have an affinity to the shoreline. He also found clear evidence of a trophic advantage to estuarine residency (abundant prey). Aitkin (1998) reviewed the estuarine habitat of anadromous salmon, including native char. His literature review found that Dolly Varden pass through estuaries while migrating, like steelhead, and inhabit coastal neritic waters (nearshore marine zone extending to a depth of 200 m (656 ft), generally covering the continental shelf), like cutthroat trout. It has not been determined if bull trout use extends to the continental shelf. Current information suggests bull trout use tends to be primarily in the shallower nearshore (Goetz et al. 2004).

In general, anadromous bull trout use shallow nearshore, subtidal, and intertidal waters. In two acoustic telemetry projects, the greatest bull trout densities were at depths greater than 2.0 to 2.5 meters, up to depths as great as 25 m (Goetz et al. 2004; USGS 2008). Upon entering marine waters, bull trout can make extensive, rapid migrations, usually in nearshore marine areas. However, bull trout have also been tracked crossing Puget Sound at depths greater than 183 m (600 ft) (Goetz et al. 2012).

During the majority of their marine residency, anadromous bull trout have been found to occupy territories ranging in size from approximately 10 m to more than 3 km within 100 to 400 m of the shoreline (USGS 2008). Aquatic vegetation and substrate common to bull trout marine habitat include eelgrass, green algae, sand, mud, and mixed fine substrates. Forage fish occurrence is also correlated with these habitat features. Bull trout prey on surf smelt Pacific herring, Pacific sand lance, and other small schooling fish, especially keying in on their spawning beaches (Kraemer 1994). Bull trout have also been noted to feed heavily on shiner perch at some locations (Berge, pers comm 2003; Castle, pers comm 2003).

Bull trout may also seasonally use reaches of river systems and estuaries that historically or currently are unlikely to support spawning populations of bull trout, such as the Samish River and Duwamish River. Bull trout may forage on juvenile salmonids or other fish species while occupying these areas. The extent of past and current bull trout use of smaller, independent creek drainages that discharge directly into Puget Sound is not well known, with only a few known reported observations. In Bellingham Bay, bull trout were observed in Squalicum Creek in the late 1970s and in lower Whatcom Creek more recently (Currence, pers. comm. 2003). In 2002, three subadult bull trout approximately 203 to 229 millimeters (8 to 9 inches) in length entered the Maritime Heritage Fish Hatchery pond in Bellingham. These were reported to be the first bull trout observed at the facility in more than a decade, although formerly one to two per year were said to be observed at the facility. In contrast, bull trout from coastal populations on the Olympic Peninsula have recently been documented using a number of small independent creek systems flowing into the Pacific Ocean (USFWS 2004a). Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams still provide an important contribution to the potential forage base for bull trout using adjacent nearshore marine waters or other parts of Puget Sound.

Factors Affecting the Bull Trout in Puget Sound

Development impacts in tributaries to the Puget Sound have resulted in significant habitat loss for anadromous salmonids, including bull trout. Floodplain function has been severely altered by constrictions resulting from diking, development encroachment, and transportation corridors. The nearshore environment provides important habitat for bull trout prey species, including spawning surf smelt, herring, and salmon smolts. Significant portions of nearshore habitat in the Puget Sound have been altered by bulkheads placed to protect various developments. In Puget Sound, marine riparian habitat was reduced by 37 percent between 1972 and 1996 (Williams and Thom 2001). Shoreline stabilization (e.g., bulkheads) has been constructed on approximately 30 percent of all Puget Sound shorelines (Puget Sound Water Quality Action Team 2002).

Threats

Individual bull trout from the three core populations described earlier are found in the marine waters of the action area and their protection and recovery is vital to maintaining and expanding the overall distribution of bull trout within the Puget Sound Management Unit. Currently, over-water structures, stormwater runoff, and non-point source pollution from residential development and urbanization are factors contributing in the decline of bull trout and bull trout habitat within the action area (USFWS 2004a). To ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout in the action area, restoration of impaired nearshore marine habitat, remediation of contaminated sites in the nearshore environments, reduction/minimization of impacts from development and transportation corridors along marine shorelines, and restoration or recreation of intertidal foraging habitats is necessary (USFWS 2004a). Bull trout are also impacted due to their incidental take in gill and net seine fisheries in Puget Sound. The current level of incidental bull trout harvest is not known (USFWS 2004a).

The primary threat to the Puget Sound marine area is development and urbanization that degrade or eliminate nearshore marine and estuarine habitats and processes critical to the persistence of the anadromous life history form and their marine prey base. Forage fish, bottom fish, and wild salmon have declined in the Puget Sound (PSWQAT 2000). Part of this decline has been attributed to human encroachment and development of the nearshore areas throughout the Puget Sound that has resulted in the loss of nearshore[3] habitat. It is likely that anadromous bull trout have been impacted by the decline in forage base and loss of habitat in this marine environment.

Hood Canal

The nearshore marine waters of Hood Canal provide FMO habitat for anadromous bull trout. Bull trout originating from the Dungeness or other, north Puget Sound core areas may occasionally occur within northern portions of Hood Canal.

The closest population of bull trout in Hood Canal is in the Skokomish River located at the southern end of Hood Canal. There are at least two local populations of bull trout in the Skokomish River. One is an adfluvial population that inhabits Lake Cushman and the North Fork Skokomish River above the lake. The North Fork Skokomish River local population has been isolated above Cushman No.1 and No. 2 dams for over a century, but Tacoma Power is in the process of restoring fish passage to the North Fork. If fish passage efforts are successful, there is a potential that the anadromous life history form of bull trout could become more prevalent in the future. Another population, found in the South Fork Skokomish River, is a depressed but stable fluvial population. Three bull trout were detected in the lower South Fork Skokomish River in 2015, between the lower South Fork and the mainstem Skokomish River (Peters and Wright, pers comm 2016). Anadromy has not been documented in the Skokomish River populations and no bull trout have been captured in the nearshore marine areas of the estuary. However, historic reports of bull trout in rivers such as the Duckabush, Dosewallips, Hamma Hamma, and Quilcene Rivers suggest that a few individuals may be present in the nearshore marine waters of Hood Canal (Brenkman and Corbett 2005; Brenkman, in litt. 2007; Goetz et al. 2004; Goetz et al. 2007). The local populations of the Skokomish River are depressed but relatively stable, with some year-to-year variation in the measured indices for abundance and reproduction.

Threats

Bull trout occurrence in Hood Canal is likely limited by habitat degradation of nearshore foraging, migration, and overwintering habitat from natural and human sources and its distance from the nearest known source population in the Skokomish River (Brennan 2007; Goetz et al. 2004; PSAT (Puget Sound Action Team) 2007; Puget Sound Partnership 2008; Puget Sound Water Quality Action Team 2002).

Bull Trout Critical Habitat

In nearshore marine areas, the inshore extent of critical habitat is the mean higher high water line, including the uppermost reach of the saltwater wedge within tidally influenced, freshwater heads of estuaries. Critical habitat extends offshore to a depth of 10 meters (33 ft) relative to the mean lower low water line (75 FR 63935; October 18, 2010).

Within the action area, the current condition of designated bull trout critical habitat varies considerably. Current conditions reflect natural variability, patterns of disturbance and recovery from both natural and man-made events, and the effects of earlier and concurrent, unrelated activities occurring in the same nearshore environments and watersheds.

Water and sediment quality conditions are generally suitable and adequately functioning, though some sub-basins and embayments fail to consistently maintain the State's surface water quality criteria (Ecology 2016). Water temperatures are generally suitable and adequately functioning throughout the action area.

Natural nearshore habitat complexity is either mildly or moderately impaired throughout much of the action area. The same can be said for the condition of the bull trout prey base. At some locations either or both of these functions may be severely impaired.

The action area includes nearshore marine environments providing five of the nine PCEs of designated bull trout critical habitat (50 FR 63898; October 18, 2010):

(2) *Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers*.

Within the action area this PCE is impaired but still functions. At some locations, where armored and hardened shorelines, marine and estuarine fill, and overwater structures are more pervasive, this PCE is moderately or severely impaired. There are currently no barriers to migration along the marine shorelines in the action area.

(3) *An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish*.

Within the action area this PCE is either mildly or moderately impaired. Most of the nearshore marine areas in the action area provide important spawning habitat for forage fish species such as Pacific herring, Pacific sand lance, and surf smelt. Across most portions of the action area, both salmonid and marine forage fish prey resources are well below historic, long-term peaks of production. However, year-to-year and geographic variability is significant and not easy to generalize with recognizable trends.

(4) *Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure*.

Within the action area this PCE is moderately impaired, but still functions. At some locations, where armored and hardened shorelines, fill, and overwater structures are more pervasive, and where important natural processes that create and maintain functional nearshore marine habitat are impeded, this PCE is severely impaired.

(5) *Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; stream flow; and local groundwater influence*.

Though some shallow embayments experience seasonally elevated temperatures (i.e., during summer months), those conditions are usually of limited duration. Water temperatures in the nearshore marine areas of Puget Sound and the coastal bays are generally not degraded. Within the action area this PCE is fully functioning, with little or no significant impairment.

(8) *Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

Water and sediment quality conditions are generally suitable and adequately functioning, though some portions of the action area exhibit mild or moderate impairment.

Climate Change

Our analyses under the ESA include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used. The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014, p. 119).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the atmosphere and the oceans, melting of glaciers and sea ice, and substantial increases in precipitation in some regions of the world and decreases in other regions (IPCC 2014, pp. 40-42; Solomon et al. 2007, pp. 35-54, 82-85). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “extremely likely” (defined by the IPCC as 95 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2014 , pp. 47-49; Solomon et al. 2007, pp. 21-35). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Ganguly et al. 2009, pp. 11555, 15558; Meehl et al. 2007, entire; Prinn et al. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2035. After 2035, model projections diverge depending on initial assumptions about greenhouse gas emissions (Collins et al. 2013, pp. 978-980; Kirtman et al. 2013, p. 1093). Although projections of the magnitude and rate of warming differ after about 2035, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Ganguly et al. 2009, pp. 15555-15558; IPCC 2014 , pp. 56-63; Meehl et al. 2007, pp.

760-764; Prinn et al. 2011, pp. 527, 529). Other changes in the global climate are likely to include longer and more frequent heat waves, extreme precipitation events over mid-latitude land masses, intensified precipitation variability related to El Niño-Southern Oscillation, reductions in spring snow cover and summer sea ice, ocean acidification, and decreases in the dissolved oxygen content of the ocean (IPCC 2014, pp. 60-62).

Various changes in climate may have direct or indirect effects on listed species. These effects may be positive, neutral, or negative, and they may change over time. Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (Glick et al. 2011, pp. 19-22; IPCC 2007, p. 89). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. In general, many species are projected to face increased extinction risk as the climate changes in the future, especially when climate changes are combined with other factors like habitat modification; but this risk can be reduced through management actions, including those that reduce the impacts of non-climate change stressors (IPCC 2014, pp. 14-15).

Marbled Murrelet

During the next 20 to 40 years, the climate of the Pacific Northwest is projected to change significantly with associated changes to forested ecosystems. Predicted changes include warmer, drier summers and warmer, wetter autumns and winters, resulting in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events (Salathe Jr et al. 2010). Initially, the Pacific Northwest is likely to see increased forest growth region-wide over the next few decades due to increased winter precipitation and longer growing seasons; however, forest growth is expected to decrease as temperatures increase and trees can no longer benefit from the increased winter precipitation and longer growing seasons (Littel et al. 2009, p. 15). Additionally, the changing climate will likely alter forest ecosystems as a result of the frequency, intensity, duration, and timing of disturbance factors such as fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, landslides, and flooding (Littel et al. 2009, p. 14).

One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. In general, wet western forests have short dry summers and high fuel moisture levels that result in very low fire frequencies. However, high fuel accumulations and forest densities create the potential for fires of very high intensity and severity when fuels are dry (Mote et al. 2008, p. 23). Westerling et al. (2006) looked at a much larger area in the western United States including the Pacific Northwest, and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period between 1970 to 1986. The total area burned was more than 6.5 times the previous level (1970 to 1986) and the average length of the fire season during 1987 to 2003 was 78 days longer compared to 1978 to 1986 (Westerling et al. 2006, p. 941). Littell et al. (2009, p. 2) project that the area burned by fire in the Pacific Northwest will double by the 2040s and triple by the 2080s.

Climate change poses a potential risk to marbled murrelets from increased marine water temperatures. Increased water temperatures in the Arctic, melting glaciers and sea ice, increased freshwater input to the oceans, altered ocean circulation and patterns of upwelling, and altered foraging resources may affect the marbled murrelet food base. Increasing ocean water temperatures over the past few years have resulted in a warmer than normal "blob" of water off the west coast of North America that extended into the Gulf of Alaska (Peterson et al. 2014). The warmer ocean temperatures shortened the upwelling season in 2013 by 6 weeks (Peterson et al. 2014). Ocean upwelling is related to marine ecosystem productivity. High water temperatures lead to low entrainment of nutrients and therefore, decreasing biological productivity, which may impact prey abundance (Peterson et al. 2014).

Hazen et al. (2012) looked at predicted habitat shifts of Pacific top predators in a changing climate. They concluded that within the west coast Exclusive Economic Zone, chlorophyll is estimated to increase and the area is expected to remain a high biodiversity area into the future (Hazen et al. 2012, p. 4). They also caution that as offshore habitat decreases or becomes less accessible, there may be increased use in the upwelling-driven California Current Marine Ecosystem leading to greater competition among top predators, and also a higher risk of anthropogenic impacts such as shipping traffic and fisheries bycatch (Hazen et al. 2012, p. 4).

Possible prey base changes can affect marbled murrelets due to climate change. A recent global analysis of seabird response to forage fish depletion in 16 seabird species found a general pattern of breeding success being fairly stable above a threshold of prey abundance, but was impacted below that threshold (Cury et al. 2011). The threshold approximated one-third of the maximum prey biomass observed in long-term studies. This study suggests that many seabird species are resilient to some level of prey depletion.

Bull Trout

Recent observations and modeling for Pacific Northwest aquatic habitats suggest that bull trout and other salmonid populations will be negatively affected by ongoing and future climate change. Rieman and McIntyre (1993, p. 8) describe several studies predicting substantial declines of salmonid stocks in some regions related to long-term climate change. More recently, Battin et al. (2007) modeled impacts to salmon in the Snohomish River Basin related to predictions of climate change. They suggest that long-term climate impacts on hydrology would be greatest in the highest elevation basins, although site specific landscape characteristics would determine the magnitude and timing of effects. Streams which acquire much of their flows from snowmelt and rain-on-snow events may be particularly vulnerable to the effects of climate change (Battin et al. 2007, p. 6724). In the Pacific Northwest region, warming air temperatures are predicted to result in receding glaciers, which in time would be expected to seasonally impact turbidity levels, timing and volume of flows, stream temperatures, and species responses to shifting seasonal patterns.

Battin et al. (2007, p. 6720) suggest that salmonid populations in streams affected by climate change may have better spawning success rates for individuals that spawn in lower-elevation sites, especially where restoration efforts result in improved habitat. Fish that spawn at higher elevations (like bull trout) would be more vulnerable to the impacts of increased peak flows on egg survival. They further note that juvenile salmonids spending less time in freshwater streams before out-migrating to the ocean would be less impacted by the higher temperatures and low flows than juveniles that rear longer in the streams. Bull trout generally spawn in cold headwater streams, and juveniles may spend one to three years rearing in cold streams before moving downstream to large river reaches or estuarine/marine habitats. Therefore, bull trout would be less likely than other salmonids to be able to adjust their spawning habitat needs related to water temperature. Connectivity between lower and upper reaches of a river system and marine waters may become even more critical for the growth and survival of fluvial and anadromous individuals that access the action area for foraging, migrating, and overwintering purposes.

Because of the historic loss of estuarine habitats within the Stillaguamish River Delta, sea-level rise associated with climate change will further reduce certain types of estuarine habitats in the future. Padilla Bay, Skagit Bay, and Port Susan Bay have significant projected losses of tidal freshwater marsh, estuarine beach, brackish marsh, tidal swamp, rocky intertidal and riverine tidal habitats (Glick et al. 2007). The decline in marsh habitats are projected to significantly reduce rearing capacity for juvenile Chinook salmon, and project changes are also said to likely affect other salmonid species including bull trout, which depend on coastal marshes and other habitats for part of their life cycle (Glick et al. 2007).

Changes in climate have been identified that are occurring now or will occur over the next 50 to 100 years (Glick et al. 2007, p. iii; Mote et al. 2005, p. 4). The predicted changing precipitation patterns are expected to result in more frequent severe weather events and warmer temperatures (Mote et al. 2005, p. 13). Glaciers in the Cascades and Olympics Mountains have been retreating during the past 50 to 150 years in response to local climate warming. Regional warming can result in reduced winter snowpack, earlier occurrence of peak runoff, and reduced summer flows. If the current climate change models and predictions for Pacific Northwest aquatic habitats are relatively accurate, bull trout from core areas in the Puget Sound and Strait of Juan de Fuca are likely to be impacted through at least one or more of the following pathways:

- Changes in distribution of bull trout within the core area, such as reduced spawning habitat, and/or seasonal thermal blockage in the migratory corridors associated with increased stream temperatures.
- Disturbance or displacement of eggs, alevins, juveniles, and adults of resident and/or migratory adults during winter flooding events.
- Short-term or long-term changes in habitat and prey species due to stochastic events during winter floods.
- Changes in flow/out-migration timing in the spring for bull trout and their prey species.
- Increased migration stressors from lower stream flows and high stream temperatures during spawning migrations.

Previously Consulted-on Effects

Marbled Murrelet and Bull Trout

Within the action area, the USFWS has conducted approximately 1,289 informal consultations and 44 formal consultations in Puget Sound (35) and Hood Canal (9). Within Puget Sound, federal projects included harbor expansions, seawall replacement, ferry terminal upgrades, aquaculture activities, and discharges from wastewater treatment plants. Within Hood Canal, federal projects involved estuarine restoration, bridge repairs, and road, pier, and wharf maintenance and upgrades.

The adverse effects to marbled murrelets and bull trout associated with most of these projects are very similar and are associated with exposure to increased sound levels from pile driving activities, decreased water quality through increased suspended sediments and contaminants, and adverse impacts to forage fish species.

Population-level Effects of Previously Consulted-on Federal Actions

Marbled Murrelet

In general, any loss of marbled murrelet reproduction associated with disturbance effects caused by the consulted-on federal actions was considered insufficient to increase the present rates of observed population declines at the Conservation Zone and range-wide scales. The consulted-on projects were also not anticipated to result in a significant reduction in marbled murrelet numbers or distribution as these federal actions were typically widely dispersed over a large managed landscape.

Bull Trout

Although these federal projects involved adverse effects to individual bull trout, forage fish and/or aquatic habitats, the USFWS determined that the effects of these actions were not expected to result in any measurable reduction in the numbers, distribution, or reproduction of the bull trout at the core area, recovery unit, or range-wide scales.

