



**UNITED STATES DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
**NATIONAL MARINE FISHERIES SERVICE**  
West Coast Region  
1201 NE Lloyd Boulevard, Suite 1100  
PORTLAND, OR 97232-1274

Refer to NMFS No:  
WCRO-2020-02137

September 1, 2020

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

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Schuh Boat Lift Project, King County, Washington (NWS-2020-502)

Dear Ms. Walker:

Thank you for your letter of August 7, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Schuh Boat Lift Project. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

In this opinion, NMFS concluded that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon. As required by section 7 of the ESA, NMFS is providing an incidental take statement (ITS) with the opinion. The ITS describes reasonable and prudent measures NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this program. The ITS also sets forth nondiscretionary terms and conditions, including reporting requirements, that the federal action agency must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of the listed species considered in this opinion.

This document also includes the results of our analysis of the program's likely effects on essential fish habitat (EFH) pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and includes three conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. Section 305(b)(4)(B) of the MSA requires federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

WCRO-2020-02137



Please contact Elizabeth Babcock at [elizabeth.babcock@noaa.gov](mailto:elizabeth.babcock@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

A handwritten signature in blue ink, appearing to read "Kim W. Kratz".

Kim W. Kratz, Ph.D  
Assistant Regional Administrator  
Oregon Washington Coastal Office

cc: Colleen Anderson, Corps  
Juliana Houghton, Corps  
Karen Walter, Muckleshoot Indian Tribe  
Matthew Baerwalde, Snoqualmie Indian Tribe  
Kurt Nelson, Tulalip Tribe

**Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens  
Fishery Conservation and Management Act Essential Fish Habitat Response for the**

Schuh Boat Lift Project  
King County, Washington (NWS-2020-502)

**NMFS Consultation Number:** WCRO-2020-02137

**Action Agency:** U.S. Army Corps of Engineers

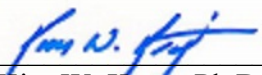
**Affected Species and NMFS' Determinations:**

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound steelhead ( <i>Oncorhynchus mykiss</i> )	Threatened	No	No	N/A	N/A
Puget Sound Chinook ( <i>O. tshawytscha</i> )	Threatened	Yes	No	N/A	N/A
southern resident killer whale ( <i>Orcinus orca</i> )	Endangered	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

**Consultation Conducted By:** National Marine Fisheries Service  
West Coast Region

**Issued By:**

  
 \_\_\_\_\_  
 Kim W. Kratz, Ph.D  
 Assistant Regional Administrator  
 Oregon Washington Coastal Office

**Date:** September 1, 2020

**TABLE OF CONTENTS**

1. Introduction..... 1

    1.1 Background..... 1

    1.2 Consultation History..... 1

    1.3 Proposed Federal Action..... 1

2. Endangered Species Act: Biological Opinion And Incidental Take Statement..... 2

    2.1 Analytical Approach..... 2

    2.2 Status of the Species and Critical Habitat..... 3

        2.2.1 Climate Change..... 3

        2.2.2 Status of the Species..... 5

    2.3 Action Area..... 6

    2.4 Environmental Baseline..... 6

    2.5 Effects of the Action..... 7

    2.6 Cumulative Effects..... 9

    2.7 Integration and Synthesis..... 9

    2.8 Conclusion..... 10

    2.9 Incidental Take Statement..... 11

        2.9.1 Amount or Extent of Take..... 11

        2.9.2 Effect of the Take..... 11

        2.9.3 Reasonable and Prudent Measures..... 11

        2.9.4 Terms and Conditions..... 12

    2.10 Reinitiation of Consultation..... 12

    2.11 “Not Likely to Adversely Affect” Determinations..... 12

        2.11.1 Puget Sound Steelhead..... 12

        2.11.2 Southern Resident Killer Whales..... 13

3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response..... 13

    3.1 Essential Fish Habitat Affected by the Project..... 14

    3.2 Adverse Effects on Essential Fish Habitat..... 14

    3.3 Essential Fish Habitat Conservation Recommendations..... 14

    3.4 Statutory Response Requirement..... 14

    3.5 Supplemental Consultation..... 15

4. Data Quality Act Documentation and Pre-Dissemination Review..... 15

5. References..... 17

## **1. INTRODUCTION**

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

### **1.1 Background**

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [<https://repository.library.noaa.gov/welcome>]. A complete record of this consultation is on file at the NMFS office in Lacey, Washington.

