



**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-2020-01408

June 30, 2020

Laura Boerner, Planning Chief  
Environmental and Cultural Resources Branch  
Corps of Engineers, Seattle District  
Post Office 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 U.S. Army Corps of Engineers spillway apron and fish ladder erosion emergency repairs at the Lake Washington Ship Canal (LWSC) Project in Seattle, King County, Washington, HUC: 171100191200 – Puget Sound and 171100120400 – Lake Washington.

Dear Ms. Boerner:

Thank you for your letter of May 29, 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 U.S. Army Corps of Engineers' (COE) proposed spillway apron and fish ladder erosion emergency repairs at the LWSC project. 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.

This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016). The enclosed document contains the biological opinion (Opinion) prepared by the NMFS pursuant to section 7 of the ESA on the effects of the proposed action. In this Opinion, the NMFS concludes that the proposed action would adversely affect but is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon. The NMFS also concludes that the proposed action is likely to adversely affect designated critical habitat for PS Chinook salmon but is not likely to result in the destruction or adverse modification of that designated critical habitat. This document also documents our conclusion that the proposed action is not likely to adversely affect PS steelhead, southern green sturgeon, and southern resident (SR) killer whales and their designated critical habitat.

This Opinion includes an incidental take statement (ITS) that describes reasonable and prudent measures (RPMs) the NMFS considers necessary or appropriate to minimize the incidental take associated with this action, and sets forth nondiscretionary terms and conditions that the COE must comply with to meet those measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species.

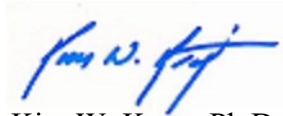
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Section 3 of this document includes our analysis of the action's likely effects on EFH pursuant to Section 305(b) of the MSA. Based on that analysis, the NMFS concluded that the action would not adversely affect designated EFH for Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species. Therefore, we have provided no conservation recommendations to the COE to avoid, minimize, or otherwise offset potential adverse effects on EFH.

Please contact Donald Hubner in the North Puget Sound Branch of the Oregon/Washington Coastal Office at (206) 526-4359, or by electronic mail at [Donald.Hubner@noaa.gov](mailto:Donald.Hubner@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,



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

cc: Katherine Cousins, COE  
Fred Goetz, COE  
Karen Walter, Muckleshoot Indian 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**

U.S. Army Corps of Engineers spillway apron and fish ladder erosion emergency repairs  
at the Lake Washington Ship Canal Project in Seattle, King County, Washington  
(6th Field HUCs: 171100191200 – Puget Sound and 171100120400 – Lake Washington)

**NMFS Consultation Number:** WCRO-2020-01408

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

**Affected Species and NMFS' Determinations:**

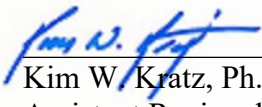
ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Chinook salmon (Oncorhynchus tshawytscha) Puget Sound (PS)	Threatened	Yes	No	Yes	No
steelhead (O. mykiss) PS	Threatened	No	No	No	No
green sturgeon (Acipenser medirostris) Southern	Threatened	No	No	No	No
killer whales (Orcinus orca) Southern resident	Threatened	No	No	No	No

**Affected Essential Fish Habitat (EFH) and NMFS' Determinations:**

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No
Pacific Coast Groundfish	No	No
Coastal Pelagic Species	No	No

**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:** June 30, 2020

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## LIST OF ABREIVIATIONS

BA – Biological Assessment  
BMP – Best Management Practices  
CFR – Code of Federal Regulations  
COE – Corps of Engineers, U.S. Army  
DQA – Data Quality Act  
EF – Essential Feature  
EFH – Essential Fish Habitat  
ESA – Endangered Species Act  
ESU – Evolutionarily Significant Unit  
FR – Federal Register  
FMP – Fishery Management Plan  
HAPC – Habitat Area of Particular Concern  
HUC – Hydrologic Unit Code  
ITS – Incidental Take Statement  
LWSC – Lake Washington Ship Canal  
mg/L – Milligrams per Liter  
MPG – Major Population Group  
MSA – Magnuson-Stevens Fishery Conservation and Management Act  
NMFS – National Marine Fisheries Service  
NOAA – National Oceanic and Atmospheric Administration  
PAH – Polycyclic Aromatic Hydrocarbons  
PBF – Physical or Biological Feature  
PCB – Polychlorinated Biphenyl  
PCE – Primary Constituent Element  
PFMC – Pacific Fishery Management Council  
PS – Puget Sound  
PSTRT – Puget Sound Technical Recovery Team  
RL – Received Level  
RPA – Reasonable and Prudent Alternative  
RPM – Reasonable and Prudent Measure  
SEL – Sound Exposure Level  
SL – Source Level  
VSP – Viable Salmonid Population  
WDFW – Washington State Department of Fish and Wildlife  
WDOE – Washington State Department of Ecology