EFFECTS OF THE ACTION: **Marbled Murrelet and Bull Trout**

The effects of the action refers to the direct and indirect effects of an action on the species or critical 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 CFR 402.02). In accordance with USFWS national policy (USFWS and NMFS 1998p. 1-6) and congressional intent [H.R. Conf. Rep. No. 697, 96^{th} Congress, 2^{nd} Session 12 (1979)], the following analysis relies on best available information and providing the benefit of the doubt to the listed species in light of uncertainty or data gaps (see also p. 19952, middle column, of the preamble to the implementing regulations for section 7 of the ESA at 50 CFR 402; 51 FR 19926). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

Our approach to the analysis of effects is based on an estimation of exposure, consideration of potential responses to any exposure that is not discountable, and a determination whether there will be any resulting adverse effects. The following effects analysis is structured according to specific activities that will occur (i.e., elevated underwater SPLs from impact-pile driving, installation of permanent structures in nearshore habitat, increased vessel traffic). Please note that stressors to listed species that are likely to cause injury, mortality, or a significant impairment or disruption of their normal behaviors such as breeding, feeding, migration, or sheltering are considered “significant adverse effects.” Stressors that are not likely to cause those effects are discussed below as “insignificant” or “discountable” effects.

For purposes of this analysis, the term “range to effect” means the distance from the source of a stressor within which injury, death, or significant behavioral changes to a listed species is likely to occur. This value varies between stressors and species. The term “group” applied to the marbled murrelet means two marbled murrelet individuals, which is the average marbled murrelet group size rounded to the nearest whole number of birds. The distribution and abundance of the marbled murrelet within the action area were modeled and those results were used to calculate the probability of overlap with RGP-6 action-related impact zones, taking into account the “range to effect” determinations.

As mentioned in the Action Area section, we consider the presence of boats, including jet skis, and the use of boats to be indirect effects of the action. Thus, this effects analysis considers the effects from the shading of boats and boat use as an indirect effect of the proposed action. We consider increased vessel traffic, increased SPLs from pile driving, increased shading from overwater structures, and changes in the physical features of habitat associated with installation of new overwater structures as direct effects. We identify the life stages of listed species we expect may be exposed to these stressors. This effects analysis reviews actions that we anticipate will lead to changes in behavior, increased predation, and habitat degradation for bull trout, marbled murrelets, and critical habitat for bull trout (where applicable).

In-water construction will occur during the approved work window for the protection of bull trout, which is between July 16 and February 15 of any year. More restrictive work-windows may be applied depending on the location of the project, the applicable tidal reference area, and presence of forage fish spawning habitat. Performing construction during the approved in-water work window reduces, but does not eliminate exposure of bull trout to project-related stressors because non-spawning bull trout may be present in marine areas at any time of year. Additionally, effects to their habitat and/or prey resources can affect them at a later time, when they return to these affected areas. Because marbled murrelets are present in marine areas year round, restricting construction to the approved in-water work window does not provide any benefit to them.

Total overwater coverage will be limited and is the metric used to assess impacts to habitat and calculate the mitigation needed to fulfill RGP-6 requirements. We assume, based on the average number of projects permitted per year and proposed PRF coverage, that over the 5 years of the permit, the maximum combined (cumulative) size of all new PRFs authorized under this permit will not exceed 96,000 ft^2 = 150*640 ft^2 (0.90 hectare, or 2.2 acres) regardless of individual float sizes. The Corps permits many more single-use PRFs than joint-use PRFs. In addition, based on this aerial coverage and the proposed design criteria, we assume that up to 3,000 pilings will be installed to support the PRFs (i.e., 150 PRFs * 20 pilings/PRF). Thus, if the Corps permits individual floats larger than 640 ft^2 under RGP-6, the number of PRF's that can be permitted until the maximum amount of overwater coverage considered in this consultation (96,000 ft^2) is reached will be proportionally fewer than 150 PRFs.

Mitigation

Mitigation includes on-site enhancements, including riparian plantings, placing spawning gravel, installing large woody material, removing pilings, removing existing overwater structures, removing bank stabilization, removing boat ramps, and removing rails. All on-site mitigation includes minimization measures developed to avoid, minimize, or reduce impacts associated with the installation of new structures, including completing the work during the approved in-water work window. Additionally, on-site mitigation in intertidal areas will occur in the dry, at low tide, and outside of forage fish spawning times. However, construction of some on-site mitigation measures may result in insignificant effects to listed species. Proposed off-site mitigation includes removal of manmade groins as well as purchasing credits from third-party mitigation sources. The mitigation requirement will be calculated when the specific proposed project application is submitted to the Corps. Mitigation projects will be fully developed and implemented after the Corps permit is issued (only the calculation of required mitigation amount is determined prior to permit issuance).

Creosote-treated wood piles will be removed for some mitigation proposals. Their removal will comply with Best Management Standards, which will minimize the amount of creosote released into the environment. However, we expect some creosote may still be released into marine waters during this process. We anticipate that the release of creosote will be intermittent, infrequent, and limited to very small quantities (ounces). Overall we expect the water quality impacts to be very minor in magnitude and beneficial over the long term and would improve water quality. Therefore, we do not expect the removal of creosote-treated wood piles would measurably improve water quality and habitat conditions for bull trout, marbled murrelets, and their prey resources.

We expect that the proposed mitigation will offset long-term impacts associated with the new structures and improve nearshore marine habitat, including improving habitat suitability and increasing the abundance and productivity of marbled murrelet and bull trout via improvements to their habitat and prey resources. Increasing riparian vegetation will result in higher abundance of insects, which in turn can increase the fitness, growth, and survival of bull trout and marbled murrelet by increasing the quantity and quality of their prey resources. Mitigating effects by removing or reducing shoreline hardening has multiple habitat benefits (Dethier et al. 2016; Toft et al. 2013), including re-establishing shallow water habitat and retention of finer grained sediments, which at times may provide higher abundance of prey resources by improving riparian habitat and forage fish spawning habitat conditions. Finer grained sediment as well as forage fish spawning habitat enhancements can result in increased forage fish spawning success and likely increased abundance of prey resources.

Overall, the mitigation proposed will address factors in the marine nearshore that limit individual fitness, survival, and productivity, such as habitat degradation and consequential declines in prey abundance. Therefore, we are reasonably certain that the mitigation actions will offset some of the effects of installing permanent structures and potentially increase habitat quality and the abundance of prey resources for listed species.

Increased Vessel Traffic

The structures that will be built under this project are reasonably certain to result in increased boating activity, including jet skis, in the vicinity of the new structures and beyond to the extent that the vessels travel from these locations. We expect the highest concentration of effects to be focused in the immediate vicinity of the PRF locations and that stressors would diminish as the vessels travel away from the access locations. Some of this boating activity may be a redistribution of vessel traffic that would have occurred elsewhere, but some increase in vessel traffic is anticipated from the installation of new infrastructure that facilitates access to marine areas. The increased vessel traffic in the action area from adding up to 150 new in-water structures over the next five years (the duration of this consultation) is anticipated to result in a measurable, though slight increase from current use and could increase levels of disturbance to marbled murrelets and bull trout that use the nearshore areas in the vicinity of the installation locations.

Boating impacts to bull trout and marbled murrelets include decreased water quality associated with increased turbidity from propeller scour and contaminants (petroleum products) from engine use; shoreline erosion from boat wakes; destruction of aquatic vegetation from propellers, and energetic cost from avoidance or behavioral modification (Asplund 2000). The energetic cost, specific to marbled murrelets and bull trout associated with potential disturbance from increased vessel traffic has not been researched or determined. Measuring energy expenditure rates of individuals requires capture and recapture, which is often impossible to implement because federally-listed species have strict limits on handling to avoid further negative impacts to them. Therefore, estimates of energy expenditure rates through the use of surrogate species and stressors, and indirect methods are used for our analyses of effects.

<u>Vessel Disturbance</u>

Marbled Murrelet

Marbled murrelets spend most of their lives in the marine environment and forage in nearshore areas. They forage by pursuit diving in relatively shallow waters, usually between 20 and 80 meters deep, but have also been observed diving in waters less than 1 meter deep and more than 100 meters deep (Strachan et al. 1995, p. 247). Most foraging occurs about 300 to 2,000 meters from shore (Strachan et al. 1995, p. 247). The new structures (i.e., PRFs, mooring buoys, watercraft lifts, marine rails, and stairs) will be installed within 300 meters of shore. Some shorelines adjacent to project areas may be productive eelgrass beds. We expect that many of the project areas may provide suitable foraging habitat for marbled murrelets, depending on location, and they could be present at any time.

Marbled murrelets move away from areas with high levels of human disturbance (Speckman et al. 2004, p. 32), but have also been observed foraging in close proximity of pile driving and continued to dive and forage despite ongoing construction disturbance (Entranco Inc. and Hamer Environmental L.P. 2005). Boat disturbance has been implicated in the decline of Kittlitz's murrelets in Prince William Sound (Kuletz 1996, p. 776). Disturbance can disrupt feeding marbled murrelets and cause them to swallow fish meant for their nestling (Speckman et al. 2004, p. 33). Persistent boat traffic may prevent marbled murrelets from using high quality foraging areas (Speckman, pers. comm. in Piatt and Naslund 1995, p. 292), resulting in their displacement to areas of lesser quality prey resources. Consequences to the species depend on their perceived trade-off between missed feeding opportunities and avoiding the disturbance.

Kuletz (1996) measured the effects of human disturbance to seabirds on the water, such as that caused by vessel traffic. That study found that the number of marbled murrelets at sea was negatively correlated with the number of boats (1996, p. 776) and evidence also suggested that breeding may have been disrupted (Kuletz 1996, p. 779). Even in areas where marbled murrelets may habituate to existing boat traffic, changes in boat activity may affect their foraging activity. Faster vessels are also associated with a greater proportion of marbled murrelets flushing (flying or diving) and at further distances and those that did flush, tended to fly entirely out of feeding areas (Bellefleur et al. 2007, p. 1). Additionally, juvenile marbled murrelets flushed more frequently than adults, but at closer distances (Bellefleur et al. 2007, p. 1).

We expect that marbled murrelets foraging in marine waters adjacent to densely populated areas are more acclimated to the higher levels of vessel traffic associated with these areas. The proposed action will add another 150 structures across a very large geographic area, and is expected to result in slight increases of in vessel traffic where they are installed. For the purposes of this analysis, we assume that all 150 new structures will be constructed primarily for use by vessels in the next five years, and that the highest frequency of boat use will be during the summer months (June, July, and August).

The summer months (June, July, and August) are critical months for breeding marbled murrelets and their young because adults face intense energetic requirements to complete chick-rearing. From mid-May through mid-September, adult marbled murrelet are incubating and/or provisioning newly hatched and/or fledged young (Carter and Stein 1995, p. 99). During July and August many adults may be flightless because they may be molting and still provisioning fledged young (molting can occur any time between approximately mid-July mid-February after young have fledged) (Hamer and Nelson 1995, p. 49).

When new fledglings first enter marine waters, they must quickly learn to forage on their own (Jahrsdoerfer and Balogh 2010, p. 17). Hentze (2006, p. iii) found that marbled murrelets did not dive when vessels approached at distances of 90 meters or greater, and did not fly at approach distances of 100 meters. Of the 3,080 observations, approximately 60 percent showed no response to boat approaches, while 31 percent dove, and 9.2 percent flushed (2006, pp. 13, 15), suggesting that most marbled murrelets would not be affected (or disturbed) by vessels at distances over 150 meters (2006, p. iii).

We expect that some marbled murrelets would be approached by boats at distances less than 150 meters and a small number of individuals may respond with avoidance behaviors. However, these effects will be broadly distributed throughout the inland marine waters and likely would not be measurable over current conditions. Exposures will be infrequent and short in duration and are not expected to result in a significant disruption of normal behaviors to an extent that would create the likelihood of injury or death. Therefore, effects to marbled murrelets associated with intermittent exposures to recreational boat traffic are considered insignificant.

Bull Trout

Although there are no studies specific to bull trout on the effects of increased vessel traffic, there are many other studies that show increases in background sound levels increases stress levels in fish Mueller 2011, Picciulin et al 2010, (Scholik and Yan 2001a; Scholik and Yan 2001b; Scholik and Yan 2002a; Scholik and Yan 2002b). One study showed that recreational boat noise diminished the ability of a resident red-mouthed goby (*Gobius cruentatus*) to maintain its territory (Sebastianutto et al. 2011, p. 207). Graham and Cooke (2008) studied the effects of paddling, trolling motors, and 9.9 horsepower combustion engines on the cardiac physiology of largemouth bass (*Micropterus salmoides*). Exposure to each treatment resulted in increased cardiac output in all fish, associated with a dramatic increase in heart rate, with the most extreme response and longest recovery time associated with exposure to combustion engines (Graham and Cooke 2008, p. 40).

Salmonids can detect sounds at frequencies between 10 Hz (Knudsen et al. 1997) and 600 Hz (Mueller et al. 1998), and we expect that bull trout also hear within these frequency ranges. Popper et al. (2007, p. 623) found the most significant auditory threshold shift occurred in rainbow trout at 400 Hz with sound levels up to 193 dB_{RMS} re: 1 µPa . A sound level of 193 dB_{RMS} is estimated to be associated with a cumulative Sound Exposure Level (SEL) of approximately 210 dB (re: 1 µPa). Therefore, based on the best available information, we expect that when any underwater sound source is operated within the hearing range of bull trout (up to approximately 600 Hz) and exceeds 210 dB SEL, the exposed fish may experience injury, including injury associated with temporary threshold shift in which hair cells or hairs in the inner ear are damaged.

Boat sound source levels range from approximately 145 to 169 dB re: 1µPa at 1 m, increasing with speed (Erbe 2002, p. 394). Underwater sound of rigid-hulled inflatable boats peaked between 70 and 400 Hz, exhibiting strong tones in this frequency range related to engine and propeller rotation (Erbe et al. 2016, p. 1). However, the sound levels associated with motors on recreational watercraft do not exceed the threshold for onset of injury (i.e., 183 dB SEL). Most boat use involves the boats being transitory, and we expect that bull trout would be temporarily disturbed while boats are started and motor away from an access point and for slightly longer durations if the vessel is idling in place.

Most boat use occurs during the summer months (June to mid-September), when bull trout presence is lower in the marine environment; however, not all bull trout spawn, and some individuals (e.g. non-spawning adults) may be present in the project areas at any time of year. Behavioral and physiological responses to disturbance from boat noise divert time and energy from other fitness-enhancing activities such as feeding, avoiding predators, and defending territories. Piers, ramps, and floats are generally used to moor one or two boats and thus the addition of 150 new structures over the life of this program would result in a slight increase in boating activity and associated engine noise levels in the project areas. This will increase fish disturbance from engine noise, propeller movement, and the physical presence of boats and humans, including fishing activities. Some of these activities are likely to disturb bull trout, cause them to temporarily leave an area, and experience sublethal physiological stress. The proposed projects will be broadly distributed throughout the action area. We expect that some bull trout will exhibit a behavioral response to watercraft noise over the duration of the project; however, we do not expect that these short-term exposures will measurably affect their normal behaviors or result in injury or death. Therefore, effects to bull trout associated with intermittent exposures to boat engine noises and vessel use are considered insignificant.

<u>Watercraft-related Impacts to Water Quality</u>

Marbled Murrelet and Bull Trout

Increased vessel traffic is expected to result in decreased water quality through increases in turbidity and suspended sediments from propeller scour and releases of contaminants in and around the nearshore locations where the new PRFs are installed. The nearshore areas where these new structures would be installed are where bull trout or marbled murrelets are more likely to be. Prolonged exposure to increased levels of turbidity, suspended sediments, and contaminants could affect bull trout and marbled murrelets that are foraging or migrating in the immediate vicinity of the new structures.

The USFWS does not expect that the vessel use will result in a significant increase in turbidity and suspended solids due to prop wash. Any disturbance to the substrate from vessel activity will be of very short duration and will not result in any significant effects to marbled murrelets, bull trout, or their prey.

Accidental releases of fuel, oil, and other contaminants that can injure or kill aquatic organisms may occur from watercraft use at the permitted structures. Petroleum-based contaminants, such as fuel, oil, and some hydraulic fluids, contain polycyclic aromatic hydrocarbons (PAHs), which can kill listed fish at high levels of exposure, and can cause sublethal effects at lower concentrations (Meador et al. 2006). Because the structures being built are for individual recreational boat use, we anticipate PAH releases will be intermittent, infrequent, and limited to very small quantities.

There currently is no evidence of how much exposure to these chemicals could result in adverse effects to marbled murrelets or bull trout. We expect that any chemicals that may be released from recreational watercraft would be very minor and quickly dispersed and diluted by tidal action. Because bull trout and marbled murrelet are highly mobile and impacts to water quality will be minor, we do not expect them to be exposed to turbidity, suspended sediments, or contaminants in concentrations or for durations that would measurably affect them. Therefore, effects to bull trout and marbled murrelets associated with decreased water quality associated with increased vessels are considered insignificant.

Prey Resources

Prey resources and forage fish spawning habitat may be measurably affected depending on whether they are exposed to high levels of contaminants over a long period of time. However, there is no evidence that bioaccumulation of PAHs in prey resources results in measurable impacts to diving seabirds and fish, nor would it be possible to directly link prey exposure to PAHs to physical injury to marbled murrelets and bull trout directly from the proposed action. Because we do not expect any measurable effects to the abundance or distribution of prey resources from decreased water quality associated with increased vessel traffic, effects to marbled murrelets and bull trout are considered insignificant.

Water Quality Impacts

<u>Turbidity and Suspended Sediment from Installation of Piles and Mooring Buoys</u>

Marbled Murrelet

Elevated levels of turbidity associated with the proposed installation of mooring buoys and piles will be short-term and temporary and are not expected to measurably affect marbled murrelets. Their exposure will be limited in duration and concentration. The turbidity created by these activities is expected to be relatively localized around installation locations. Additionally, marbled murrelets are highly mobile and injury is not currently associated with exposure to elevated levels of turbidity. We do not expect the proposed activities to result in a measurable disturbance to their normal behaviors or result in injury. Therefore, effects to marbled murrelets associated with short-term exposures to elevated levels of turbidity are considered insignificant.

Bull Trout

Installing piles and mooring buoys causes short-term and localized increases in turbidity and total suspended solids (TSS). The effects of suspended sediment on fish increase in severity with sediment concentration and exposure time and can progressively include behavioral avoidance and/or disorientation, physiological stress (e.g., coughing), gill abrasion, and death—at extremely high concentrations. Newcombe and Jensen (1996) identified a scale of ill effects based on sediment concentration and duration of exposure (dose) and found exposure to concentrations of elevated suspended sediments expected during pile driving could elicit sublethal effects such as a short-term reduction in feeding rate or success, temporary avoidance of areas, or minor physiological stress such as coughing or increased respiration. Studies show that salmonids have an ability to detect and distinguish turbidity and other water quality gradients (Quinn 2005; Simenstad et al. 1988), and that larger juvenile salmonids are more tolerant to suspended sediment than smaller juveniles (Newcombe and Jensen 1996; Servizi and Martens 1991).

Very little information exists on temporary increases in suspended sediment associated with pile driving. Some limited information exists from a project at Jimmycomelately Creek in Sequim Bay (Weston Solutions and Pascoe Environmental Consulting 2006). In that study, TSS concentrations associated with vibratory pile driving used to loosen a pile from the substrate ranged from 13 to 42 milligrams per liter (mg/L) and averaged 25 mg/L, while pile installation resulted in elevated levels of TSS averaging 40 mg/L near the pile and 26 mg/L at the sensors approximately 16 to 33 ft from the pile. Concentrations during extraction ranged from 20 to 82.9 mg/L, and were sometimes visible in the water column as a 10- to 16-foot diameter plume extending 15 to 20 ft from the pile removal location. Although concentrations decreased after pile extraction, the time interval was unavailable due to tug movement as soon as the pile cleared the water's surface. We expect similar concentrations and dispersal of TSS would occur from the proposed pile driving for this action.