### **1.2 Consultation History**

The US Army Corps of Engineers (the Corps) requested consultation on August 7, 2020. Consultation was initiated on that date.

### **1.3 Proposed Federal Action**

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02). The applicant proposes to install a new boat lift within an existing nine-foot wide by 15-foot long boat slip. It will take place between July 16 to July 31, 2020 and will take less than a week to complete.

## **2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT**

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The Corps determined the proposed action is not likely to adversely affect PS steelhead and southern resident killer whales (SRKWs). Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.13).

### **2.1 Analytical Approach**

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). 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. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

## **2.2 Status of the Species and Critical Habitat**

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

### **2.2.1 Climate Change**

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2016; Mote et al. 2014). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Mote et al. 2014; Tague et al. 2013).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4 degrees Fahrenheit as an annual average, and up to 2 degrees Fahrenheit in some seasons (based on average linear increase per decade; (Abatzoglou et al. 2014; Kunkel et al. 2013)).

Recent temperatures in all but two years since 1998 ranked above the 20th century average (Mote et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10 degrees Fahrenheit, with the largest increases predicted to occur in the summer (Abatzoglou et al. 2014).

Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (Abatzoglou et al. 2014). Precipitation is more likely to occur during October through March and less during summer months. More winter precipitation will be rain than snow (ISAB 2007) (Mote et al. 2013; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al., 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

The combined effects of increasing air temperatures and decreasing spring through fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5-5.3 degree Celsius increases in Columbia Basin streams and a peak temperature of 26 degrees Celsius in the Willamette (NWFSC 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009).

Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Isaak et al. 2012; Mantua et al. 2010). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic food webs (Crozier et al. 2008; Tillmann and Siemann 2011; Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999; Raymondi et al. 2013; Winder and Schindler 2004). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Raymondi et al. 2013; Wainwright and Weitkamp 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (Lawson et al. 2004; McMahon and Hartman 1989).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by



1.0-3.7 degrees Celsius by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Reeder et al. 2013; Tillmann and Siemann 2011).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38 percent to 109 percent increase in acidity is projected by the end of this century in all but the most stringent CO<sub>2</sub> mitigation scenarios, and is essentially irreversible over a time scale of centuries (IPCC 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al. 2012; Feely et al., 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Reeder et al. 2013; Tillmann and Siemann 2011). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Reeder et al. 2013; Tillmann and Siemann 2011).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these Evolutionarily Significant Units (ESUs) (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

### **2.2.2 Status of the Species**

NMFS listed the Puget Sound Chinook salmon ESU as threatened on June 28, 2005 (70 FR 37160). We adopted the recovery plan for this ESU in January 2007. This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have

declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the TRT planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery (NWFSC 2015; Shared Strategy for Puget Sound 2007; NMFS 2006).

Limiting factors for this ESU include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Degraded riparian areas and loss of in-river large woody debris
- Excessive fine-grained sediment in spawning gravel
- Degraded water quality and temperature
- Degraded nearshore conditions
- Impaired passage for migrating fish
- Severely altered flow regime

More information can be found in recovery plans and status reviews for these species. These documents are available on the NMFS West Coast Region website (<http://www.westcoast.fisheries.noaa.gov/>).

### **2.3 Action Area**

“Action area” means 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). The action area includes the project footprint on the Sammamish River and an area of the river 300 feet downstream due to the extent of elevated suspended sediment.

### **2.4 Environmental Baseline**

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency’s discretion to modify are part of the environmental baseline (50 CFR 402.02).

The project is located on the Sammamish River upstream from Lake Washington. The river is about 14 miles long, and drains several tributary creeks and Lake Sammamish into the north end of Lake Washington. One of the tributaries, Bear Creek, has the largest natural run of Chinook

salmon in the north Lake Washington population. The Sammamish River drainage area is about 242 square miles, including the surface of Lake Sammamish (King County 2009).