## **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 Oregon Washington Coastal Office.

### **1.2 Consultation History**

On April 14, 2020 the NMFS received an email from the COE that indicated the COE's desire to discuss needed emergency repairs for a part of the spillway/stilling basin next to the fish ladder at the Chittenden Locks. On April 22nd, the COE hosted a teleconference to provide information about the damage and repair options, and to discuss consultation requirements. On May 22nd, the COE provided a draft biological assessment (BA) for the emergency repair project. The NMFS provided comments the same day.

On May 29, 2020, the NMFS received the COE's request for formal consultation (COE 2020a), with an enclosed BA (COE 2020b). Formal consultation for the proposed action was initiated on that date.

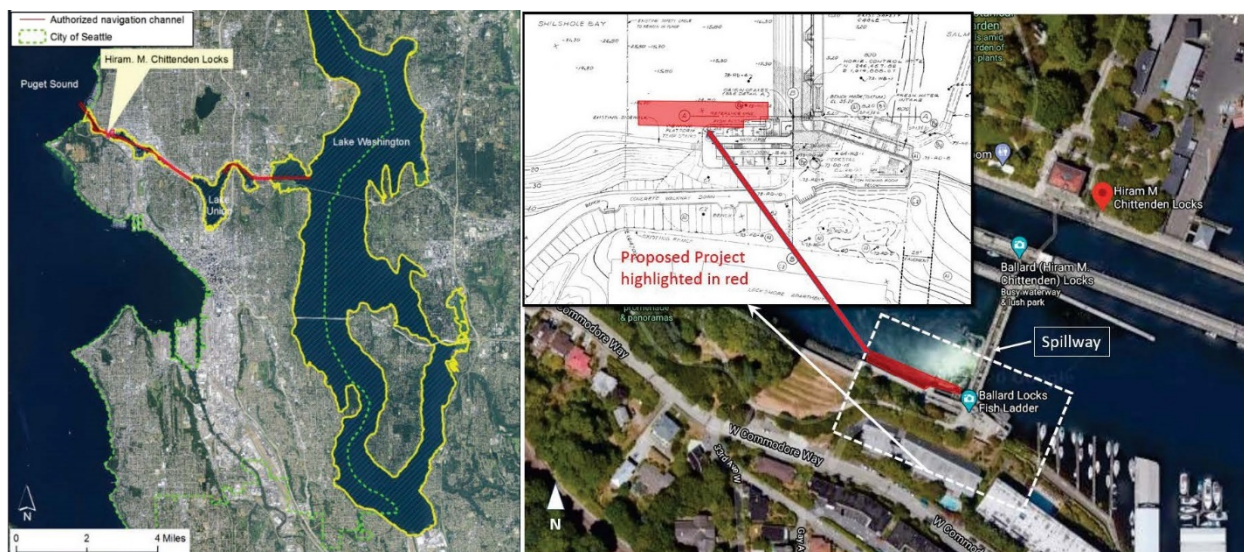
No conference is required for this action concerning the September 19, 2019, proposed rulemaking by the NMFS to revise designated critical habitat for SR killer whales (84 FR 49214), because the proposed additional critical habitat is located well outside of the action area.

This Opinion is based on the information in the COE BA; recovery plans, status reviews, and critical habitat designations for ESA-listed PS Chinook salmon; published and unpublished scientific information on the biology and ecology of that species; and relevant scientific and gray literature (see Literature Cited).

### 1.3 Proposed Federal Action

Under the ESA, “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), whereas the EFH definition of a federal action is any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

The COE proposes to conduct urgently needed repairs of scoured concrete and damaged sheet piles in the tailrace below the spillway immediately west (downstream) of the Hiram M. Chittenden Locks portion of the LWSC Project (Figure 1). The repairs are required to prevent additional damage that could lead to failure of the structure before permanent repairs are designed and implemented. All work would be done within the footprint of the existing structures, and would result in no changes to the character, scope, or size of the original structures.