Additionally, bull trout are highly mobile and injury is not currently associated with exposure to the concentration of elevated levels of turbidity that would be associated with this proposed action, which are relatively minor. Given the low levels and short duration of suspended solids released during pile installation, we do not expect the proposed action to result in a significant impairment of normal behaviors or result in injury. Therefore, effects to bull trout associated with short-term exposures to elevated levels of turbidity and suspended solids are considered insignificant.

Prey Resources

It is reasonable to assume that effects from TSS and turbidity on prey resources for bull trout and marbled murrelets are unlikely to result in measurable effects because the TSS will be localized, short-duration, and of relatively low concentration. Pacific herring exhibited no mortalities during or following continuous exposure to concentrations of 250 mg/L of TSS for 16 hours (Griffin et al. 2012). As the duration of these exposures (Griffin et al. 2012) is higher than we expect for the proposed activities and are not within the range of TSS observed from similar activities (i.e., pile driving), we do not expect forage fish to be measurably affected by short-term exposures to elevated levels of turbidity. Because we do not expect minor impacts to water quality to adversely affect forage fish or measurably affect the abundance or distribution of prey resources, effects to marbled murrelets and bull trout are considered insignificant.

<u>Use of ACZA-Treated Wood</u>

The proposed action allows for ACZA-treated pilings to be used only outside of forage fish spawning habitat or state-owned aquatic lands. All treated wood, pilings and above water ACZA- treated wood, need to meet post treatment BMPs, which are designed to reduce leaching. In any one location, a maximum installation of 20 pilings per PRF is proposed. In addition, the use of ACZA-treated structural wood (stringers) which is commonly used for above-water portions of piers and floats are not restricted in the proposed action. Treated wood for decking is becoming rare as most builders have switched to plastic lumber, metal grating, and untreated wood.

Some of the metals used in ACZA-treated wood are expected to leach into the environment. Of these metals, dissolved copper is of most concern to fish because of its higher leaching rate in the marine environment compared to arsenic or zinc (Poston 2001; Stratus 2006) and low level sublethal effects on olfactory function (Hecht et al. 2007; McIntyre et al. 2012). Copper is also likely to leach from recreational vessels treated with anti-fouling paint which we expect to be associated with a few of the proposed structures (Sommers et al. 2016).

The quantity of dissolved copper released into the environment depends on the quantity of treated wood installed, how much is below and above the water, leaching rate, BMPs applied, and water chemistry. Leaching from ACZA-treated wood has been shown to be highest during the first few weeks after installation and then sharply decreases to low concentrations, with post-treatment BMPs further reducing the initial leaching amount and duration (Stratus 2006). In addition to copper released from leaching, concentrations of dissolved copper adjacent to the proposed structures depend on flow/mixing conditions, and water quality parameters including salinity, and pH (Stratus 2006). We expect dilution to be moderate to high because of the tidally-influenced water movement around the proposed structures. Also, waters with higher salinity decrease leaching of copper from ACZA-treated wood (Stratus 2006), and all of the proposed structures will be installed in the marine environment. Therefore, we expect generally low copper concentrations in water and sediment around structures containing treated wood because of the low number of ACZA-treated wood pilings and above water treated wood, proposed post-treatment BMPs, accelerated dilution from tidal action, and lower leaching in saltwater.

Marbled Murrelet

There is currently no evidence what level of exposure of marbled murrelets to ACZA would result in adverse effects. We expect that ACZA leaching into marine waters would be generally localized around the source and would be dispersed and diluted by tidal action. Because marbled murrelets are highly mobile, we do not expect them to be exposed to chemicals at concentrations or for durations that would cause injury or result in a significant impairment of normal behaviors or measurable effects. Therefore, effects to marbled murrelets associated with short term exposures to chemicals in ACZA-treated wood are considered insignificant.

Bull Trout

Sub-lethal concentrations of dissolved copper have been shown to impair olfactory function in salmon in freshwater (Tierney et al. 2009). This copper-induced loss of smell leads to a reduction in predator avoidance (McIntyre et al. 2012) and fish have shown avoidance of sub-lethal levels of dissolved copper in freshwater (Giattina et al. 1982). While the avoidance behavior was also observed in saltwater, no impairment of olfactory function in salmon has been found in saltwater (Sommers et al. 2016). Thus, we believe that the effects of the proposed action will be restricted to behavioral responses, mainly the avoidance of waters around the proposed structures in which elevated, sub-lethal levels of dissolved copper may be present.

As discussed above, we expect the elevated concentration of copper to be limited in space, time, and duration because affected areas will be isolated to the areas immediately surrounding the proposed structures and the duration of impacts to water quality is primarily limited to within two weeks post-installation of any treated wood. Additionally, bull trout exposure to elevated levels of dissolved copper would be intermittent, occurring mainly during slack tides when dilution is lowest. While some bull trout are likely to encounter short-term elevated sub-lethal levels of dissolved copper, we do not expect them to be exposed to chemicals at concentrations or for durations that would result in injury. Bull trout exposure to elevated dissolved copper concentration is anticipated to be short-term and intermittent and focused in the areas immediately adjacent to the proposed structures. Because we do not expect these exposures to measurably disrupt their normal behaviors, effects associated with minor impacts to water quality with the use of ACZA-treated wood are considered insignificant.

Prey Resources

Exposure of prey resources to chemicals in treated wood, including forage fish and their spawning habitat, may be measurable depending on whether they are exposed to these contaminants over prolonged periods of time. However, currently there is no evidence that exposure of forage fish to chemicals in ACZA-treated wood results in bioaccumulation or measurable impacts to diving seabirds and/or predatory fish, nor would it be possible to directly link prey exposure to ACZA to physical injury to marbled murrelets and bull trout directly from the proposed action. The proposed action will restrict installation of new structures to areas outside of suitable and/or documented forage fish spawning areas. So any exposure of forage fish to ACZA would require dispersal of ACZA to areas of occupancy and/or spawning suitability, which based on the rationale described above, is extremely unlikely to occur because of the very low concentrations, short duration of leaching and localized impacts to water quality near the installation locations. Because exposure to chemicals from the use of ACZA-treated wood is not expected to measurably impact prey resources, effects to marbled murrelets and bull trout are considered insignificant.

Elevated Sound Pressure Levels

The proposed action will result in temporary increases in underwater and in-air SPLs during pile driving. Over the next five years, up to 150 new PRFs will be authorized by the Corps in the action area. The proposed maximum number of pilings per year is estimated to be 540 (20 pilings per PRF * 30 PRF per year), for a total of up to 3,000 pilings that may be installed throughout the action area over the 5-year duration of the program. The pilings will vary in size with the largest proposed diameter for steel pilings being 12 inches in diameter. All piles will be installed between July 16 and February 15. Vibratory pile driving will be the primary means of pile installation and impact pile driving will be used for proofing or if hard substrate is encountered that requires full installation of piles. Pilings for stairs and trams are usually driven in the dry and are not expected to result in a measurable increase of elevated underwater SPLs.

Exposure to elevated SPLs from impact-hammer pile driving steel piles can cause auditory injury, physical injury, and mortality. The acoustic impedance of fish and other aquatic animals nearly matches that of water, so most of the sound energy will enter their bodies if they are exposed (Hastings 1995, p. 979). As a sound travels from a fluid medium into these gas-filled cavities there is a dramatic drop in pressure which can cause rupture of the hollow organs (Gisiner et al. 1998, p. 61). Hastings reports that "fish suffer damage to their auditory system and other parts of their bodies, and may even die when exposed to high SPLs underwater for relatively short periods of time" and "damage may be apparent physically, or by changes in behavior or morphology of sensory cells" (1995, p. 979). Many types of damage appear to be temporary, but no studies found in the literature have assessed long-term effects (Hastings 1995, p. 979).

Thresholds for Onset of Injury to Bull Trout and Marbled Murrelets from Pile Driving

A multi-agency work group identified criteria and established thresholds for onset of injury, defining the SPLs where effects to fish are likely to occur from pile driving activities (FHWG 2008). These thresholds represent the onset of injury, not the levels at which fish are severely injured or killed. The greatest risk is associated with fish exposure to a single strike peak noise level greater than 206 dB_{peak}[a], in which direct injury or death of fish can occur. The other metric used to assess whether injury occurs is the sound exposure level (SEL), which is the amount of energy the fish receives. Onset of injury occurs to bull trout larger than 2 grams when the cumulative SEL exceeds 187 dB[b] and injury occurs to bull trout smaller than 2 grams when the cumulative SEL exceeds 183 dB_{SEL} (FHWG 2008). Additionally, when fish are exposed to a root mean squared (RMS) SPL exceeding 150 dB_{RMS}[c] we expect they may be exposed to levels of underwater sound that could alter their normal behavior. Any bull trout within the range to effects described above could experience threshold shift (TS) in hearing from fatigue to their auditory system, which can increase the risk of predation and reduce their success in foraging and spawning (Stadler and Woodbury 2009).

In July, 2011, a science panel recommended thresholds for marbled murrelets for onset of non-injurious TS in hearing, onset of auditory injury, and onset of non-auditory injury (barotrauma) (SAIC 2011). Thresholds recommended were:

- Non-injurious TS of 187 dB SEL re: 1 μPa^2-sec
- Auditory injury threshold of 202 dB SEL re: 1 μPa^2-sec
- Barotrauma at 208 SEL re: 1 μPa^2-sec

In March, 2012, in response to the lack of data regarding non-injurious TS and masking effects to marbled murrelets from pile driving, the USFWS and the Navy convened a second science panel to evaluate the onset of non-injurious TS (SAIC 2011). Masking is interference with the detection of one sound by another (Dooling and Therrien 2012). This science panel recommended a threshold for effects that result in masking of communications and ranges to the masking threshold: 42 meters for piles smaller than 36-inches in diameter and 168 meters for

---

[a] dB_{peak} is referenced to 1 micro Pascal (re: 1µPa or one millionth of a Pascal) throughout the rest of this document. A Pascal is equal to 1 newton of force per square meter).

[b] dB_{SEL} is referenced to 1 micro Pascal-squared·seconds (re: $1\mu Pa^2$·sec) throughout the rest of this document

[c] dB_{RMS} is referenced to 1 micro Pascal (re: 1µPa) throughout the rest of this document

piles equal to or greater than 36-inches in diameter and recommended moving away from a non-injurious TS threshold. However, the masking guidance does not apply to impact proofing of hollow steel piles or full impact-hammer installation of wood, concrete or plastic piles.

Auditory Effects to Bull Trout and Marbled Murrelets

Exposure to elevated SPLs, including those associated with impact-hammer pile driving can cause "threshold shift" where there is decreased hearing capability, at specific frequencies, for periods lasting from hours to days, or permanently. The onset and degree of TS resulting from noise exposure varies among species. Popper et al. (2005) and Song et al. (2008) investigated the effects of exposing three species of fish to seismic and airgun shots. The inner ears of these fishes were examined and no physical damage to the sensory cells was found (Song et al. 2008, pp. 1362-1365); specific to fishes, this is referred to as non-injurious TS.

When hearing loss is temporary it is sometimes categorized as a short-term fatiguing of the auditory system (rather than "injury") (Popper et al. 2005). However, Ryals et al. (1999) documented hair cell loss in birds that experienced acoustic overexposure. Using scanning electron photomicrographs the authors showed that hair cell loss and damage occurred on the surface of the papillae in the inner ears of birds. In several instances the hair cells did not recover, and the TS was permanent. When exposure to acoustic sources results in shifts in hearing sensitivity and there is loss and/or physical damage of hair cells, whether permanent or temporary, we refer to this as TS and consider it a form of injury.

With 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 resulting impact 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 (Gisiner et al. 1998, p. 25; Saunders and Dooling 1974, p. 1).

Non-Auditory Injury to Bull Trout and Marbled Murrelets

Exposure to underwater sound can also result in internal bleeding and stunning (complete immobilization) (Hastings 1995). Gouramis (*Trichogaster* sp.) and goldfish exposed to continuous sound waves for 2 hours experienced stunning between 8 and 30 minutes and/or death. Approximately 50 percent of the fish died when exposed to a sound level of 192 dB_{peak} and 400 Hz, 56 percent died at a sound level of 198 dB_{peak} and 150 Hz, and 25 percent died when exposed to a sound level of 204 dB_{peak} and 250 Hz. If the amplitude and exposure of a fish to elevated underwater SPLs is sufficient, we would expect they may be injured or killed.

Impulses can also injure and/or kill fishes by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs) (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005). The injuries associated with exposure to impulses are referred to as barotraumas, and include hemorrhage and rupture of internal organs, hemorrhaged eyes, and temporary stunning (Yelverton et al. 1973, p. 37; Yelverton et al. 1975, p. 17; Yelverton and Richmond 1981, p. 6; Turnpenny and Nedwell 1994; Hastings and Popper 2005). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). Physical injury to aquatic organisms may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. Necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to impulses showed fish with extensive internal bleeding and a ruptured heart chamber were still capable of swimming for several hours before death (Abbott et al. 2002). Sublethal injuries can reduce osmoregulatory efficiency and increase energy expenditure (Gaspin et al. 1976, p. 32; Govoni et al. 2008, p. 1) and can affect equilibrium and interfere with the ability to carry out essential life functions such as feeding and predator avoidance (Gaspin 1975; Turnpenny et al. 1994; Hastings et al. 1996; Popper 2003).

Exposure to impulsive sound can cause the swim bladder of fishes to repeatedly expand and contract, which essentially hammers adjacent tissue and organs that are bound in place near the swim bladder (Gaspin 1975). This pneumatic pounding can cause rupture of capillaries in the internal organs, as observed in fishes with blood in the abdominal cavity, and maceration of kidney tissues (Abbott et al. 2002; Stadler, pers. comm. 2002). Exposure to this type of pneumatic pounding can cause rupture of capillaries in the internal organs, as observed in fishes with blood in the abdominal cavity, and maceration of kidney tissues (Abbott et al. 2002; Stadler, pers. comm. 2002).

Marbled murrelets may also be injured or killed when exposed to high underwater pressure waves, which occur over a continuum of potential effects, ranging from mortality to sub-lethal physical effects including TS and gastrointestinal tract lesions, to non-injurious effects that might result in significant disruption of normal behaviors. At the most severe end of the spectrum, direct mortality or obvious injuries can occur. For example, after submerging dog's heads and exposing them to blasts at 223 dB_{peak}, Richmond et al. (1973) estimated that 50 percent of the ears facing the blast had tympanic rupture. Yelverton et al. (1973) documented less eardrum rupture in submerged mallards exposed to blasting, but noted extensive lung hemorrhage and a 50 percent prevalence of liver and kidney damage. At the least severe end of the spectrum of injurious effects, there may be temporary hearing shifts or small burst blood vessels.

Sound Pressure Levels Associated with Impact-Hammer Pile Driving

To analyze the effects from pile driving, we consider guidance by the Washington State Department of Transportation (WSDOT 2014) and the California Department of Transportation Compendium for Pile Driving Sound Data (Illingworth & Rodkin 2010) for information on sound generated when driving 12-inch diameter pilings; these data are presented below in Table 2. Commonly used pile drivers to install piles that are 12 inches in diameter are a compressed-air driven impact hammer and pneumatic vibratory hammer. In the absence of specific sound impact data for compressed-air driven impact hammer we use data for a diesel or air/steam hammer, which is likely the most similar to the air-driven impact hammer (Ehinger 2016, p. 32). Since there is considerable variability in the level of sound attenuation achieved during pile driving tests, and hydroacoustic monitoring has not verified consistent effectiveness of any attenuation measure (Buehler et al. 2015), we assume no reduction in SPLs from the attenuation measures, unless hydroacoustic monitoring occurs to verify SPLs, and provide the analysis for a worst-case scenario.

Table 2. Pile driving sound pressure levels and sound exposure data from Illingworth and Rodkin

Source	dB_{peak}	dB_{RMS}	dB_{SEL}
Point Isabell Foundation: 12-inch diameter steel pile with diesel hammer in shallow water	192	177	174[1]
Sausalito Dock: 12-inch diameter steel pile with drop hammer in shallow water	177	165	152
Mad River: 13-inch diameter steel pile with vibratory hammer	171	155	155

[1] SEL data available for 14-inch piling, only.
(2007, p. I.1-1)

We made the following assumptions for estimating the effects of the pile driving:

- The number of pilings that may be driven annually is estimated to be approximately 600 = 20 pilings/project * 30 projects, with a total max of 150 projects over a five-year period.
- Pilings will not exceed 12-inches in diameter.
- The proposed number of total pile strikes per project will not exceed 300 per day.
- If an impact hammer (e.g., drop, hydraulic, diesel, or sledge hammer) is used to drive or proof steel pilings
  - A bubble curtain that distributes air bubbles around 100 percent of the perimeter of the piles over the full depth of the water column will be used.
- The proposed number of projects per year is approximately 30 new PRFs, not to exceed a total of 150 new PRFs over the next five years.
- Bull trout present in the vicinity of pile driving activity during the approved in-water work window will be larger subadults or adults weighing more than 2 grams.
- The in-water work window for marine areas is July 16 to February 15 depending, and the window may be truncated if forage fish spawning areas are present in the vicinity.
- Adults and juvenile marbled murrelets may be present during pile installations.

Effects to Bull Trout from Impact Pile Driving

Based on the data in Table 3, we used the SPLs data associated with the Point Isabell Foundation Project and impact installation of 12-inch diameter steel piles to be 192 dB_{peak}, 174 dB_{SEL}, and 177 dB_{RMS}. For instantaneous injury impacts to bull trout there is a high likelihood of injury from exposure to instantaneous pulses of SPLs above 206 dB_{peak} (FHWG 2008). For the proposed projects the worst-case scenario estimates sound pressure levels generated by impact pile driving of 12-inch diameter steel pilings to be 192 dB_{peak}, which is below the threshold for onset of injury (206 dB_{peak}). Therefore, it is extremely unlikely that a bull trout would be injured when exposed to single-strike peak pressure levels.

For calculating the potential cumulative (multiple pile strikes) effects on fish we used the NMFS spreadsheet calculator (http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm), assuming that no more than 300 impact-hammer pile strikes per day would be employed for this program. The model assumes that cumulative effect would 'reset' overnight because of the anticipated movement of fish, so only strikes that occur within a single day are counted toward cumulative impacts. We estimated the area of adverse effects to bull trout for each in-water structure as 125,427 ft^2 (1.17 hectares), with a range to effects where onset of injury could occur extending 61 meters from the pile installation/pile driving location.

Table 3. Sound Pressure Levels and range to effects for onset of injury to bull trout

Input values for single strike noise			**Onset of Physical Injury**			**Behavior**
Peak	**SEL**	**RMS**	**Peak**	**Cumulative SEL dB**		**RMS**
192	**174**	**177**	**dB**	**Fish ≥ 2 g**	**Fish < 2 g**	**dB**
Thresholds from the Hydroacoustic Working Group (FHWG 2008)			206	187	183	150
Distance to threshold			**0 m**	**200 ft/ 61m**	**369 ft/ 113m**	**2070 ft/ 631m**
Approximate Area affected				125,427 square feet/ 1.17 hectares	428,278 square feet/ 3.98 hectares	125 hectares

Each project will typically require three to five days of pile driving, depending on location and conditions. If we assume a worst-case scenario, substrate conditions may require that each pile be installed only with impact pile driving, not to exceed a maximum of 300 strikes per day. The total number of days that impact pile driving may occur could extend 20 days because a maximum of 20 piles per project may be installed.