The geography and ecosystems within the Sammamish River watershed have been dramatically altered by human activity since European settlers first arrived in the 1800s. Heavy timber harvests from the 1870s through the early twentieth century removed almost all of the area's forests. Development since then has converted most of the lowland areas to urban, agricultural, and industrial uses, and forestry and agricultural practices continue to impact the upper portions of the watershed (WRIA 8).

Completion of the Lake Washington Ship Canal in 1916 dried the Sammamish River marshes and lowered the water level in Lake Sammamish (WRIA 8 2005). Between 1962 and 1964, the Corps dredged the Sammamish River into its current configuration. This deepened the river by five feet, hardened its banks, and dramatically reduced floodplain connectivity along most of its length (Martz et al. 1999). They also constructed a weir as part of the project to maintain the water level in Lake Sammamish.

Recreational boats can access the Sammamish River from Lake Washington, from approximately 100 residential overwater structures on the river, and from several small marinas. The weir and shallow water prevent navigation between Lake Sammamish and the lower river where the overwater structure are. Most vessel traffic therefore is from boats moored along the river accessing Lake Washington.

Urban and residential runoff and sewage discharges have reduced water quality across the watershed. The project site is located near the center of a stream reach that is identified on the State's 303D list for exceedance of water quality thresholds for dissolved oxygen, bacteria, and temperature (Ecology 2019).

Riparian vegetation along the river banks is limited to narrow bands of trees and shrubs that are scattered along the length of the river, with riparian vegetation being completely absent along much the river's length. Along its length, about 26 bridges cross the river, and many docks and piers line its banks, creating harsh overwater shadows that limit aquatic productivity and reduce the river's value as rearing and migration habitat for juvenile salmonids. Additionally, those overwater structures (OWSs) provide habitat conditions that favor fish species that prey on juvenile salmonids, especially the non-native smallmouth bass. Other predators in the lake include the native northern pikeminnow and the non-native largemouth bass (Celedonia et al. 2008a; 2008b; Tabor et al. 2010).

The project site is a private residence with a concrete bulkhead along the river and a boat ramp. There are two established birch trees and one western hemlock within 20 feet of the river.

## **2.5 Effects of the Action**

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not

occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

### ***Overwater Structure***

Juvenile salmon, in both the marine nearshore and in freshwater, migrate along the edge of shadows rather than through them (Nightingale and Simenstad 2001; Southard et al. 2006; Celedonia et al. 2008a; Celedonia et al. 2008b; Moore et al. 2013; Munsch et al. 2014). In freshwater, about three-quarters of migrating Columbia River fall Chinook salmon smolts avoided a covered channel and selected an uncovered channel when presented with a choice in an experimental flume setup (Kemp et al. 2005). In Lake Washington, actively migrating juvenile Chinook salmon swam around structures through deeper water rather than swimming underneath a structure (Celedonia et al. 2008b). Structure width, light conditions, water depth, and presence of macrophytes influenced the degree of avoidance. Juvenile Chinook salmon were less hesitant to pass beneath narrower structures (Celedonia et al. 2008b). Overwater structures also provide habitat for non-native predators of juvenile Chinook salmon. Celedonia et al. (2008b) found that smallmouth bass overwhelmingly selected for nearshore overwater structures. Outmigrating juvenile Chinook encountering the new boat lift (and shade cast by the supported boat) will experience short-term migration delays and increased predation risk.

### ***Elevated Suspended Sediment***

Salmonids typically avoid areas of higher suspended sediment which can displace them from their preferred habitats. Fish unable to avoid suspended sediment can experience adverse effects. The severity of effect of suspended sediment increases as a function of the sediment concentration and exposure time, or dose (Newcombe and Jensen 1996; Bash et al. 2001). Suspended sediments can cause sublethal effects such as elevated blood sugars and cough rates (Servizi and Martens 1991), physiological stress, and reduced growth rates. Elevated turbidity levels can reduce the ability of salmonids to detect prey, cause gill damage (Sigler et al. 1984; Lloyd et al. 1987; Bash et al. 2001), and cause juvenile steelhead to leave rearing areas (Sigler et al. 1984). Additionally, short-term pulses of suspended sediment influence territorial, gill-flaring, and feeding behavior of salmon under laboratory conditions (Berg and Northcote 1985). Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991). However, research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Lloyd et al. 1987; Servizi and Martens 1991).