Most bull trout present in marine waters during the approved in-water work window are foraging, migrating, and/or overwintering along shoreline habitats. Because bull trout are transitory, we anticipate they would be moving along the shoreline areas and it is reasonable to assume that some individuals will be exposed to elevated sound pressure levels during pile driving at levels that could result in injury. The cumulative SEL for 300 impact-hammer pile strikes would result in a radius of effects extending 61 meters from the pile locations (where the cumulative SEL of underwater SPLs would exceed the threshold for onset of injury).

There are certain geographic regions where bull trout presence is so rare or unlikely that we consider exposure to underwater SPLs to be discountable. Those areas are: south Puget Sound, south of the Tacoma Narrows Bridge; Kitsap Peninsula, including Vashon Island, Bainbridge Island, and the eastern shore of Hood Canal; the San Juan Islands; Lake Washington; Lake

Sammamish; the Lake Washington Ship Canal; Cedar River below Chester Morse Dam; the Green/Duwamish River below Tacoma's Headworks Diversion Dam; and the lower Columbia River, downstream of the Bonneville Dam.

Geographic areas where bull trout exposure to underwater SPLs is not considered discountable include Puget Sound north of the Tacoma Narrows bridge, the western shore of Hood Canal, and the Strait of Juan de Fuca. The proposed work would occur in marine waters when bull trout presence is expected to be lower, during the approved in-water work window, between July 16 and February 15. However, non-spawning bull trout may still be present and exposed in Puget Sound (north of the Tacoma Narrows Bridge), the western shore of Hood Canal, and the Strait of Juan de Fuca. All bull trout within 61 meters of impact pile driving may be injured or killed by exposure to cumulative elevated underwater SPLs.

Impact-hammer installation of hollow 12-inch diameter steel piles will result in SPLs of 177 dB_{RMS}, which exceeds the threshold (150 dB_{RMS}) where behavioral effects could occur. Using the NMFS calculator, sound pressure levels would attenuate to below 150 dB_{RMS} within 631 meters (2,070 ft) of impact pile driving, affecting a total area of approximately 125 hectares around each pile. However, only about half of that area is actually waterward of the ordinary high water mark (OHWM), so only about 62 hectares of water would be affected. Behavioral effects will extend into deeper areas where adults may be exposed. We expect bull trout in marine areas mainly use nearshore habitat, and the impact to them can better be described as affecting shallow habitat along approximately 1,262 meters or 4,140 linear ft, of shoreline per project. We expect varying levels of behavioral responses from no response, to mild awareness, or a startle response (Hastings and Popper 2005). However, we do not expect these responses to these sound levels to result in a significant impairment of normal behaviors or measurable effects.

Effects to Marbled Murrelets from Impact Pile Driving

We do not expect that communication between marbled murrelets would be masked during impact pile driving because of the short duration and intermittent nature of noise-generating activities. The proposed action would limit the total number of pile strikes to fewer than 300 per day. The in-air sound resulting from 300 pile strikes per day amounts to a total of 8 minutes per day of in-air sound, which is not expected to impede communication between foraging marbled murrelets. Because the elevated in-air sound levels will be intermittent, and only occur for such limited durations, we do not expect communication between marbled murrelets to be measurably affected. The remainder of this section focuses on effects to marbled murrelets associated with exposure to elevated underwater SPLs.

Exposure Analysis

As was stated above under effects to bull trout, the highest underwater SPLs for impact pile driving 12-inch steel piles will be 192 dB_{peak}, 174 dB_{SEL}, and 177 dB_{RMS}. There is no threshold for onset of injury to marbled murrelets from instantaneous pulses of SPLs associated with impact pile driving. We estimated the probability of exposure of marbled murrelets to underwater SPLs using marbled murrelet density data compiled for the NWFPEM. In Puget

Sound, Hood Canal, the San Juan Islands and the Strait of Juan de Fuca waters, the first step towards determining the likelihood of marbled murrelets encountering stressors associated with the proposed impact pile driving is to describe the structure of the population in Conservation Zone 1, based on bird density in the various geographic areas in Table 4.

Table 4. Average marbled murrelet density and population size during the summer months (April through September) in Conservation Zone 1 between 2011 and 2015

Conservation Zone 1 (Strata)	**Mean Density (birds/km^2)**	**Mean Population Size Estimate with 95% CI**			**Survey Area (km^2)**
		Mean	**Lower**	**Upper**	
1	3.7	3,144	1,661	4,688	845
2	1.3	1,582	786	2,404	1,194
3	0.5	701	252	1,624	1,458
All	**1.6**	**5,427**	**2,699**	**8,716**	**3,497**

(Falxa et al. 2015; Falxa and Raphael 2015)

We used a Poisson probability model based on murrelet density to estimate the group size and number of birds exposed to stressors and to evaluate the likelihood of one or more marbled murrelets being within the range of a critical field (i.e., onset of injury, mortality, or disturbance). We considered the foreseeable future when determining the cumulative probability, which is 5 years in this case. 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. The estimated group size of marbled murrelets in Conservation Zone 1 is 2 birds.

In this analysis, the number of marbled murrelet foraging groups exposed is calculated from the average group density (groups/km^2) of birds foraging in Puget Sound, Hood Canal, the Strait of Juan de Fuca, or the San Juan Islands. Although underwater sound pressure waves can continue for distances exceeding several kilometers (depending on the wave characteristics, frequency, source levels, etc.), it is of foremost interest to us to predict the probability of exposure (**p**), which always has a value between 0 and 1.0. We treated results where **p** ≥ 0.1 as an "encounter" and values of **p** < 0.1 were treated as a "miss." Additionally, we expect exposure is reasonably certain to occur when **p** > 0.5 because exposure is more likely than not to occur.

Foraging Behavior

Marbled murrelets spend a considerable amount of time on the surface (not foraging) in any given day. Marbled murrelets dive to depths of 3 to 36 m when foraging (Jodice and Collopy 1999, p. 1409). During the summer, marbled murrelets spent 30 to 45 minutes on the surface without feeding, remaining within a few meters of each other. When diving, they can be separated by 100 meters or more, after which they have been seen immediately calling and paddling toward each other, and once reunited, they billed, circled each other, stretched wings, and rested on surface or started diving again (Thorensen 1989, p. 36).

Marbled murrelets are also aggressive feeders during a typical, 30-minute foraging bout, spending up to 22 minutes of the bout (75 percent) submerged/foraging. Thorensen (1989, p. 36) found that during a foraging bout, the mean dive time was 45 seconds and mean time spent on the surface was 15 seconds. If a 30-minute foraging bout is comprised of intervals where the birds dive 45 seconds and surfaces for 15 seconds, this would represent 75 percent of the 30-minute foraging bout spent underwater; total of 22.5 minutes out of 30 minutes (assuming the averages mentioned above, not the upper and lower range values).

Marbled murrelets generally forage during the day, and are most active during early morning and late afternoon (Strachan et al. 1995, p. 247). Although we expect they would be underwater for approximately 75 percent of a foraging bout, they also spend a significant amount of each day loafing, preening, and other activities on the surface of the water. It is impossible to predict whether a marbled murrelet would be on the surface or underwater at any given point in a day when impact pile driving would occur. Therefore, we assume equal likelihood that a marbled murrelet would be on the surface as underwater at any given point in a day.

Area of Effect (Exposure)

The exposure model assumes that cumulative effects would ‘reset’ overnight because of the anticipated movement of marbled murrelets, so only strikes that occur within a single day are counted toward cumulative impacts (maximum of 300 strikes per day). Based on the anticipated underwater SPLs associated with impact pile driving in Table 5 , we estimate the area of adverse effects to marbled murrelets for each in-water structure as 1,256 ft^2 (0.01 hectare), with a range to effects where onset of injury could occur extending 6 meters from the pile installation/pile driving location.

Table 5. Sound pressure levels and range to effects for onset of injury to marbled murrelet

Input values for single strike noise			**Onset of Physical Injury**		**Behavior**
Peak	**SEL**	**RMS**	**Cumulative SEL dB**		**RMS**
192	**174**	**177**	**Auditory Injury**	**Barotrauma**	**dB**
Thresholds for Onset of Injury			206	208	150
Distance to threshold			**20 ft/ 6m**	**8 ft/ 2m**	**2070 ft/ 631m**
Approximate Area affected			1,256 ft^2/ 0.01 hectare	201ft^2/0.002 hectare	125 hectares

Each project will typically require three to five days of pile driving to install the maximum of 20 piles allowed, depending on location and conditions. Some projects may take up to 20 days to complete pile installations. Work will start after July 16 and ceases prior to the end of the approved in-water work window, February 15 or sooner if the project is located in or near forage fish spawning habitat.

Marbled murrelets present in marine waters during the approved in-water work window are engaging in activities such as foraging, pair-bonding, preening, and/or loafing. Because marbled murrelets engaging in these activities are moving around, we anticipate they would be moving along the shoreline areas and not remaining stationary in one location for prolonged periods of time. We anticipate that it would be extremely unlikely for them to be within 6 meters (20 ft) of pile installation locations (probability of exposure, $p < 0.006$). Therefore, we do not expect marbled murrelets to be exposed to SPLs that could result in injury from the proposed pile driving activities.

Impact-hammer installation of hollow 12-inch diameter steel piles can result in instantaneous SPLs of 177 dB_{RMS}, which exceeds the threshold where behavioral effects to marbled murrelets can occur. Using the NMFS calculator, sound pressure levels would attenuate to below 150 dB_{RMS} within 631 meters (2,070 ft) of impact pile driving, affecting a total area of approximately 125 hectares around each pile. However, only about half of that area is actually waterward of the OHWM, so only about 62 hectares of water would be affected. Adult marbled murrelets may be molting, starting around September, and unable to fly during the molting process. Behavioral effects will extend into deeper waters along the shorelines and in areas where adults and recently fledged young may be exposed. Impact pile driving will be intermittent and would occur for less than approximately 8 minutes per day, assuming a maximum of 300 strikes per day and 1.5 seconds per strike. Adults would still be transitory even while molting and flightless. We expect marbled murrelets would move away from pile driving activities if they were disturbed, especially if barges are deployed for pile driving in shoreline areas. We expect varying levels of behavioral responses from no change, to mild awareness, or a startle response, which may include diving or flying away (if they are able to fly, and not molting). If disturbed, we expect they would return to their normal behaviors relatively quickly. Therefore, we do not expect exposure to underwater sounds at these levels to result in measurable alterations to their normal behaviors.

Vibratory Pile Driving

Vibratory pile driving is not currently associated with injury or death to fishes or other aquatic organisms, including diving seabirds. This may be attributable to slower rise times (the time taken for the impulse to reach its peak pressure) associated with vibratory pile driving, and the fact that the energy produced is distributed over the duration of pile installation (WSDOT 2014). We anticipate that vibratory pile driving will cause only minor behavioral effects to marbled murrelets and bull trout and these behavioral effects are extremely unlikely to result a measurable effects or a significant impairment of their normal behaviors. Therefore, effects to marbled murrelets and bull trout associated with vibratory installation of piles are considered insignificant.

Permanent Structures Installed in Shoreline Areas

Prey Resources

Submerged aquatic vegetation is crucial in providing cover and a food base for forage fish and juvenile salmonids, which are prey resources for bull trout and marbled murrelets. When submerged aquatic vegetation (SAV) is shaded the primary productivity is reduced, especially if the vegetation does not receive the light it needs to survive. Some of the proposed new overwater structures will shade SAV for the life of the structure (Kelty and Bliven 2003) because most these structures will not be removed in the foreseeable future. Additionally, the area of effect of the proposed action likely extends beyond the immediate footprint of the structure. We anticipate short-and/or long-term effects extending approximately 10 ft beyond the structures, given that many of the RPFs will be used for boat moorage and the effects of shading shifts over the course of the day.

Piers, ramps and floats and the boats associated with them shade intertidal habitat. New floats are generally grated, but boats and floating boat lifts are not; floating boat lifts can create more shade than the PRF or lift structures do depending on their size. The additional shading from the boat lifts and boats reduces the light transmission to aquatic vegetation that provides refuge for some spawning forage fish (i.e., Pacific herring). Shading in intertidal areas also impedes migration of juvenile salmonids and can shade forage fish spawning habitat, both of which are prey for bull trout. Grating is assumed to provide a benefit to intertidal areas by increasing the amount of light transmission to submerged aquatic vegetation, thereby sustaining its health.

There are few studies that specifically examine the effect of overwater structures on submerged aquatic vegetation types other than eelgrass and kelp (Mumford 2007). Fresh et al. (2006) researched the effects of grating in residential floats on eelgrass, one matrix upon which Pacific herring spawn, and reported a statistically significant decline in the density of eelgrass shoots under most floats studied in northern Puget Sound. The physiological mechanism that reduces shoot density and biomass associated with shading applies to all types of submerged aquatic vegetation because of their universal need for adequate light transmission to survive. Reductions in submerged aquatic vegetation are expected to reduce the primary production of the various types epibenthos present (Haas et al. 2002). A reduction to the primary production of submerged aquatic vegetation is likely to incrementally reduce the food sources and cover for marine forage fish and juvenile salmonids. Additionally, reductions in the biomass and shoot density of submerged aquatic vegetation from shading have also been correlated with reduced diversity of epibenthos assemblages (Haas et al. 2002).

Pacific herring are one of many primary sources of prey for bull trout and marbled murrelets. An essential element of Pacific herring spawning habitat appears to be the presence of perennial marine vegetation beds at rather specific locations (Penttila 2007). Spawning areas for Pacific herring are largely limited to depths where submerged aquatic vegetation can grow; Pacific herring also use several other species of macroalgae for spawning. In shallower areas, *Zostera marina* is of primary importance, and in slightly deeper areas, *Gracilaria* spp. predominates (Penttila 2007). Other types of submerged aquatic vegetation used for spawning by Pacific herring include “algal turf,” often formed by dozens of species of red, green and brown algae, (Penttila 1973). In deeper water and in areas where native eelgrass beds do not predominate, herring spawn on the mid-bottom-dwelling red alga *Gracilariopsis sp.* (referred to as *Gracilaria* in some sources) (Penttila 2007). In Wollochet Bay WDFW documented spawning for Pacific herring is mainly on *Ulva sp.*

Pacific herring spawning may be impacted by shading from overwater structures, grounding of floats, and accumulation of shell fragments that fall from the structure {{17095 Penttila,Daniel E. 2001/f, p. 15;}}. There are few species of marine macro-vegetation that can tolerate the reduction in ambient light within the direct footprint of a typical overwater dock or pier, including plant species used by spawning herring (WDFW unpub. data *in* {{17095 Penttila,Daniel E. 2001/f, p. 15;}}). Additionally, herring eggs deposited on wood pilings associated with overwater structures may be impacted by contaminants and higher risk of thermal shock and desiccation of eggs {{17095 Penttila,Daniel E. 2001/f, p. 15;}}.

New overwater structures can also impact other forage fish spawning habitat (i.e., Pacific sand lance and surf smelt) by introducing propwash scour and reducing input of sediment by changing the drift cell pattern. However, surf smelt and Pacific sand lance spawning habitats may persist beneath overwater structures if the structures span the spawning habitat zone, and piling have minimal displacement of beach area, so that the upper intertidal sediment distribution and movement are not affected (WDFW unpub. data *in* {{17095 Penttila,Daniel E. 2001/f, p. 15;}}). Removing overwater structures and other barriers to nearshore drift can improve conditions for eelgrass and kelp and can improve nearshore process function for fine sediments {{17095 Penttila,Daniel E. 2001/f, p. 13;}}.

Many studies suggest that overwater structures can disrupt migration of juvenile salmonids in the Puget Sound nearshore. Swimming around structures lengthens the salmonid migration route, which can increase mortality. Based on the findings of numerous studies, we are reasonably certain that the installation of new PRFs and associated floating boat lifts and boats in shallow water will adversely affect juvenile salmonid migration (Ehinger 2016). In the Puget Sound nearshore, 35 millimeter to 45 millimeter juvenile chum and pink salmon were reluctant to pass under docks (Heiser and Finn 1970). Southard et al. (2006) snorkeled underneath ferry terminals and found that juvenile salmon were not underneath the terminals at high tides when the water was closer to the structure, but only moved underneath the terminals at low tides when there was more light penetrating the edges. Ono (2010) reports that juveniles tended to stay on the bright side of the shadow edge, two to five meters away from the dock, even when the shadow line moved underneath the dock. The NMFS has determined that the increase in migratory path length from swimming around overwater structures as well as the increased exposure to piscivorous predators in deeper water likely will result in proportionally increased mortality of juvenile salmonids.

While the studies discussed above mostly examined larger structures than proposed under RGP-6, we are reasonably certain that the results reported for larger piers, where juvenile salmon avoid shaded areas under large structures, concentrate at the edge of structures, and/or are pushed into deeper waters where predation increases, are also likely to occur for residential floats — though likely to a lesser degree (Ehinger 2016). The above referenced studies lead to the conclusion that an increase of predation on juvenile salmonids as a result of modified migration and schooling behavior is reasonably certain to occur from the presence of PRFs, associated boat lifts, and boats in the nearshore (Ehinger 2016). While this may be a short-term beneficial effect for bull trout, as they prey on juvenile salmonids, the long-term effect would be detrimental if it led to an overall reduction in prey abundance.

The adverse effects of the proposed action on juvenile salmonids and other prey resources for bull trout and marbled murrelets will occur at various locations over the course of 5 years. Both bull trout and marbled murrelets rely on a variety of prey resources besides juvenile salmonids. The effects will be broadly distributed throughout the action area and will affect these prey resources. Given the size of the structures and their wide distribution within the action area, we expect measurable effects to marbled murrelets and bull trout from impacts to prey resources. However, we do not expect these impacts would create the likelihood of injury to an individual because bull trout and marbled murrelets rely on a variety of prey resources and we expect sufficient prey is available beyond the footprint of each structure.

There are few studies that provide relevant and specific information to describe interactions between overwater structures and prey resources that are considered most important to bull trout and marbled murrelets foraging in the marine environment (e.g., marine forage fish, juvenile salmonids). Further complicating matters, conditions resulting from the installation and use of recreational PRFs reflect variable patterns and rates of recovery from disturbance. The discernable direct and indirect effects of these projects are further influenced by natural variability, patterns of disturbance and recovery from natural events, and the confounding effects of concurrent, unrelated activities occurring in the same nearshore environments.

The locations where new PRFs will be installed are broadly distributed throughout the Puget Sound, Hood Canal, the Strait of Juan de Fuca, and/or the San Juan Islands. Specific locations of proposed PRFs are unknown and not all spawning areas for Pacific herring have been identified. Therefore, we anticipate that some adverse impacts to Pacific herring, surf smelt, and Pacific sand lance spawning habitat would result from the proposed action. Additionally, most PRFs are likely to result in a reduction of epibenthic prey and some reduction of submerged aquatic vegetation, regardless of where they are installed. We anticipate there will be measurable effects and potential incremental reductions in prey resources for bull trout and marbled murrelets from overwater structures being installed in nearshore habitat.

Bull trout, marbled murrelets, and their prey resources will be exposed to the measurable, persistent and long-term effects associated with the installation and use of new overwater structures. The Service expects that persistent and long-term stressors and exposures resulting directly and indirectly from adverse effects to juvenile salmonids (and other marine forage fish) will in some instances have adverse effects to bull trout and marbled murrelets. However, we are not able to demonstrate that exposures are reasonably certain to result in a significant disruption of their normal behaviors (i.e., the ability to successfully feed, move, and/or shelter) or increase the likelihood of injury. The best available information is currently insufficient to demonstrate that persistent and long-term stressors and exposures are reasonably certain to result in measurable adverse effects to energetics, growth, fitness, or long-term survival (injury or mortality) of bull trout and marbled murrelets associated with adverse effects to prey resources.

Removal of Riparian Vegetation

Access to construction areas may require the removal of vegetation along shorelines for the proposed action. While RGP-6 incorporates measures to avoid, minimize, and mitigate the effects of impacts to riparian vegetation, we expect that some degradation of the riparian areas will still occur. Shoreline and riparian vegetation in Puget Sound has already been significantly degraded by timber harvest, urban development, roads, railroads, and other infrastructure and activities (Brennan, 2007). About 27 percent of the Puget Sound shorelines are hardened and those shorelines have little native or woody vegetation behind the bulkhead/armor. Although the effects are relatively small at the scale of each project, these effects do accumulate and degrade baseline conditions.

Riparian vegetation provides many functions, including providing terrestrial litter that feeds aquatic invertebrates (Romanuk and Levings, 2003) and shade for forage fish spawning areas (Penttila 2007) which serve as prey for marbled murrelets and bull trout. Further, terrestrial insects that drop into the nearshore marine waters directly feed juvenile salmonids (Toft et al. 2007), which are prey for bull trout. Forage fish spawn in the upper shore zone where shade is important to keep their eggs from desiccation during the summer incubation period (Penttila 2001; Rice 2006).

We anticipate that over the next five years, installation of 150 PRFs and 25 marine rails, trams and stairs, and the associated impacts to riparian vegetation may result in a temporary reduction of prey resources for bull trout and marbled murrelets. However, these effects will be broadly distributed across the geographic extent of the action area (Puget Sound, Hood Canal, the Strait of Juan de Fuca, and the San Juan Islands) with most impacts being localized near the structures. Riparian plantings will mitigate for these impacts over the long-term as the newly planted areas mature and provide full function. Because bull trout and marbled murrelets have fairly diverse diets, relying on a variety of prey resources, we are unable to conclude that the removal of riparian vegetation will measurably affect the inputs of terrestrial prey resources (macroinvertebrates) into the marine environment or alter the distribution and abundance forage fish. Therefore, effects to bull trout and marbled murrelets associated with impacts to riparian vegetation are considered insignificant.

Long-Term Effects from Use and Operation of Overwater and Shoreline Structures

Most new overwater structures, stairs, boat lifts, and trams will not be removed in the foreseeable future but will be maintained, repaired and/or upgraded by the homeowners. This consultation does not cover the effects associated with maintenance or repairs to these structures in the future. This consultation only considers the effects of their installation and effects over the expected life of the structure, which is assumed to be a total of 40 years. This does not account for additional effects anticipated when they are maintained beyond the 40-year life expectancy.

Marbled murrelets are not known to dive underneath docks and juvenile fish avoid dark shadows, moving around docks and piers rather than swimming under them. These overwater structures will not be removed and we consider them to be permanent features. We anticipate the installation of new overwater structures will reduce the amount of available marine foraging areas for both marbled murrelets and bull trout within the footprint of the overwater structures and would reduce prey abundance (i.e., forage fish and juvenile salmonids).

Long-term additive effects of these new permanent overwater and nearshore structures may affect both marbled murrelets and bull trout that would otherwise forage in these the nearshore areas. Given the habitat alterations expected from installing the permanent structures and their wide distribution within the action area, we expect measurable effects to marbled murrelets and bull trout from impacts to prey resources associated with the installation of these overwater structures over the long term. However, we do not expect these impacts would create the likelihood of injury to an individual because bull trout and marbled murrelets rely on a variety of prey resources and we expect sufficient prey is available beyond the footprint of each structure.

Summary of Effects to Marbled Murrelets and Bull Trout

Overall, the mitigation proposed will address factors in the marine nearshore that limit individual fitness, survival, and productivity (i.e., habitat degradation and consequential declines in prey abundance). We expect that the mitigation will significantly improve nearshore marine habitat by enhancing habitat suitability and increasing the abundance and productivity of marbled murrelets and bull trout from improvements to their habitat and prey resources. The mitigation will offset some of the effects of installing permanent overwater and nearshore structures in nearshore habitat. Therefore, we are reasonably certain that the mitigation actions will increase habitat quality and the abundance of prey resources for listed species over the duration of this consultation.

Increased vessel traffic is likely to result from the proposed actions The structures that will be built under this project are reasonably certain to result in increased boating, including jet skis, activity in the vicinity of the new structures and beyond to the extent that the vessels travel from these locations. Marbled murrelets would be approached by boats at distances less than 150 meters and a small number of individuals may respond with avoidance behaviors. However, these effects will be broadly distributed throughout the inland marine waters and likely would not be measurable over current conditions. Exposures will be infrequent and short in duration and are not expected to result in a significant disruption of normal behaviors to an extent that would create the likelihood of injury or death. Therefore, effects to marbled murrelets associated with intermittent exposures to recreational boat traffic are considered insignificant.

Increased vessel traffic from the addition of 150 new structures over the life of this program would result in a slight increase in boating activity and associated engine noise levels in the project areas. This will increase fish disturbance from engine noise, propeller movement, and the physical presence of boats and humans, including fishing activities. Some of these activities are likely to disturb bull trout, cause them to temporarily leave an area, and experience sublethal physiological stress. The proposed projects will be broadly distributed throughout the action area. We expect that some bull trout will exhibit a behavioral response to watercraft noise over the duration of the project; however, we do not expect that these short-term exposures will measurably affect their normal behaviors or result in injury or death. Therefore, effects to bull trout associated with intermittent exposures to boat engine noises and vessel use are considered insignificant.

Water quality will be temporarily impacted during the installation of mooring buoys, overwater structures, piles, and other permanent features. Bull trout, marbled murrelet, and forage fish may be temporarily disturbed by elevated levels of turbidity from the proposed activities. Effects include temporary alterations in their normal behaviors from exposure to elevated levels of turbidity, but these effects are temporary and there will not be long-term exposure of bull trout or marbled murrelets to persistent water quality impacts. Additionally, we do not anticipate measurable alterations of habitat and forage fish spawning areas from the amount of suspended sediments introduced, nor do we anticipate a measurable reduction in prey abundance.

Contaminant concentrations may increase slightly for short durations from watercraft use and installing ACZA-treated wood piles. We anticipate the release of these materials will be intermittent, infrequent, and limited to very small quantities. Therefore, effects to marbled murrelets and bull trout are not likely to be measurable or result in a significant impairment of normal behaviors. Overall we expect the water quality impacts to be very minor in magnitude. There is no evidence that bioaccumulation of ACZA and PAHs in prey resources results in measurable impacts to diving seabirds and fish, nor would it be possible to directly link prey exposure to ACZA and PAHs to physical injury to murrelets and bull trout directly from the proposed action. Effects to marbled murrelets and bull trout associated with short-term exposures to chemicals are considered insignificant.

Underwater and in-air SPLs will be temporarily elevated during pile driving activities. Because the elevated in-air SPLs from impact pile driving will be intermittent, and only occur for less than 8 minutes (cumulatively) per day, we do not expect communication between marbled murrelets to be measurably affected and there would be no measurable reduction in foraging efficiency. Additionally, we anticipate marbled murrelets are extremely unlikely to be within 6 meters (20 ft) of pile installation locations, with a probability of exposure less than 0.006. Additionally, any disturbance will be temporary and would not measurably affect their normal behaviors. Therefore, marbled murrelets are extremely unlikely to be measurably disturbed, injured, or killed by the proposed impact pile driving activities.

Elevated underwater SPLs would occur in marine waters when bull trout presence is expected; non-spawning bull trout may be present and exposed in Puget Sound (north of the Tacoma Narrows Bridge), the western shore of Hood Canal, and the Strait of Juan de Fuca. All bull trout larger than 2 grams present within 61 meters of impact pile driving in the geographic areas listed above may be injured or killed by exposure to elevated underwater SPLs. In other geographic regions bull trout presence is so rare or unlikely that we consider exposure to underwater SPLs to be discountable. Those areas are: south Puget Sound, south of the Tacoma Narrows Bridge; Kitsap Peninsula, including Vashon Island, Bainbridge Island, and the eastern shore of Hood Canal; the San Juan Islands; Lake Washington; Lake Sammamish; the Lake Washington Ship Canal; Cedar River below Chester Morse Dam; the Green/Duwamish River below Tacoma’s Headworks Diversion Dam; and the lower Columbia River, downstream of the Bonneville Dam.

Installing permanent structures in nearshore habitat is anticipated to result in increased shading of submerged aquatic vegetation. Increased shading from overwater structures in nearshore habitat is reasonably certain to result in measurable impacts to the behavior of juvenile salmonids as well as increased predation on them. Increased shade of submerged aquatic vegetation and installation of permanent structures are also reasonably certain to decrease the abundance of Pacific herring. The adverse effects of the proposed action on prey resources for bull trout and marbled murrelets will occur at various locations over the course of 5 years. Both bull trout and marbled murrelets rely on a variety of prey resources and the effects will be broadly distributed throughout the action area. Given the size of the structures and their wide distribution within the action area, we expect measurable effects to marbled murrelets and bull trout from impacts to prey resources. However, because bull trout and marbled murrelets rely on a variety of prey resources and we expect sufficient prey to available in the action area, we do not expect impacts to juvenile salmonids to be at a level that would create a likelihood of injury.

Vessel traffic will increase in the vicinity of the new structures and beyond to the extent that the vessels travel from these locations. We are unable to determine the extent, frequency and duration of potential vessel-related interactions with individual marbled murrelets and bull trout that would result in significant disruptions of normal behaviors or injury. We expect that marbled murrelets would not be measurably affected over the long term by the incremental increased level of boat traffic throughout the action area. Additionally, disturbance of bull trout from engine noise, propeller movement, and the physical presence of boats and humans, including fishing activities are not likely to result in a significant disruption of their normal behaviors. Because these exposures will be infrequent and short in duration, intermittent exposure to boat noise associated with increased vessel use is not expected to measurably affect bull trout.

Installing permanent features in nearshore areas may require the removal of riparian vegetation and may shade submerged aquatic vegetation. We anticipate an incremental reduction in prey resources for bull trout and marbled murrelets from 150 new overwater structures and 25 marine rails, trams and stairs (25 each) being installed in nearshore habitat. Over the next five years, we are reasonably certain this will reduce prey resources for bull trout and marbled murrelets. We anticipate the reductions will be incremental and the effects will be broadly distributed across a large geographic area (Puget Sound, Hood Canal, the Strait of Juan de Fuca, and San Juan Islands) with most impacts being localized near the structures. The habitat will still provide sources of prey, though we anticipate a minor reduction in prey quality, abundance, and species diversity in the immediate vicinity of some overwater structures. Because bull trout and marbled murrelets have fairly diverse diets, relying on multiple sources of prey, effects associated with impacts to riparian vegetation are considered insignificant.

New overwater structures installed in the nearshore will permanently affect foraging areas for marbled murrelets because they are not expected to forage underneath piers and floats. We anticipate that installing new permanent overwater structures will reduce the use of marine waters within the footprint of the overwater structures. Long-term accumulative effects of installing new overwater and nearshore permanent structures may adversely affect marbled murrelets that would otherwise forage in these the nearshore areas. However, because other foraging areas are still be available, the width of the structures is relatively small and they are widely distributed over a large geographic area, we are unable to conclude that the minor loss of foraging areas represents a measurable level of disruption to their normal behaviors to an extent that would lead to injury.

We expect measurable effects to marbled murrelets and bull trout associated with a reduction of juvenile salmonids and forage fish due to the installation of new permanent overwater structures. The adverse effects of the proposed action on juvenile salmonids and other prey resources for bull trout and marbled murrelets will occur at various locations over the course of 5 years. Both bull trout and marbled murrelets rely on a variety of prey resources besides juvenile salmonids. Given the relatively small size of the structures and their wide distribution within the action area, we do not expect these impacts to create the likelihood of injury.

In summary, the proposed action is expected to result in the following adverse effects:

- Bull trout larger than 2 grams within 61 meters of impact pile driving of steel piles will be injured or killed.
- Marbled murrelets and bull trout will be measurably affected by reduced prey abundance associated with the short and long-term effects of new permanent structures in intertidal habitat.

EFFECTS TO BULL TROUT CRITICAL HABITAT

The nearshore marine environment in Puget Sound and the Strait of Juan de Fuca were designated as bull trout critical habitat on October 18, 2010 (75 FR 63898). The nearshore areas are used by anadromous bull trout seasonally for foraging and migration. The *Existing Condition* section of this Opinion describes how human alterations such as bank armoring, removal of shoreline vegetation, development, and surface runoff have affected many of the primary constituent elements and are compromising the function of critical habitat. Refer to Appendix F for a discussion of the Rangewide Status of Bull Trout Critical Habitat.

The proposed project is anticipated to result in both short- and long-term effects to designated critical habitat. The proposed action will further degrade the baseline conditions and result in adverse effects to the following PCEs in the action area:

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The action area is used by bull trout for migrating and foraging. Construction elements that will result in short-term localized impacts to the migratory corridor include: 1) elevated underwater sound levels during pile driving, 2) increased turbidity, 3) contaminants from vessels, and 4) degradation of nearshore habitat. These activities combined may deter bull trout from migrating through the area, and may cause bull trout to be displaced or temporarily avoid the site when construction activities are occurring. We do not anticipate that impacts to the migratory corridor from these short-term stressors will measurably affect this PCE because they will be temporary and would not affect the function of this PCE over the long-term.

Elevated underwater SPLs would occur in marine waters where bull trout are expected to be present. There is a high likelihood that some adult and larger subadult bull trout in northern Puget Sound (north of the Tacoma Narrows Bridge), the western shore of Hood Canal, and the Strait of Juan de Fuca will be exposed to high levels of underwater sound during impact pile driving of steel piles. All bull trout present within 61 meters of pile driving will be injured or killed by exposure to elevated underwater SPLs. Furthermore, individuals that avoid the construction area will experience temporary delays in movement.

Impacts to water quality (degradation) associated with periodic releases of contaminants from vessels and operation of the residential shoreline facilities are expected to increase and will continue into the future for the life of the facilities. Water quality will also be temporarily impacted by elevated levels of turbidity during installation of the proposed structures. However, we do not expect these episodic and short-term impacts to water quality or the presence of overwater structures to present a barrier for migration.

Part of the proposed action is to mitigate for the impacts to nearshore habitat from the installation of permanent structures. Mitigation includes on-site enhancements, including riparian plantings, placing spawning gravel, installing large woody material, removing pilings, removing existing overwater structures, removing bank stabilization, removing boat ramps, and removing rails. All on-site mitigation includes minimization measures developed for the installation of new structures, including work windows. Additionally, on-site mitigation in intertidal areas will occur in the dry, at low tide, and outside of forage fish spawning times. Proposed off-site mitigation includes removal of manmade groins as well as purchasing credits from third-party mitigation sources. The benefits of off-site mitigation can be used to offset habitat impacts from the actions proposed under RGP-6.

The project will not preclude bull trout from moving through the area. However, it will impair the function of the migratory corridor over the long-term. Mitigation will offset some of the effects to this PCE. Other stressors are unlikely to result in a measurable impact to the migratory corridor (i.e., elevated levels of turbidity and contaminants).

PCE 3: An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Installing permanent features in the nearshore will degrade conditions of the nearshore and migratory habitat that is designated critical habitat for bull trout. Permanent structure installation in nearshore habitat is anticipated to increase shading of submerged aquatic vegetation. Increased shading from installing overwater structures in nearshore habitat is reasonably certain to result in measurable impacts to the behavior of juvenile salmonids as well as increased predation on them. Increased shading is also expected to reduce the quantity of submerged aquatic vegetation and reduce the abundance of Pacific herring. The adverse effects of the proposed action on prey resources for bull trout will occur at various locations over the course of 5 years.

We expect a measurable reduction in juvenile salmonids and Pacific herring from installing permanent overwater structures in nearshore habitat. Some prey resources may be lost from the removal and installation of piles and elevated levels of turbidity and suspended sediments. Effects from these activities will result in prey items such as aquatic macroinvertebrates and forage fish being injured or killed during impact pile driving and other construction activities. Installing permanent features in the nearshore will also result in long-term impacts to nearshore habitat by altering natural tidal functions along the shoreline and the complex habitat created by these processes, including forage fish spawning areas. Although no ACZA-treated wood piles will be installed in suitable or documented forage fish spawning areas, there is no restrictions on installing permanent features within these areas.

We expect that the mitigation will significantly improve nearshore marine habitat, including improving habitat suitability and we are reasonably certain that the mitigation actions will increase habitat quality and the abundance of prey resources for bull trout. Mitigation will offset some degree of the effects to prey resources. However, we are unable to conclude whether mitigation would entirely offset the effects of reduced prey abundance because effectiveness monitoring to assess this is not proposed by the Corps. We expect a measurable effect to this PCE from reduced prey abundance for bull trout (i.e., juvenile salmonids and marine forage fish).

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

Installing permanent features in the nearshore will degrade habitat conditions in the action area and may alter natural tidal functions, including drift cell patterns, which can reduce the effectiveness of natural processes and result in degradation of the shoreline. Processes that create and maintain complexity, such as natural sediment recruitment, and varieties in depths, gradients, substrate size, and structure will continue to be degraded over the long term. Mitigation actions may offset some of the effects from the action, including potential changes in nearshore drift or current patterns that may be caused by the new overwater structures. However, even with all the proposed conservation measures (See Appendix A, RGP-6) the project may still result in a permanent net increase of 96,000 ft^2 (0.90 hectare, or 2.2 acres) of overwater coverage. The exact locations of installation are unknown and we cannot determine whether they would be installed within critical habitat for bull trout. Assuming that each structure were installed within critical habitat and would reduce habitat complexity and processes that maintain them, we anticipate a measureable effect to this PCE.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The proposed project will result in the short-term localized release of contaminants (ACZA, creosote, and PAHs) into the marine environment. Creosote released from removal of treated-wood piles will be minimal, and overall the effects to water quality will be an improvement. Contaminant concentrations may increase in marine waters from the increased use of watercraft (PAHs) and installation of ACZA-treated wood piles. Water quality will also be temporarily impacted during the installation of mooring buoys, overwater structures, piles, and other permanent features from elevated levels of turbidity. These effects will be temporary and no measurable long-term effects to habitat are expected from the proposed activities. We anticipate the release of these materials will be intermittent, infrequent, and limited to very small quantities (ounces). Overall we expect the water quality impacts to be very minor in magnitude. Therefore, we do not expect the proposed action would measurably affect this PCE.