Vibratory removal of hollow 30-inch steel piles in Lake Washington mobilized sediments that adhered to the piles as they were pulled up through the water column (Bloch 2010). Much of the mobilized sediment likely included material that fell out of the hollow piles. Turbidity reached a peak of about 25 NTU above background levels at 50 feet from the pile, and about 5 NTU above background at 100 feet. Turbidity returned to background levels within 30 to 40 minutes. Pile installation created much lower turbidity. The planned boat lift installation is extremely unlikely to mobilize as much sediment as described above, because the lift supports are much smaller. Therefore, the mobilization of bottom sediments and the intensity of resulting turbidity from the

planned boat lift installation is extremely unlikely to exceed the levels reported by Bloch, and may be much less. However, given river currents, turbidity plumes may extend 300 feet downstream.

Installing the boat lift in the Sammamish River will cause temporary increases in suspended sediments in the immediate vicinity of work locations. For the proposed action, the area of elevated suspended sediment levels could extend up to 300 feet downstream from the project site and would return to background levels quickly after the end of construction. All in-water work will take place when Chinook salmon are not present. We do not expect Chinook salmon to be exposed to this stressor.

### ***Vessels***

The property where the boat lift will be constructed already has a dock and boat slip. The new boat lift will not support increased vessel traffic because the owner can already access the river from the ramp.

## **2.6 Cumulative Effects**

“Cumulative effects” are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02 and 402.17(a)). 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.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area’s future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

We expected existing levels of vessel traffic to continue into the future. Any other activities in the action area would require federal authorization and would therefore be federal actions requiring ESA Section 7 consultation.

## **2.7 Integration and Synthesis**

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency’s biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

The current status of the ESU is poor. Abundance across the ESU has generally decreased between 2010 and 2014, with only 6 small populations of 22 total populations showing a positive change in natural-origin spawner abundances. Climate change is expected to make recovery targets for PS Chinook salmon more difficult to achieve. The ESU is split into five Major Population Groups (MPGs). The Lake Washington populations are within the South MPG along with the Green, White, Puyallup, and Nisqually populations. Recovery criteria for the ESU includes 2 to 4 Chinook populations in each of the MPGs within the ESU achieve viability and that the populations that do not meet the viability criteria for all 4 VSP parameters are sustained in order to provide ecological functions and preserve options for ESU recovery. Given the extensive and intense development in the Lake Washington watershed, the Lake Washington populations are the least likely in the South MPG to achieve viability (NWFSC 2015).

Within the action area, the shoreline modifications have degraded the environmental baseline for shoreline-dependent juvenile Chinook salmon. Boat traffic has contributed to the low abundance of the Lake Washington populations of PS Chinook salmon and will likely continue to have these effects into the future.

The timing of in-water construction associated with the proposed action will avoid exposure of Chinook salmon to elevated suspended sediment. The response to the shading from the new boat lift (and boat) will range from no response to a delay in migration of up to a few hours. The vast majority of actively migrating juvenile Chinook salmon will experience delays of less than an hour (Celedonia et al. 2009). Migration times from the Sammamish River to the locks in the Ship Canal averages between 13 and 16 days. Because the area of overwater cover for the boat lift is very minor compared to the available habitat in the Samammish River and the existing area of overwater cover, we do not expect the migration times or predation rates to be measurably changed. Similarly, the new in-water supports of the lift will not meaningfully change predation risk at the population level because the decrease will not significantly change the predation risk for any individual juvenile Chinook salmon.

The increase in overwater cover will not be significant and will maintain the existing baseline conditions for PS Chinook salmon. The effects of the proposed action and the cumulative effects, when added to the environmental baseline, are likely to maintain the Lake Washington Chinook salmon populations at their current levels. Sustaining these populations will meet the recovery plan's goal of preserving options for ESU recovery.

## **2.8 Conclusion**

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon. The proposed action is not within the areas designated as PS Chinook critical habitat.