CUMULATIVE EFFECTS: Marbled Murrelet, Bull Trout, and Bull Trout Critical Habitat

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 ESA.

The proposed action will impact shoreline habitat in marine waters of Puget Sound, Hood Canal, the Strait of Juan de Fuca, and the San Juan Islands. In addition to the PRFs proposed by RGP-6, there are several other types of shoreline development occurring in, or affecting, this same shoreline habitat. Other types of future non-federal actions that are unrelated to the proposed action include residential and commercial development, road and railroad maintenance and construction, and agricultural development. Additionally, non-federal actions in tributary systems to these marine waters can also result in impacts to marine waters, including timber harvest, land conversion, transportation and other infrastructure development, and other types of development that has indirect impacts to marine water tributaries but doesn't require section 7 consultation. These development activities can alter the conditions of marine waters by degrading water quality and quantity, and sedimentation levels.

At the site-specific scale, the effects of each individual project may or may not result in measurable changes to habitat or species. But over time these incremental effects accumulate, and a site-specific effect compounds with other site-specific effects, resulting in overall degraded conditions. Habitat quality slowly declines, while prey quantity and quality changes. Each incremental change may not be apparent, but when enough time passes, these changes manifest in degraded habitat and prey resources, and consequently reduce the fitness and abundance of listed species.

Development is driven by human population growth. The population in Puget Sound increased from approximately 1.3 million people in 1950 to almost 4 million in 2014, and is predicted to exceed 5 million by 2040 (Puget Sound Regional Council, 2016). Private and public development is reasonably certain to continue occurring and result in habitat degradation. Although some effects of this development will be avoided, minimized, and/or mitigated, it is extremely unlikely that the conservation measures proposed under RGP-6 will completely offset impacts. We expect that the majority of environmental effects related to population growth will result in habitat degradation, especially shoreline development that isn't below ordinary high water mark, land-use changes including clearing native vegetation, impervious surfaces and runoff, and associated introduction of contaminants that get marine waters via surface water runoff. Although regulations exist that will decrease adverse effects on habitat and listed species, we expect human development will still degrade habitat for listed species, especially considering that there is "no change in Human Sound Behavior Index", indicating that increase in population is likely to continue to degrade habitat quality because human use practices that likely affect habitat and water quality and quantity are likely to continue (Puget Sound Ecological Fire Partnership 2015).

Several actions undertaken by state, federal, and non-profit agencies are implementing actions to enhance habitat and help recover listed species. Also, Federal agencies are implementing recovery actions identified in recovery plans. It is currently unknown whether these actions combined with beneficial effects of habitat restoration will be sufficient to offset the adverse effects from future development. Until restoration becomes more profitable than development, we expect that cumulative impacts from human-related growth development will continue to degrade shoreline habitat conditions for bull trout, marbled murrelets, and their prey resources.

INTEGRATION AND SYNTHESIS OF EFFECTS: Marbled Murrelet, Bull Trout, and Bull Trout Critical Habitat

In this section, we describe whether the proposed action is likely to: 1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or 2) reduce the value of designated critical habitat for the conservation of the species. We consider the risk posed to species and critical habitat as a result of the proposed action. We take into account the effects of the action, the cumulative effects, and the status of the species and critical habitat.

Marbled Murrelet

Marbled murrelet fitness and survival in the marine environment are threatened by reductions in the quality and abundance of forage fish species through overfishing and marine habitat degradation (USFWS 2009, pp. 27-67). Marine habitat degradation is most prevalent in the Puget Sound area where anthropogenic activities (e.g., shipping lanes, boat traffic, and shoreline development) are an important factor influencing the marine distribution and abundance of marbled murrelets in Conservation Zone 1 (Falxa and Raphael 2015, p. 163). Marbled murrelet populations have declined at an average rate of 1.2 percent per year since 2001. The most recent annual population estimate for the entire NWFP area ranged from about 16,600 to 22,800 marbled murrelets during the 14-year period, (Falxa and Raphael 2015, p. 7). While the overall trend estimate was negative (-1.2 percent per year), this trend was inconclusive because the confidence intervals for the estimated trend overlap zero (95 percent CI:-2.9 to 0.5 percent), indicating the population may be declining, stable, *or* increasing at the range-wide scale (Falxa and Raphael 2015, pp. 7-8).

Baseline habitat conditions for marbled murrelets and their prey species have been degraded primarily by human development that has altered natural processes that maintain those conditions. Relevant habitat modifications are increased impervious surface, complexity reductions in river deltas and shoreline habitat, reduced introduction of sediment from beach armoring, elimination of natural coastal bays, and loss of tidal wetlands (Fresh et al. 2011). Other shoreline changes reduce marine nearshore habitat quality including overwater structures, marinas, roads, railroads, and bridges (Simenstad et al. 2011). All these activities modify habitat in ways that reduce the function they provide for marbled murrelets.

Increased temperatures and decreased water flow into marine waters are already exacerbating water quality issues. Climate change is likely to continue to affect several ongoing habitat issues such as sea level rise and seawater acidification. Sea level rise will further increase requests to armor shorelines. Increased shoreline armoring and other development will reduce habitat quality for marbled murrelets and their prey resources. Climate change-related habitat stressors combined with further development in shoreline areas are expected to further degrade habitat conditions. We do not expect that the level of restoration activities currently underway, combined with mitigation proposed by this RGP-6 will entirely offset these effects.

While the abundance status of marbled murrelets is inconclusive (Falxa and Raphael 2015, pp. 7-8), the status of the species, their habitat, and prey resources are poor. The baseline conditions of habitat are considerably degraded, primarily by human development. Accumulative effects will continue to intensify, driven by human-related development and climate change. Development and overwater structures are rarely removed once installed, and are considered permanent features. While marbled murrelets may still be able to use habitat adjacent to these structures, we expect that it will function at an impaired level.

Each project may have effects that are localized near the project areas, but the large-scale effects combined with cumulative effects and climate change, are expected to accumulate and further degrade the habitat function at the scale in which the ecosystem functions. Alternately, some effects, such as removal of submerged aquatic vegetation may be measurable at the scale of the project area, but would not accumulate to a measurable effect at the scale of the ecosystem. The installation of 150 PRFs over the next five years, including the footprint of boats, boat lifts, and an approximately 10-foot buffer around them, will affect approximately 350,000 ft^2 of nearshore habitat, which is approximately 0.002 percent of the total available nearshore area. This does not include stairs and trams, which would be smaller, but would still have a footprint of effects.

Other contributors to cumulative effects are expected from commercial and residential construction and shoreline stabilization occurring above the OHWM. The sources of these additional cumulative effects may be projects that are without federal nexus and are not regulated by the Corps. They will not undergo consultation, nor would they provide mitigation. These alterations may occur in upland areas adjacent to nearshore marine areas used by marbled murrelets and/or their prey resources. The biological functions provided by shoreline habitat affected by this action are expected to continue to decline, although they will still provide the necessary features for marbled murrelets. Although habitat function will be affected by the action, the effects to marbled murrelets at the individual, population, and rangewide scale are not likely to jeopardize the existence of the species because marbled murrelets are broadly distributed and rely on various sources of prey.

Because of the proposed conservation measures, short-term construction-related effects are not expected to result in injury, mortality, or measurable behavioral effects to marbled murrelets. Some short-term, temporary effects may occur at the site-specific scale, including reduction in prey resources. However, these impacts are not expected to result in reduced fitness of marbled murrelets or measurable effects at the population level or at the rangewide scale.

Small incremental declines in habitat function are anticipated over the long term with proportional declines in productivity of the habitat. The long term effects are expected to persist for the life of the structures, at least 40 years, and possibly beyond as most are maintained or upgraded, but rarely removed. Effects to individual marbled murrelets are obstructed habitat use, reduced diversity and abundance of aquatic vegetation (e.g., reduced complexity and refuge), reduced abundance and diversity of prey resources, and increased sources of disturbance. However, we expect that the effects will be proportional to the small percentage of habitat affected by the proposed action, which overall is less than 0.002 percent of available shoreline habitat and widely distributed over a very large geographic area. Additionally, proposed mitigation will offset some habitat function lost by the installation of new permanent structures in nearshore habitat.

Bull Trout and Designated Critical Habitat

Bull trout populations are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, incidental angler harvest; entrainment and introduced non-native species (64 FR 58910 [Nov. 1, 1999]). Since bull trout were listed, there has been very little change in the general distribution of bull trout in the coterminous United States, and we are not aware that any known, occupied bull trout core areas have been extirpated (USFWS 2014, p. iv). Degradation and loss of marine nearshore foraging and migration habitat from urban and residential development is a major contributing factor to the degradation of physical and biological features of bull trout critical habitat. Nearshore foraging and migration habitat appears to be in a legacy of particularly degraded habitat conditions.

Baseline habitat conditions for bull trout and their prey species, including designated critical habitat for bull trout, have been degraded primarily by human development that has altered natural processes that maintain those conditions. Relevant habitat modifications are increased impervious surface, reductions in instream habitat complexity, river deltas and shoreline habitat, reduced introduction of sediment from beach armoring (feeder bluffs create beaches and shallow intertidal habitats), elimination of natural coastal bays, and loss of tidal wetlands (Fresh et al.

2011). Other shoreline changes reduce marine nearshore habitat quality including overwater structures, marinas, roads, railroads, and bridges (Simenstad et al. 2011). All these activities modify habitat in ways that reduce the function they provide for bull trout and their prey.

Increased temperatures and decreased water flow into marine waters are already exacerbating water quality issues. Climate change is likely to continue to affect several ongoing habitat issues such as sea level rise and seawater acidification. Sea level rise will further the desire to armor shorelines. Increased shoreline armoring and other development will reduce habitat quality for bull trout and their prey resources. Climate change-related habitat stressors combined with further development in shoreline areas are expected to further degrade habitat conditions. We do not expect that current restoration activities combined with mitigation proposed by this RGP-6 will entirely offset these effects.

The status of the species for bull trout and their habitat and prey resources are poor. The baseline conditions of habitat are considerably degraded, primarily by human development. Cumulative effects will continue to intensify driven by development and climate change. While overwater structures will affect nearshore marine areas, the marine environment is only used seasonally by bull trout for foraging and movement between core areas. Each project may have effects that are localized near the project areas, but the large-scale effects combined with cumulative effects and climate change, are expected to accumulate and further degrade nearshore habitats in the action area. Alternately, some effects, such as removal of submerged aquatic vegetation may be measurable at the scale of the project area, but would not accumulate to a measurable effect at the scale of the ecosystem. The installation of 150 PRFs over the next five years, including the footprint of boats, boat lifts, and an approximately 10-foot buffer around them, will affect approximately 350,000 ft^2 of nearshore habitat, which is approximately 0.002 percent of the total available nearshore area.

Other contributors to cumulative effects are expected from commercial and residential construction and shoreline stabilization occurring above the OHWM. The sources of these additional cumulative effects may be projects that do not have a federal nexus and are not regulated by the Corps. These alterations may occur in upland areas adjacent to nearshore marine areas used by bull trout. The biological functions provided by shoreline habitat affected by this action are expected to continue to decline, although they will still provide the necessary features for bull trout.

Although the proposed action includes conservation measures, short-term construction related effects are expected to result in injury, mortality, or measurable behavioral effects to bull trout. Some short-term, temporary effects that may cause injury or mortality to bull trout may occur at the site-specific scale. These short-term site-specific impacts are expected to either kill and/or injury bull trout, and may reduce fitness of bull trout at the individual level. The activities that may result in injury or mortality of bull trout will be broadly distributes across the Puget Sound, Hood Canal and Strait of Juan de Fuca.

It is impossible to predict the total number of bull trout that will be injured or killed by the proposed action. Assuming a worst-case scenario, if one bull trout were injured or killed during the installation of each of the 150 new structures, we do not expect this to result in significant declines in the abundance of bull trout at the population level, nor at the rangewide scale. Although we cannot predict the total number of bull trout that will be injured or killed, we expect it to be significantly fewer than 150 individuals because of their broad distribution, migratory nature, short duration of impact pile driving, and because in-water work will be conducted at a time of year when bull trout are less likely to be in the marine environment. Bull trout travel many kilometers in short spans of time, and their use of nearshore habitat in marine areas is unpredictable. We expect that although some bull trout may be present and exposed during impact-pile driving, very few will be present and exposed for durations that would result in injury or mortality. Given the low potential for direct mortality, we do not expect the effects to bull trout at the individual, population, and rangewide scale to jeopardize the existence of the species.

Small incremental declines in habitat function, including within critical habitat, are anticipated over the long term with proportional declines in productivity of the habitat. The long-term effects are expected to persist for the life of the structures, at least 40 years, and possibly beyond as most are maintained or upgraded, but rarely removed. Effects to individual bull trout and critical habitat are obstructed habitat use (e.g., migratory corridors and/or foraging areas), reduced diversity and abundance of aquatic vegetation (e.g., reduced complexity and refuge), reduced abundance and diversity of prey resources, and increased sources of disturbance. However, we expect that the effects will be proportional to the small percentage of habitat affected by the proposed action, which overall is less than 0.002 percent of available shoreline habitat. Additionally, proposed mitigation will offset some habitat function lost by the installation of new permanent structures in nearshore habitat.

CONCLUSION: **Murrelet, Bull Trout, and Bull Trout Critical Habitat**

After reviewing and analyzing the current status of the species for bull trout and marbled murrelets, the environmental baseline for the action area, the effects of RGP-6, and the cumulative effects, it is the USFWSs opinion that RGP-6 is not likely to jeopardize the continued existence of bull trout or marbled murrelets, and is not likely to destroy or adversely modify designated critical habitat.

Marbled Murrelet

The USFWS has reviewed the current rangewide status of the marbled murrelet, the environmental baseline for the action area, the direct and indirect effects of the proposed action, the effects of interrelated and interdependent actions, and the cumulative effects that are reasonably certain to occur in the action area. It is the USFWS' Biological Opinion that the action, as proposed, will not appreciably reduce the likelihood of survival and recovery of the marbled murrelet in the wild. The action, as proposed, is not likely to jeopardize the continued existence of the marbled murrelet.

Bull Trout and Designated Critical Habitat

The USFWS has reviewed the current rangewide status of the bull trout, the environmental baseline for the action area, the direct and indirect effects of the proposed action, the effects of interrelated and interdependent actions, and the cumulative effects that are reasonably certain to occur in the action area. It is the USFWS' Biological Opinion that the action, as proposed, will not appreciably reduce the likelihood of survival and recovery of the bull trout in the wild. The action, as proposed, is not likely to jeopardize the continued existence of the bull trout. It is the USFWS' Biological Opinion that the action, as proposed, will not destroy or adversely modify designated bull trout critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA 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 USFWS 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 USFWS 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 ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The USFWS 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 USFWS 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 USFWS Law Enforcement Office at (425) 883-8122, or the USFWS's Washington Fish and Wildlife Office at (360) 753-9440.

The measures described below are non-discretionary, and must be undertaken by the (agency) 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 (agency) has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the Corps 1) fails to assume and implement the terms and conditions or 2) fails to require the (applicant) 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 Corps must report the progress of the action and its impact on the species to the USFWS as specified in this Incidental Take Statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

The USFWS anticipates incidental take of bull trout will be difficult to detect for the following reasons: incidental take of actual species numbers may be difficult to detect because the species is wide-ranging; migrates great distances; finding a dead or impaired specimen is unlikely; and the species is aquatic, which makes detection very difficult. However the following level of take is anticipated: All bull trout within 61 meters of impact pile driving in northern Puget Sound (north of the Tacoma Narrows Bridge), the western shore of Hood Canal, and the Strait of Juan de Fuca will be injured or killed by exposure to elevated underwater SPLs over the next five years.

EFFECT OF THE TAKE

In the accompanying Opinion, the USFWS 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. Although some individual bull trout may be injured and/or killed, the loss of these bull trout will be broadly distributed throughout northern Puget Sound, Hood Canal and Strait of Juan de Fuca. We do not anticipate the loss of these individuals to measurably impact the population abundance of bull trout at a local level, core area level, or at the scale of the recovery unit.

REASONABLE AND PRUDENT MEASURES

The conservation measures negotiated in cooperation with the USFWS and included as part of the proposed action (see pages 11 of this document and RGP-6 in Appendix A) constitute all of the measures necessary to minimize the impacts of incidental take and long-term effects to critical habitat. On that basis, no Reasonable and Prudent Measures except for monitoring and reporting requirements are included in this Incidental Take Statement.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the Corps must comply with the following terms and conditions, which outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. Monitor and report the quantity, size, and locations of structures that include impact pile driving of steel piles in northern Puget Sound (north of the Tacoma Narrows Bridge), Hood Canal and the Strait of Juan de Fuca over the next five years.
2. Provide a report in five years, upon expiration of the Incidental Take Permit, which includes the total overwater coverage of piers and floats (area in ft^2 or hectares), quantity of new structures, and the UTM GPS coordinates of each structure to the USFWS.

The USFWS believes that bull trout within 61 meters of impact pile driving will be incidentally taken as a result of the proposed action in Puget Sound north of the Tacoma Narrows Bridge, the western shore of Hood Canal, and the Strait of Juan de Fuca. The Conservation Measures and the implementing terms and conditions are designed to minimize and/or monitor the impact of incidental take 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 conservation measures provided (i.e., exceed 300 impact pile strikes per day or steel piles larger than 12 inches in diameter). The federal agency must immediately provide an explanation of the causes of the taking and review with the USFWS the need for possible modification of the conservation measures.

The USFWS 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 USFWS' Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA 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.

We recommend the Corps fund a research project that analyzes the long term impacts of installing permanent features in the nearshore, which should include an assessment of the benefits of grating and other site-specific alterations to habitat and prey resources over the long term. The study should compare the impacts from a representative sample of locations, considering an adequate sample size to provide statistically significant results. Research, data analysis, and reporting should be performed by a third party organization comprised of qualified biologists.

We also recommend the Corps keep a database of information tracking all activities permitted in their jurisdiction so that a study of cumulative effects can be assessed from the data. Information should include the information required for submission in the NMFS Opinion Terms and Conditions: area of vegetation removal, total number of piles installed, total footprint of overwater coverage, presence/absence of forage fish spawning, presence/absence of submerged aquatic vegetation, what mitigation actions were implemented, and the GPS coordinates of impacts and restoration.

Other measures that would enhance habitat and minimize the effects associated with RGP-6:

- Restrict the use of chemicals on any overwater structures, especially treated wood, which inevitably leach these products into water system and reduce water quality for listed species and their prey.
- After attaining results of research on effects of installation of permanent overwater structures in the nearshore, adjust the mitigation requirement accordingly. This may ensure that mitigation is adequate to offset effects of these structures to listed species, their habitat, and prey.
- Boats are associated features of the proposed structures and although the Corps does not have jurisdiction to regulate boats or boat use, the Corps should include boats in their calculations of required mitigation. Estimates of shading and other habitat impacts associated with boat use of the structures being permitted should be incorporated into the calculations for mitigation requirements.
- Most overwater structures are not removed once they are installed. The current consultation does not address effects associated with maintenance of these structures beyond the life expectancy of 40 years. It is reasonably certain that the structures will be maintained or upgraded, and will be present and used beyond 40 years. When the Corps renews this permit, they should project effects into the foreseeable future, rather than only five years.

In order for the USFWS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the USFWS 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.

LITERATURE CITED

Aitkin, J.K. 1998. The importance of estuarine habitats to anadromous salmonids of the Pacific Northwest: a literature review. U.S. Fish and Wildlife Service Western Washington Office Aquatic Resources Division Puget Sound Program, Lacey, Washington, August 1998. 25 pp.

Anderson, J.J., E. Gurarie, and R.W. Zabel. 2005. Mean free-path length theory of predator- prey interactions: Application to juvenile salmon migration. *Ecological Modelling*. 186:196-211.

Battin, J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Beamish, R.J., C. Mahnken, and C.M. Neville. 2004. Evidence That Reduced Early Marine Growth Is Associated with Lower Marine Survival of Coho Salmon. *Transactions of the American Fisheries Society*. 133:26-33.

Beauchamp, W.D., F. Cooke, C. Lougheed, L.W. Lougheed, C.J. Ralph, and S. Courtney. 1999. Seasonal movements of marbled murrelets: evidence from banded birds. Condor 101(3):671-674.

Bellefleur, D., P. Lee, and R.A. Ronconi. 2007. The impact of recreational boat traffic on marbled murrelets (*Brachyramphus marmoratus*). Journal of Environmental Management 90(1):531-538.

Bentivoglio, N., J. Baldwin, P.G.R. Jodice, D. Evans Mack, T. Max, S. Miller, S.K. Nelson, K. Ostrom, C.J. Ralph, M.G. Raphael, C.S. Strong, C.W. Thompson, and R. Wilk. 2002. Northwest Forest Plan marbled murrelet effectiveness monitoring 2000 annual report. U.S. Fish and Wildlife Service, Portland, Oregon, April 2002. 73 pp.

Berge, H.B. 2003. 5/13/2003 record of telephone conversation with Hans Berge, fisheries biologist, King County DNR, regarding native char captured during beach seining efforts in 2001 and 2002.

Bloxton, T.D., and M.G. Raphael. 2006. At-sea movements of radio-tagged marbled murrelets in Washington. Northwestern Naturalist 87(2):162-162.

Brenkman, S.J. 2007. Email and attachment from Sam Brenkman, NPS, to Shelley Spalding, USFWS, re: Update North Fork Skokomish. March 21, 2007.

Brenkman, S.J., and S.C. Corbett. 2003. Seasonal movements of threatened bull trout (*Salvelinus confluentus*) in the Hoh River basin and coastal Washington. Northwest Scientific Association Meeting, Forks, WA, 2003. 3 pp.

Brenkman, S.J., and S.C. Corbett. 2005. Extent of anadromy in bull trout and implications for conservation of a threatened species. North American Journal of Fisheries Management 25:1073-1081.

Brenkman, S.J., and Corbett, S. 2003. Email on 4/25/03 re: Radio tracking of bull trout in the Hoh basin and coastal Washington. 04/25/2003.

Brennan, J.S. 2007. Marine riparian vegetation communities of Puget Sound: prepared in support of the Puget Sound nearshore partnership. U.S. Army Corps of Engineers, Seattle District, Puget Sound Nearshore Partnership Technical Report 2007-02, Seattle, Washington. 25 pp.

Buehler, D., R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects on Pile Driving on Fish. Caltrans, CTHWANP-RT-15-306.01.01, Sacramento, CA, 11/15. 532 pp.

Burger, A.E. 1995. Marine distribution, abundance and habitat of marbled murrelets in British Columbia. Pages 295-312 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report.PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Carter, H.R., and S.G. Sealy. 1990. Daily foraging behavior of marbled murrelets. Studies in Avian Biology 14:93-102.

Carter, H.R., and J.L. Stein. 1995. Molts and plumages in the annual cycle of the marbled murrelet. Pages 99-109 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Castle, P. 2003. Chan, J. Phone record 06/12/03 regarding bull trout observations in marine areas. 06/12/2003.

Celedonia, M.T., R.A. Tabor, and S. Sanders. 2000. Movement and habitat use of juvenile salmonids and predatory fishes in Lake Washington: 2003-2005 acoustic tracking studies. Report to the City of Seattle. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, T.M. Lee, D.W. Lantz, Z. Li, J. Pratt, B. Price, and L. Seyda. 2008. Movement and habitat use of Chinook salmon smolts, northern pikeminnow, and smallmouth bass near the SR 520 Bridge - 2007 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington, October, 2008. 139 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, T.M. Lee, D.W. Lantz, Z. Li, J. Pratt, B. Price, and L. Seyda. 2009. Movement and habitat use of Chinook salmon smolts, northern pikeminnow, and smallmouth bass near the SR 520 Bridge - 2008 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington, October, 2009. 139 pp.

Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and J. Grettenberger. 2008. Movement and habitat use of Chinook salmon smolts and two predatory fishes in Lake Washington and the Lake Washington Ship Canal - 2004-2005 acoustic tracking study. U.S. Fish and Wildlife Service, Lacey, Washington. 129 pp.

Collins, M., R. Knutti, J. Arblaster, J. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski Jr., T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver, and M. Wehner. 2013. Long-term climate change: Projections, commitments and irreversibility. Pages 1029-1136 *In* T.F. Stocker, D. Qin, G.-. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY.

Cooper, B.A., M.G. Raphael, and D. Evans Mack. 2003. Refining a landscape-scale habitat model and inland monitoring program for marbled murrelets in the Olympic Peninsula. U. S. Forest Service Pacific Northwest Research Station, Olympia, Washington, April 2, 2003. 36 pp.

Currence, N. 2003. Chan, J. Whatcom and Squalicum Creek char and descriptions for review, floy tag in lower Fraser. 01/22; 2003/01.

Cury, P.M., I.L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R.J.M. Crawford, R.W. Furness, J.A. Mills, E.J. Murphy, H. Osterblom, M. Paleczny, J.F. Piatt, J. Roux, L. Shannon, and W.J. Sydeman. 2011. Global seabird response to forage fish depletion - One-third for the birds. Science 334:1703-1706.

Dethier, M.N., W. Raymond, A. McBride, J. Toft, J. Cordell, A. Ogston, S. Heerhartz, and H. Berry. 2016. Multiscale Impacts of Armoring on Salish Sea Shorelines: Evidence For Cumulative and Threshold Effects. Estuar.Coast.Shelf Sci. (175):106.

Dooling, R.J. and S.C. Therrien. 2013. Hearing in birds: what changes from air to water. Book chapter in the effects of noise on aquatic life, Part II-Advances in Experimental Medicine and Biology, Volume 730, pp. 77-82. Springer New York.

Duffy, E.J., D.A. Beauchamp, R.M. Sweeting, R.J. Beamish, and J.S. Brennan. 2010. Ontogenetic Diet Shifts of Juvenile Chinook Salmon in Nearshore and Offshore Habitats of Puget Sound. *Transactions of the American Fisheries Society*. 139:803-823.

Ehinger, S. 2016. Endangered Species Act Section 7(a) (2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response [and Fish and Wildlife Coordination Act Recommendations] for the Regional General Permit 6(RGP-6): Structures in Inland Marine Waters of Washington State. 11/2016. Personal Observation.

Entranco Inc. and Hamer Environmental L.P. 2005. Marbled murrelet hazing report - SR 104 Hood Canal Bridge east-half replacement and west-half retrofit project. Washington State Department of Transportation, May 2005. 22 + appendices pp.

Erbe, C. 2002. Boats and Potential Effects on Killer Whales (Orcinus Orca), Based On An Acoustic Impact Model. Marine Mammal Science 18(2):394.

Erbe, C., S. Liong, M. Koessler, A. Duncan, and T. Gourlay. 2016. Underwater Sound of Rigid-Hulled Inflatable Boats. Acoustical Society of America .

Evans, D., and Asso. INC. 1999. Environmental baseline assessment for Chinook salmon (*Oncorhynchus tshawytscha*) and native char (*Salvelinus confluentus, Salvelinus malma*) in the Sauk River and Sauk River Forks fifth-field watersheds. Prepared for Mt. Baker Snoqualmie National Forest, April 30, 1999. 13 pp.

Ewart, P.J., and J.S. Ford. 1974. Probability for statistical decision making. Pages 177-194 *In* Probability for statistical decision making, Prentice-Hall Inc, Englewood Cliffs, New Jersey.

Falxa, G.A., and M.G. Raphael. 2015. Northwest Forest Plan—The first 20 years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station., Draft Gen. Tech. Rep. PNW-GTR-XXXX., Portland, OR, May 26, 2015. 191 pp.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2015. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2014 summary report. Northwest Forest Plan, Marbled Murrelet Effectiveness Monitoring Team, Interagency Regional Monitoring Program - http://www.reo.gov/monitoring., August 2015. 18 pp.

Falxa, G.A., D. Baldwin, S.K. Lynch, S.L. Nelson, and S.F. Miller. 2009. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2008 summary report, August 2009. 19 pp.

Falxa, G.A., and M.G. Raphael. 2015. Northwest Forest Plan □The First Twenty 2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR-XXXX, Portland, OR, May 26, 2015. 191 pp.

Falxa, G., J. Baldwin, M. Lance, D. Lynch, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2015. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2014 summary report. Northwest Forest Plan Interagency Regional Monitoring Program, Portland, OR, August 2015. 18 pp.

FHWG. 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Fisheries Hydroacoustic Working Group, June 12, 2008. 3 pp.

Fresh, K.L. 2006. Juvenile pacific salmon and the nearshore ecosystem of Puget Sound - final draft. U.S. Army Corps of Engineers, Technical Report 2006-06, Seattle, Washington, November, 2006. 24 pp.

Fresh, K., M. Dethier, C. Simenstad, M. Logsdon, H. Shipman, C.D. Tanner, T.M. Leschine, T.F. Mumford, G. Gelfenbaum, R. Shuman, and J.A. Newton. 2011. Implications of Observed Anthropogenic Changes to the Nearshore Ecosystems in Puget Sound. Prepared for the Puget Sound Nearshore Ecosystem Restoration Project.

Freudenthal, J. 2001. October 1997 bull trout/Dolly Varden observation, 0.45 on Bell Creek.

Ganguly, A.R., K. Steinhaeuser, D.J. Erickson, M. Branstetter, E.S. Parish, N. Singh, J.B. Drake, and L. Buja. 2009. Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. Proceedings of the National Academy of Sciences 106(37):15555-15559.

Giattina, J., R. Garton, and D. Stevens. 1982. Avoidance of Copper and Nickel by Rainbow Trout as Monitored by a Computer-Based Data Acquisition System. Transactions of the American Fisheries Society 111(4):491.

Gisiner, R.C., E. Cudahy, G.V. Frisk, R. Gentry, R. Hofman, A.N. Popper, and J.W. Richardson. 1998. Effects of anthropogenic noise in the marine environment. Pages 1-141 *In* Gisiner, R.C. ed. Workshop on the effects of anthropogenic noise in the marine environment, February 10-12, 1998, Marine Mammal Science Program, Office of Naval Research, Arlington, VA. 141 pp.

Glick, P., B.A. Stein, and N.A. Edelson. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C., 2011. 168 pp.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level rise and coastal habitats in the Pacific Northwest an analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Washington, D.C., July 2007. 106 pp.

Goetz, F., E. Connor, E. Jeanes, and M. Hayes. 2012. Migratory patterns and habitat use of bull trout in the Puget Sound. Presentation at the Salvelinus Confluentus Curiosity Society Meeting, Nature Bridge, Lake Crescent, Olympic National Park, August 15-17, 2012.

Goetz, Fred. U.S. Army Corps of Engineers. 2002. Email 12/04/02 to Shelley Spalding, U.S. Fish and Wildlife Service. Subject: Bull trout mixing in estuary and nearshore marine areas of Puget Sound.

Goetz, F. 2003. Example of a couple of fish migrating from Port Susan/Everett to Skagit.

Goetz, F., E.D. Jeanes, and E.M. Beamer. 2004. Bull trout in the nearshore. U.S. Army Corps of Engineers, Preliminary draft, Seattle, Washington, June 2004. 396 pp.

Goetz, F., E.D. Jeanes, and C.M. Morell. 2007. Puget Sound bull trout migration and habitat use study: Nooksack River and estuary and northeast Puget Sound nearshore, USFWS Interagency Agreement # 13410-6-H001, September 2007. 28 pp.

Graham, A., and S. Cooke. 2008. The Effects of Noise Disturbance From Various Recreational Boating Activities Common to Inland Waters On the Cardiac Physiology Of a Freshwater Fish, the Largemouth Bass (Micropterus Salmoides). Aquatic Conservation: Marine and Freshwater Ecosystems 18:1315.

Grettenberger, J., M.M. Lance, D. DeGhetto, and M. Mahaffy. 1998. Contaminant levels, body condition and food habits of marbled murrelets in Washington. U.S. Fish and Wildlife Service, Lacey, WA. 6 pp.

Griffin, F., T. DiMarco, K. Menard, J. Newman, E. Smith, C. Vines, and C. Gary. 2012. Larval Pacific Herring (Clupea Pallasi) Survival in Suspended Sediment. Estuaries and Coasts 35:1229.

Haas, M.E., C.A. Simenstad, J.R. Cordell, D.A. Beauchamp, and B.S. Miller. 2002. Effects of large overwater structures on epibenthic juvenile salmon prey assemblages in Puget Sound, Washington. School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA.

Hamer, T.E., and K.S. Nelson. 1995. Nesting chronology of the marbled murrelet. Pages 49-56 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, U.S. Forest Service, Albany, California.

Haring, D. 1999. Water resource inventory area 18. Washington State Conservation Commission. 202 pp.

Hastings, M.C. 1995. Physical effects of noise on fishes. Inter-noise, Newport Beach, California. 6 pp.

Hastings, M.C., and A.N. Popper. 2005. Effects of sound on fish. California Department of Transportation, Contract No. 43A0139, Task Order, 1, Sacramento, CA, January 28, 2005. 82 pp.

Hazen, E.L., S. Jogensen, R.R. Rykaczewski, S.J. Bograd, D.G. Foley, I.D. Jonsen, S.A. Shaffer, J.P. Dunne, D.P. Costa, L.B. Crowder, and B.A. Block. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change doi:10.1038/nclimatel686.

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NWFSC 83, Seattle, Washington, October 2007.

Heiser, D.W., and E.L. Finn 1970. Observations of Juvenile Chum and Pink Salmon in Marina and Bulkheaded Areas. State of Washington Department of Fisheries.

Hentze, N.T. 2006. The effects of boat disturbance on seabirds off Southwestern Vancouver Island, British Columbia. Bachelor of Science. University of Victoria, Victoria, BC. 54 pp.

Huber, M., and R. Knutti. 2011. Anthropogenic and natural warming inferred from changes in Earth’s energy balance. Nature Geoscience 5(1):31-36.

Illingworth & Rodkin. 2007. Compendium of pile driving sound data. Prepared for The California Department of Transportation, Sacramento, CA, September 27, 2007. 129 pp.

Illingworth & Rodkin. 2010. Underwater sound levels associated with driving steel piles for the State Route 520 bridge replacement and HOV project installation test program. Illingworth & Rodkin, Inc., Final, Petaluma, CA, March 2010. 143 pp.

Intergovernmental Panel on Climate Change. 2007. Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change; Geneva, Switzerland, 2007. 52 pp.

IPCC 2014. 2014a. Climate change 2014: Impacts, adaptation, and vulnerability part A: Global and sectoral aspects, contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK. 1150 pp.

IPCC 2014. 2014b. Climate change 2014: Synthesis report, contribution of working groups I, II, and III to the fifth assessment report of the intergovernmental panel on climate change. Intergovernmental Panel on Climate Change, Geneva, Switzerland. 151 pp.

Jahrsdoerfer, S., and G. Balogh. 2010. U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form: Kittlitz's Murrelet.

Jodice, P.G.R., and M.W. Collopy. 1999. Diving and foraging patterns of marbled murrelets (*Brachyramphus marmoratus*): testing predictions from optimal-breathing models. Canadian Journal of Zoology 77(9):1409-1418.

Kelty, R.A., and S. Bliven. 2003. Environmental and aesthetic impacts of small docks and piers, Workshop report: Developing a science-based decision support tool for small dock management, Phase 1: status of the science. National Centers for Coast Ocean Science, Silver Spring, MD.

Kemp, P.S., M.H. Gessel, and J.G. Williams. 2005. Fine-scale behavioral responses of Pacific salmonid smolts as they encounter divergence and acceleration of flow. Transactions of the American Fisheries Society 134(2):390-398.

Kirtman, B., S.B. Power, A.J. Adedoyin, G.J. Boer, R. Bojariu, I. Camilloni, F. Doblas-Reyes, A.M. Fiore, M. Kimoto, G. Meehl, M. Prather, A. Sarr, C. Schär, R. Sutton, G.J. van Oldenborgh, G. Vecchi, and H. Wang. 2013. Near-term climate change: Projections and predictability. Pages 953-1028 *In* T.F. Stocker, D. Qin, G.-. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY.

Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology 51(4):824-829.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, dolly varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) of the north Puget Sound region. Washington Department of Fish and Wildlife, Olympia, WA.

Kraemer, C. 2003. Management brief: Lower Skagit bull trout, age and growth information developed from scales collected from anadromous and fluvial char. Washington Department of Fish and Wildlife, Olympia, WA, January 1, 2003. 16 pp.

Kraemer, C. 2003. Chan, J. Observations of bull trout in marine waters in north Puget Sound. 03/31/2003.

Kuletz, K.J. 1996. Marbled murrelet abundance and breeding activity at Naked Island, Prince William Sound, and Kachemak Bay, Alaska, before and after the Exxon Valdez oil spill. American Fisheries Society Symposium 18:770-784.

Lance, M.M., and S.F. Pearson. 2016. 2015 Washington at-sea marbled murrelet population monitoring: Research progress report. Washington Department of Fish and Wildlife, Wildlife Program, Science Division, Olympia, WA, January 2016. 23 pp.

Lehman, E. 2014. Research suggests that flooding from sea level rise will prove more costly than building barriers to protect coastlines. February 4, 2014. ClimateWire and Scientific American.

Littel, J.S., M. McGuire Elsner, L.W. Binder, and A.K. Snover. 2009. The Washington climate change impacts assessment: evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington.

Lynch, D., G. Falxa, J. Baldwin, M.M. Lance, S.K. Nelson, S.F. Pearson, M.G. Raphael, C. Strong, and R. Young. 2016. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: 2015 summary report. 19 pp.

Martinson, E.C. 2013. Early marine growth as an indicator for chum salmon production. NPAFC, Vancouver, BC (Canada), [mailto:secretariat@npafc.org]. 150-152.

McIntyre, J., D. Baldwin, D. Beauchamp, and N. Scholz. 2012. Low-level Copper Exposures Increase Visibility and Vulnerability Of Juvenile Coho Salmon to Cutthroat Trout Predators. Ecological Applications 22(5):1460.

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Department of Zoology, University of British Columbia, Fisheries Management Report Number 104, Vancouver, British Columbia. 36 pp.

McShane, C., T.E. Hamer, H.R. Carter, R.C. Swartzman, V.L. Friesen, D.G. Ainley, K. Nelson, A.E. Burger, L.B. Spear, T. Mohagen, R. Martin, L.A. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. Evaluation reports for the 5-year status review of the marbled murrelet in Washington, Oregon, and California. EDAW, Inc, Seattle, Washington. 370 pp.