## **2.9 Incidental Take Statement**

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a 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 further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

### **2.9.1 Amount or Extent of Take**

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

In the biological opinion, we determined that the proposed action will cause incidental take of juvenile PS Chinook salmon by delaying migration and increasing the risk of predation. Accurately quantifying the number of fish taken as a result of is not possible. For take resulting from the creation of overwater cover, we use the total area of rearing and migratory habitat shaded by the boat held by the new lift as a habitat surrogate. This surrogate is proportional to the amount of take as we expect migration delays and additional vulnerability to predators with increasing coverage in the Sammamish River. The take represented by this surrogate is equivalent to the maximum amount of take considered in our jeopardy analysis. Therefore, if the surrogate is exceeded, reinitiation of consultation will be required. This surrogate will function as an effective reinitiation trigger because, the area of habitat shaded by the boat will be measured and reported. Take of juvenile PS Chinook salmon due to overwater cover is exempted for the 135 square feet of habitat impacted by the boat lift.

### **2.9.2 Effect of the Take**

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy PS Chinook.

### **2.9.3 Reasonable and Prudent Measures**

“Reasonable and prudent measures” are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. Minimize incidental take from overwater structures.

#### **2.9.4 Terms and Conditions**

The terms and conditions described below are non-discretionary, and the Corps or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The Corps or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following term and condition implements reasonable and prudent measure 1:
  - a. The Corps shall monitor the amount of habitat shaded by the new boat lift and associated boat and ensure no more than 135 square feet of habitat is covered upon completion of the project.

#### **2.10 Reinitiation of Consultation**

This concludes formal consultation for the Schuh Boat Lift Project.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the federal agency or by the Service 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 taking specified in the ITS 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 identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

#### **2.11 “Not Likely to Adversely Affect” Determinations**

##### **2.11.1 Puget Sound Steelhead**

Lake Washington Basin steelhead are virtually extirpated (less than 10 adult fish per year). Pinniped predation on adult steelhead at the Ballard locks decimated the population (Foley 1995; NMFS 1997). Between 2000 and 2004, escapement averaged 38 fish (WDFW 2002). From 2005 to 2008, escapement continued to decline. The average escapement was 11 with a low of four in 2008. Since 2008, returns have been less than 10 fish each year (Friends of the Ballard Locks in litt.).

WDFW operates smolt traps in Bear Creek (a tributary to the Sammamish River) and the Cedar River to estimate the production of juvenile Chinook salmon, coho salmon, and steelhead. Between 2007 and 2009, WDFW captured one smolt per year in the Cedar River. In Bear Creek, WDFW capture one smolt in 2007 and 2008 and none in 2009 (Kiyohara and Volkhardt 2008; Kiyohara and Zimmerman 2009; 2011). In 2014 and 2015, no steelhead were caught in Bear Creek (Kiyohara 2015; 2016). Kiyohara (2017) reported two steelhead smolts in 2016 There has



been a loss of connectivity between the Duwamish (Green) and Snohomish rivers due to the virtual extirpation of steelhead in the Lake Washington watershed.

In the Lake Washington watershed, wild steelhead are closely related to resident *O. mykiss*. Marshall et al. (2004) studied the relationship between steelhead and resident *O. mykiss*. They found that resident Cedar River *O. mykiss* produce out-migrating smolts and speculated that steelhead could produce adult resident *O. mykiss*. They concluded that the conservation of resident *O. mykiss* in the Lake Washington watershed is likely an important aspect of reducing extinction risk for steelhead.

The proposed action will increase suspended sediment in the action area. However, given the extremely low abundance of steelhead in the watershed, the chance of any individual steelhead being exposed to elevated suspended sediment from this project is discountable. Because juvenile steelhead are larger and not shoreline dependent, the project will not affect their migration or risk of predation.

### **2.11.2 Southern Resident Killer Whales**

The proposed action will not have any direct effects on SRKWs or their critical habitat. However, the project may indirectly affect the quantity of prey available to SRKWs. Any salmonid take up to the aforementioned maximum extent and amount would result in an insignificant reduction in adult equivalent prey resources for SRKWs that may intercept these species within their range. The Lake Washington populations of Chinook salmon are an extremely small proportion of the total number of fish available to SRKWs. The proposed action will not significantly reduce the abundance of these populations. Therefore, we concur with the determination that the proposed action may affect, but is not likely to adversely affect SRKWs.