Meador, J.P., F.C. Sommers, G.M. Ylitalo, and C.A. Sloan. 2006. Altered growth and related physiological responses in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). Canadian Journal of Fisheries and Aquatic Sciences 63(10):2364-2376.

Meehl, G., T. Stocker, W. Collins, P. Friedlingstein, A. Gaye, J. Gregory, A. Kitoh, R. Knutti, J. Murphy, A. Noda, S. Raper, I. Watterson, A. Weaver, and Z. Zhao. 2007. Global Climate Projections. Pages 747-845 *In* S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on
Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Menza, C., J. Leirness, T. White, A. Winship, B. Kinlan, J.E. Zamon , L. Ballance, E. Becker, K. Forney, J. Adams, D. Pereksta, S. Pearson, J. Pierce, L. Antrim, N. Wright, and E. Bowlby. 2015. Modeling seabird distributions off the Pacific coast of Washington. NOAA: National Centers for Coastal Ocean Science, Silver Springs, MD, June 2015. 63 pp.

Merizon, R.A.J., S.P. Courtney, W. Beattie, D.M. Brosnan, D. Evans, T. Grubba, W. Kerschke, J.M. Luginbuhl, R. Millner, E.A. Neatherlin, D. Nysewander, M. Raphael, and M. Salema. 1997. Seabird surveys in Puget Sound 1996. Sustainable Ecosystems Institute, Inc, Portland, Oregon, March 1997. 36 pp.

Mongillo, P.E., and M. Hallock. 1993. Native trout and char investigations: annual report July 1, 1992 - June 30, 1993. Report prepared for USFWS, Federal Aid in Fish Restoration Program. 29 pp.

Morley, S.A., J.D. Toft, and K.M. Hanson. 2012. Ecological Effects of Shoreline Armoring on Intertidal Habitats of a Puget Sound Urban Estuary. *Estuaries and Coasts*. 35:774-784.

Mote, P., A. Petersen, S. Reeder, H. Shipman, and L.W. Binder. 2008. Sea level rise in the coastal waters of Washington State. University of Washington Climate Impacts Group; Washington Department of Ecology, January 2008. 11 pp.

Mote, P.W., A.K. Snover, L.W. Binder, A.F. Hamlet, and N.J. Mantua. 2005. Uncertain future: climate change and its effects on Puget Sound - foundation document. A report prepared for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere, University of Washington), Seattle, Washington, October 2005. 37 pp.

Mueller, R.P., D.A. Neitzel, and W.V. Mavros. 1998. Evaluation of low and high frequency sound for enhancing fish screening facilities to protect outmigrating salmonids. U.S. Department of Energy, Bonneville Power Administration, BPA Report DOE/BP-62611-13, Portland, Oregon, February 1998. 26 pp.

Mumford, T.F. 2007. Kelp and eelgrass in Puget Sound. U.S. Army Corps of Engineers, Seattle District, Puget Sound Nearshore Partnership Technical Report 2007-05, Seattle, Washington, 200. May 2007 pp.

Munsch, S., J. Cordell, J. Toft, F. Stevick, C. Levy, E. Morgan, and M. Caputo. 2014. Elliott Bay seawall project: Fish, algae, and light studies, 2011-2013. Wetland Ecosystem Team, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA. 71 pp.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16(4):693-727.

Nightingale, B., and C.A. Simenstad. 2001. Overwater structures: marine issues. Washington State Department of Transportation, Washington State Transportation Center, White Paper - Research Project T1803, Task 35, Seattle, WA, May 9, 2001. 174 pp.

Ogg, L. 2006. U. S. Forest Service, Olympia, Washington. RE: DRMT meeting (*bull trout in Valley and Morse Creeks*). Email message to Shelley Spalding, Fish and Wildlife Biologist, Western Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, Lacey, Washington. May 24, 2006. 12:32 p.m

Olympic Peninsula Recovery Team. 2003a. Meeting notes from 01/14/2003 at U.S. Fish and Wildlife Service, Lacey, Washington. Distribution of spawning and rearing habitat and FMO habitat within bull trout core areas
. January 14, 2003.

Olympic Peninsula Recovery Team. 2003b. Meeting notes from 03/12/2003 at U.S. Fish and Wildlife Service, Lacey, Washington. Importance of FMO habitat outside of core areas for bull trout. March 12, 2003.

Ono, K. 2010. Assessing and Mitigating Dock Shading Impacts on the Behavior of Juvenile Pacific Salmon (Oncorhynchus spp.): can artificial light mitigate the effects? *In* School of Aquatic and Fishery Sciences. Vol. Master of Science. University of Washington.

Penttila, D. 1973. Observations on some Puget Sound spawning beaches of the Surf Smelt (Hypomesus Pretiosus, Girard). State of Washington Dept. of Fisheries, Olympia, WA, May 1973. 20 pp.

Penttila, D. 2007. Marine forage fishes in Puget Sound. U.S. Army Corps of Engineers, Puget Sound Nearshore Partnership Report 2007-03, Seattle, Washington. 30 pp.

Penttila, D.E. 2001. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. Pages 1-8 *In* Proceedings of the Puget Sound Research - 2001 Conference, February 12-14, 2001, Puget Sound Water Quality Action Team8 pp.

Peters, R., and Wright, L. 2016. Wright, L. Bull trout in Skokomish.

Peterson, W.T., C.A. Morgan, J.O. Peterson, J.L. Fisher, B.J. Burke, and K. Fresh. 2014. Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current. NMFS, Fish Ecology Division, Northwest Fisheries Science Center, Newport, OR and Seattle, WA, December 2014. 83 pp.

Piatt, J.F., and N.L. Naslund. 1995. Chapter 28: Abundance, distribution, and population status of marbled murrelets in Alaska. USDA Forest Service, Gen. Tech. Rep. PSW-152. 10 pp.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A. MacGillivray, M.E. Austin, and D.A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Popper, A.N., M.B. Halvorsen, A. Kane, D.L. Miller, M.E. Smith, J. Song, P. Stein, and L.E. Wysocki. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. The Journal of Acoustical Society of America 122(1):623-635.

Poston, T. 2001. Treated wood issues associated with overwater structures in marine and freshwater environments. 85 pp.

Prinn, R., S. Paltsev, A. Sokolov, M. Sarofim, J. Reilly, and H. Jacoby. 2011. Scenarios with MIT integrated global systems model: significant global warming regardless of different approaches. Climatic Change 104:515-537.

Puget Sound Regional Council. 2016. Population forecasts. http://www.psrc.org/data/forecasts/. Accessed online November 23, 2016.

PSAT (Puget Sound Action Team). 2007. State of the Sound 2007. Puget Sound Action Team, PSAT 07-01, Olympia, Washington, July 22, 2007. 96 pp.

PSWQAT. 2000. 2000 Puget Sound update: seventh report of the Puget Sound ambient monitoring program. Puget Sound Water Quality Action Team, Olympia, Washington, March 2000. 127 pp.

Puget Sound Ecological Fire Partnership. 2015. Puget Sound ecological fire program 2015 summary report. Puget Sound Ecological Fire Partnership. 30 pp.

Puget Sound Partnership. 2008. Discussion paper: habitat and land use. Puget Sound Partnership, July 11, 2008. 103 pp.

Puget Sound Water Quality Action Team. 2002. Puget Sound update 2002: Eighth report of the Puget Sound ambient monitoring program. Puget Sound Water Quality Action Team, Olympia, WA, September 2002. 144 pp.

Quinn, T.P. 2005. The behavior and ecology of pacific salmon and trout. University of Washington Press, Seattle, WA.

Ralph, C.J., G.L. Hunt, M.G. Raphael, and J.F. Piatt. 1995. Ecology and conservation of the marbled murrelet in North America: An overview. Pages 3-22 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. General Technical Report. PSW-GTW-152, Pacific Southwest Experimental Station, United States Department of Agriculture, Forest Service, Albany, California.

Raphael, M.G., J. Baldwin, G.A. Falxa, M.H. Huff, M.M. Lance, S. Miller, S.F. Pearson, C.J. Ralph, C. Strong, and C. Thompson. 2007. Regional population monitoring of the marbled murrelet: field and analytical methods. U.S. Department of Agriculture Forest Service, PNW-GTR-716, Portland, Oregon, May 2007. 70 pp.

Rice, C.A. 2006. Effects of shoreline modification on northern Puget Sound beach: Microclimate and embryo mortality in surf smelt (*Hypomesus pretiosus*). Estuaries and Coasts 29(1):63-71.

Richmond, D.R., J.T. Yelverton, and R.E. Fletcher. 1973. Far-field underwater-blast injuries produced by small charges. Lovelace Foundation for Medical Education and Research, Contract Number DASA-01-71-C-0013, Washington, D.C.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of Bull Trout. USDA, Forest Service, Intermountain Research Station, General Technical Report INT-302, Ogden, Utah, September 1993. 38 pp.

Romanuk, T.N., and C.D. Levings. 2003. Associations Between Arthropods and the Supralittoral Ecotone: Dependence of Aquatic and Terrestrial Taxa on Riparian Vegetation. *Environmental Entomology*. 32:1343-1353.

Salathe Jr, E.P., L.R. Leung, Y. Qian, and Y. Zhang. 2010. Regional climate model projections for the State of Washington. Climatic Change 102(1-2):51-75.

Sanborn, S. 2005. Lynch, D. Email on 04/07/05 to Deanna Lynch, USFWS, re: Mamu calls. 04/07/2005.

Sanborn, S., K. Nelson, J. Bower, and S.W. Singer. 2005. Categorization of the marbled murrelet vocal repertoire.

Saunders, J., and R.J. Dooling. 1974. Noise-induced threshold shift in the parakeet (*Melopsittacus undulatus*). Proceedings of the National Academy of Sciences of the United States of America 71(5):1962-1965.

Schlenger, P., A. MacLennan, E. Iverson, K. Fresh, C. Tanner, B. Lyons, S. Todd, R. Carman, Myers, S. Campbell, and A. Wick. 2011. Strategic Needs Assessment: Analysis of Nearshore Ecosystem PRocess Degradation in Puget Sound. Prepared for the Puget Sound Nearshor Ecosystem Restoration Project.

Scholik, A.R., and H.Y. Yan. 2001a. The effects of underwater noise on auditory sensitivity of fish. Proceedings of the Institute of Acoustics :27-36.

Scholik, A.R., and H.Y. Yan. 2001b. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing research 152(1-2):17-24.

Scholik, A.R., and H.Y. Yan. 2002a. Effects of boat engine noise on the auditory sensitivity of the fathead minnow, *Pimephales promelas*. Environmental Biology of Fishes 63:203-209.

Scholik, A.R., and H.Y. Yan. 2002b. The effects of noise on the auditory sensitivity of the bluegill sunfish, *Lepomis macrochirus*. Comparative Biochemistry and Physiology Part A 133:43-52.

Science Applications International Corporation. 2011. Environmental sound panel for marbled murrelet underwater noise injury threshold. Science Applications International Corporation, Bothwell, Washington, August 31, 2011. 38 pp.

Sebastianutto, L., M. Picciulin, M. Costanitini, and E. Ferrero. 2011. How Boat Noise Affects an Ecologically Crucial Behaviour: The Case of Territoriality in Gobius Cruentatus (Gobiidae). Environmental Biology of Fishes 92:207.

Servizi, J.A., and D.W. Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to Coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 48(3):493-497.

Shafer, D.J. 1999. The effects of dock shading on the seagrass Halodule wrightii in Perdido Bay, Alabama. *Estuaries*. 22:936-943.

Shafer, D.J. 2002. REcommendations to minimize potential impasts to seagrasses from single family residantil doct structures in the PNW. S.D. Prepared for the U.S. Army Corps of Engineers, editor.

Shaffer, J.A., R. Moriarty, J. Sikes, and D. Penttila. 2003. Nearshore habitat mapping of the central and western Strait of Juan de Fuca phase 2: final report. Washington Department of Fish and Wildlife and National Marine Fisheries Service. 24 pp.

Simenstad, C.A., R.M. Thom, and K.A. Kuzis. 1988. Nearshore community studies of Neah Bay, Washington. USACE, FRI-UW-8811, Seattle, WA, June 1988. 201 pp.

Simenstad, C.A., M. Ramirez, B.J. Burke, M. Logsdon, H. Shipman, C. Tanner, Toft J., B. Craig, C. Davis, J. Fung, P. Bloch, K.L. Fresh, S. Campbell, D. Myers, E. Iverson, A. Bailey, P. Schlenger, C. Kiblinger, P. Myre, W.I. Gertsel, and A. MacLennan. 2011. Historical Changes and Impairment of Puget Sound Shorelines. *In* Puget Sound Nearshore Ecosystem Restoration Project.

Solomon, S., D. Qin, M. Manning, R. Alley, T. Berntsen, N. Bindoff, Z. Chen, A. Chidthaisong, J. Gregory, G. Hegerl, M. Heimann, B. Hewitson, B. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T. Stocker, R. Stouffer, P. Whetton, R. Wood, and D. Wratt. 2007. Technical Summary. Pages 19-91 *In* S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Sommers, F., E. Mudrock, J. Labenia, and D. Baldwin. 2016. Effects of Salinity on Olfactory Toxicity and Behavioral Responses of Juvenile Salmonids from Copper. Aquatic Toxicology 175:260.

Song, J.K., D.A. Mann, P.A. Cott, B.W. Hanna, and A.N. Popper. 2008. The inner ears of northern Canadian freshwater fishes following exposure to seismic air gun sounds. Journal of the Acoustical Society of America 124(2):1360-1366.

Southard, S.L., R.M. Thom, G.D. Williams, J.D. Toft, C.W. May, G.A. McMichael, J.A. Vucelike, J.T. Newell, and J.A. Southard. 2006. Impacts of Ferry Terminals on Juvenile Salmon Movement along Puget Sound Shorelines. Prepared by the Battelle Memorial Institute for the Washington State Department of Transportation, Richland, Washington.

Speckman, S.G., J.F. Piatt, and A.M. Springer. 2004. Small boats disturb fish-holding marbled murrelets, 85.

Speckman, S.G., J.F. Piatt, and A.M. Springer. 2003. Deciphering the social structure of marbled murrelets from behavioral observations at sea. Waterbirds 26(3):266-274.

Speich, S.M., and T.R. Wahl. 1995. Marbled murrelet populations of Washington -- marine habitat preferences and variability of occurrence. Pages 313-326 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. USDA Forest Service Gen. Tech Rep. PSW-152. USDA.

Stadler, J.H., and D.P. Woodbury. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. *In* Proceedings of the 38th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2009), August 23-29, 2009, 8 pp.

Stein, J., and D. Nysewander. 1999. An estimate of marbled murrelet productivity from observations of juveniles on the inland marine waters of Washington State during the 1993 through 1995 post-breeding seasons. Washington Department of Fish and Wildlife, Olympia, WA, July 1999.

Strachan, G., M. McAllister, and C.J. Ralph. 1995. Marbled murrelet at-sea and foraging behavior. Pages 247-253 *In* C.J. Ralph, G.L. Hunt, M.G. Raphael, and J.F. Piatt, eds. Ecology and conservation of the marbled murrelet. PSW-GTR-152, U.S. Department of Agriculture, Albany, CA.

Stratus. 2006. Treated Wood In Aquatic Environments: Technical Review and Use Recommendations.

Thompson, C.W. 1997. Distribution and abundance of marbled murrelets on the outer coast of Washington - Winter 1996-1997. Washington Department of Fish and Wildlife, Olympia, WA, September 1997. 16 pp.

Thorensen, A.C. 1989. Diving times and behavior of pigeon guillemots and marbled murrelets off Rosario Head, Washington. Western Birds 20:33-37.

Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. Estuaries 17(1).

Tierney, K., D. Baldwin, T. Hara, P. Ross, N. Scholz, and C. Kennedy. 2009. Olfactory Toxicity in Fishes. Aquatic Toxicology (doi:10.1016/j.aquatox.2009.09.019).

Toft, J., A. Ogston, S. Heerhartz, J. Cordell, and E. Flemer. 2013. Ecological Response and Physical Stability of Habitat Enhancements Along an Urban Armored Shoreline. Ecological Engineering 57:97.

Toft, J., J.R. Cordell, C.A. Simenstad, and L. Stamatiou. 2007. Fish distribution, abundance, and behavior along city shoreline types in Puget Sound. North American Journal of Fisheries Management 27:465-480.

Tomaro, L.M., D.J. Teel, W.T. Peterson, and J.A. Miller. 2012. When is bigger better? Early marine residence of middle and upper Columbia River spring Chinook salmon. *Marine Ecology Progress Series*. 452:237-252.

U.S. Fish and Wildlife Service. 2015. Recovery plan for the coterminous United States population of bull trout (Salvelinus confluentus). U.S. Fish and Wildlife Service, 2015. 195 pp.

USFWS. 1997. Recovery Plan for the threatened marbled murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. U.S. Department of the Interior, Portland, Oregon, 1997. 203 pp.

USFWS. 2002. Bull trout (*Salvelinus confluentus*) draft recovery plan - Chapter 2: Klamath River. U.S. Fish and Wildlife Service, Portland, Oregon. 82 pp.

USFWS. 2004a. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

USFWS. 2004b. Draft recovery plan for the Jarbidge River distinct population segment of the bull trout (*Salvelinus confluentus*). U.S. Fish and Wildlife Service, Portland, Oregon, May 2004. 132 pp.

USFWS. 2009. Marbled Murrelet (*Brachyramphus marmoratus*) 5-Year Review. U.S. Fish and Wildlife Service, Lacey, Washington, June 12, 2009.

USFWS. 2012. Report on Marbled Murrelet recovery implementation team meeting and stakeholder workshop. USFWS, Lacey, Washington, April 17, 2012. 66 pp.

USFWS. 2014. Revised draft recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). USFWS, Portland, Oregon, 2014. 151 pp.

USFWS, and NMFS. 1998. Final endangered species consultation handbook: Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U. S. Fish and Wildlife Service and National Marine Fisheries Service, U.S. GPO: 2004-690-278, Washington, D.C., March 1998. 189 pp.

USGS. 2008. Migration timing and habitat characteristics of anadromous bull trout in Skagit Bay, Washington.

WDFW. 1997. The Watershed Recovery Inventory Project. WDFW, First Draft Report, Olympia, WA, November 1997.

WDFW. 1998. Washington state salmonid stock inventory: bull trout/dolly varden. WDFW, Olympia, Washington, July 1998. 437 pp.

WDFW. 2000. Critical spawning habitat for herring, surf smelt, sand lance, and rock sole in Puget Sound, Washington. Washington Department of Fish and Wildlife, Olympia, WA, March 2000. 162 pp.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940-943.

Weston Solutions, and Pascoe Environmental Consulting. 2006. Jimmycomelately piling removal monitoring project, Jamestown S'Klallam Tribe, Sequim, WA. 116 pp.

Williams, G.D., and R.M. Thom. 2001. Marine and estuarine shoreline modification issues, April 17, 2001. 140 pp.

WSDOT. 2014. Biological assessment for preparation for transportation projects - advanced training manual - version 2014. 7.0 Construction noise impact assessment. WSDOT, Olympia, Washington, 2014. 84 pp.

Yelverton, J.T., D.R. Richmond, R.E. Fletcher, and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Lovelace Foundation for Medical Education and Research, DNA 3114 T, Albuquerque, NM, July 13, 1973. 64 pp.