## **3. MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE**

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the Corps and descriptions of EFH for Pacific Coast salmon (PFMC 2014) in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

### **3.1 Essential Fish Habitat Affected by the Project**

The proposed action and action area for this consultation are described in the Introduction to this document. The action area includes areas designated as EFH for various life-history stages of Chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*), but does not occur within a Habitat Area of Particular Concern.

### **3.2 Adverse Effects on Essential Fish Habitat**

We determined that the proposed action will have adverse effects to EFH designated for Chinook salmon and coho salmon, based on the analysis of effects presented in the ESA portion of this document. The proposed action will adversely affect EFH by temporarily elevating suspended sediment levels and increasing overwater cover. The amount of EFH that will be adversely by shading from overwater cover is 135 square feet.

### **3.3 Essential Fish Habitat Conservation Recommendations**

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, approximately zero acres of designated EFH for Pacific Coast salmon.

The following conservation recommendation is necessary to avoid, mitigate, or offset the impact of the proposed action on EFH:

The Corps shall monitor the amount of habitat shaded by the new boat lift and associated boat and ensure no more than 135 square feet of habitat is covered upon completion of the project.

### **3.4 Statutory Response Requirement**

As required by section 305(b)(4)(B) of the MSA, the Corps must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH

portion of this consultation, you clearly identify the number of conservation recommendations accepted.

### **3.5 Supplemental Consultation**

The Corps must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(1)).

## **4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW**

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

### **4.1 Utility**

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Corps and the applicant. Other interested users could include the City of Kenmore, WA and the general public. Electronic copies of this opinion were provided to the Corps. The document will be available within two weeks at the NOAA Library Institutional Repository [<https://repository.library.noaa.gov/welcome>]. The format and naming adheres to conventional standards for style.

### **4.2 Integrity**

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

### **4.3 Objectivity**

***Information Product Category:*** Natural Resource Plan

***Standards:*** This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

**Best Available Information:** This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

**Referencing:** All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

**Review Process:** This consultation was drafted by NMFS staff with training in ESA [*and MSA implementation, if applicable*], and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

## 5. REFERENCES

- Abatzoglou, J.T., D.E. Rupp, and P.W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. *Journal of Climate* 27(5): 2125-2142.
- Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington, Seattle, Washington.
- Berg, L. and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1410-1417.
- Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. *American Fisheries Society Special Publication* 19: 83-138.
- Bloch, P. 2010. SR 520 Test Pile Turbidity Monitoring Technical Memorandum. Washington State Department of Transportation. Olympia, WA. July 19, 2010. 10 pp.
- Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and J. Grettenberger. 2008a. 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 Studies. U.S. Fish and Wildlife Service, Lacey, Washington. 129 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. 2008b. Movement and Habitat Use of Chinook Salmon Smolts, Northern Pikeminnow, and Smallmouth Bass Near the SR 520 Bridge. U.S. Fish and Wildlife Service, Lacey, Washington. 139 pp.
- Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, D.W. Lantz, T.M. Lee, Z. Li, B.E. Price, W. Gale, and K. Ostrand. 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, Washington Fish and Wildlife Office, Fisheries Division, Lacey, Washington.
- Crozier, L.G., A.P. Hendry, P.W. Lawson, T.P. Quinn, N.J. Mantua, J. Battin, R.G. Shaw, and R.B. Huey, 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. *Evolutionary Applications* 1(2): 252-270.
- Dominguez, F., E. Rivera, D. P. Lettenmaier, and C. L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. *Geophysical Research Letters* 39(5).

- Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. *Annual Review of Marine Science* 4: 11-37
- Foley, S. 1995. Preliminary report on monitoring of 1994-1995 California sea lion predation in the Lake Washington estuary. Washington Department of Fish and Wildlife, Mill Creek, WA.
- 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, Seattle, WA.
- Goode, J.R., Buffington, J.M., Tonina, D., Isaak, D.J., Thurow, R.F., Wenger, S., Nagel, D., Luce, C., Tetzlaff, D. and Soulsby, C., 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. *Hydrological Processes* 27(5): 750-765.
- Isaak, D.J., Wollrab, S., Horan, D. and Chandler, G., 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. *Climatic Change* 113(2): 499-524.
- Kiyohara, K. 2017. Evaluation of downstream migrant salmon production in 2014 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Annual Report.
- Kiyohara, K. 2016. Evaluation of downstream migrant salmon production in 2014 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Annual Report.
- Kiyohara, K. 2015. Evaluation of downstream migrant salmon production in 2014 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Annual Report.
- Kiyohara, K. and Volkhardt, G. 2008. Evaluation of downstream migrant salmon production in 2007 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Annual Report.
- Kiyohara, K. and M. S. Zimmerman. 2009. Evaluation of juvenile salmon production in 2008 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Olympia, Washington.
- Kiyohara, K. and M. S. Zimmerman. 2011. Evaluation of juvenile salmon production in 2009 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife, Olympia, Washington.

- Kunkel, K. E., L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K. T. Redmond, and J. G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6. 83 pp. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.
- Lawson, P. W., Logerwell, E. A., Mantua, N. J., Francis, R. C., & Agostini, V. N. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 61(3): 360-373
- Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. *North American Journal of Fisheries Management* 7: 18-33.
- Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. In *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate*, edited by M. M. Elsner, J. Littell, L. Whitely Binder, 217-253. The Climate Impacts Group, University of Washington, Seattle, Washington.
- Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102(1): 187-223.
- Marshall, A.R., M. Small, and S. Foley. 2004. Genetic Relationships among Anadromous and Non-anadromous *Oncorhynchus mykiss* in Cedar River and Lake Washington— Implications for Steelhead Recovery Planning. Progress report to Cedar River Anadromous Fish Committee and Seattle Public Utilities, Washington Department of Fish and Wildlife, Olympia and Mill Creek, Washington. June 2004.
- McMahon, T.E., and G.F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 46: 1551–1557.
- Mote, P.W., J.T. Abatzoglou and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. Chapter 2 in M.M. Dalton, P.W. Mote and A.K. Snover (eds.) *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities*. Island Press, Washington D.C.
- Mote, P., A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. Raymond, and S. Reeder. 2014. Ch. 21: Northwest. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T. Richmond, and G. Yohe, Eds., U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX. <http://nca2014.globalchange.gov/report/regions/northwest>

- Mote, P.W., D.E. Rupp, S. Li, D.J. Sharp, F. Otto, P.F. Uhe, M. Xiao, D.P. Lettenmaier, H. Cullen, and M. R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States, *Geophysical Research Letters*, 43, doi:10.1002/2016GLO69665
- National Marine Fisheries Service (NMFS). 1997. Investigation of Scientific Information on the Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and on the Coastal Ecosystems of Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-28, 172 p.
- Newcombe, C.P. and J. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management* 16: 693-727.
- Nightingale, B., and C.A. Simenstad. 2001. *Overwater Structures: Marine Issues*. University of Washington, Washington State Transportation Center. 133.
- NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.
- PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.
- Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation. In *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities*, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, DC.
- Reeder, W.S., P.R. Ruggiero, S.L. Shafer, A.K. Snover, L.L. Houston, P. Glick, J.A. Newton, and S.M. Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. In *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities*, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, DC
- 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: 493-497
- Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. *Transactions of the American Fisheries Society* 113: 142-150.



- Sunda, W. G., and W. J. Cai. 2012. Eutrophication induced CO<sub>2</sub>-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO<sub>2</sub>. *Environmental Science & Technology*, 46(19): 10651-10659
- Tabor, R.A., D. Lantz, and S. Sanders. 2010. Distribution and Habitat Use of Fish in Seattle's Streams Final Report, 2005 and 2006. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington.
- Tague, C. L., Choate, J. S., & Grant, G. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. *Hydrology and Earth System Sciences* 17(1): 341-354
- Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.
- Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. *Northwest Science* 87(3): 219-242
- WDFW (Washington Department of Fish and Wildlife). 2002. Salmonid Stock Inventory. Olympia, WA.
- Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. *Ecology* 85: 2100–2106
- Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. *Conservation Biology* 20(1):190-200