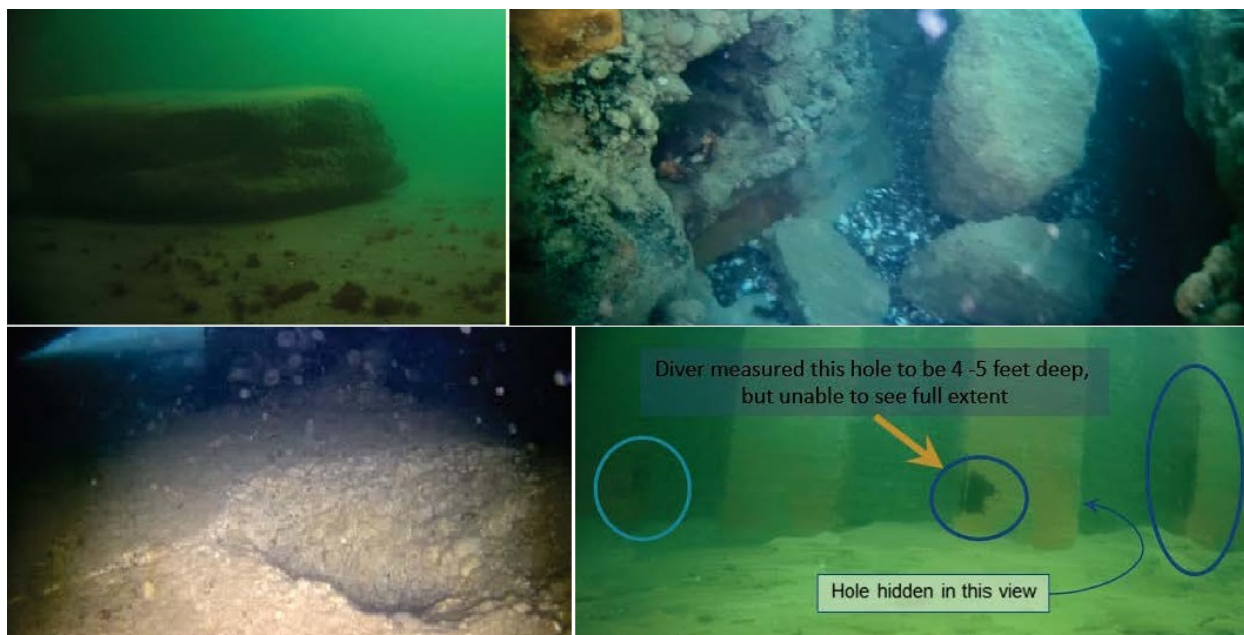


**Figure 1.** Google satellite photographs of the project site at the Hiram M. Chittenden Locks in Seattle, Washington (Adapted from COE 2020b Figures 1 & 2).

The proposed work is described in detail in the COE’s BA (COE 2020b). In summary, the COE or their contractors would operate barge-mounted and land-based equipment and employ divers between September 15, 2020 and October 15, 2020 to remove concrete debris, repair scoured concrete, replace lost fill, and repair holes in a steel sheet-pile wall. In-water work may require short closures of the fish ladder and/or intermittent changes in spill patterns. The barges would be tethered to shore or to COE structures, and all work would comply with the best management practices (BMPs) and conservation measures identified in the BA.

The concrete debris up to about three-feet by three-feet and 1,000 pounds (Figure 2) would be removed from the stilling basin apron using divers and a barge-mounted crane that would hoist the debris onto the barge for upland disposal. Divers would fill scour holes (Figure 2) on the spillway ogee and stilling basin apron by hand using pumped-in hydraulic concrete (tremie style). Depending on their size and other factors, scour holes would be filled with grout bags that would be placed in the hole then pumped full of hydraulic concrete, or divers would pump the

hydraulic concrete into the hole behind temporary forms that would be removed after the concrete sets. Care will be taken to prevent overfilling of grout bags or forms so that the elevation of new concrete is flush with the surrounding area.



**Figure 2.** Photographs of typical damage. The upper left image shows concrete debris. Scour holes are shown in the upper right and lower left, and holes in the steel sheet-pile wall are shown in the lower right (Adapted from COE 2020b Figures 5 & 7 - 9).

Five holes in the steel sheet-pile wall (Figure 2) would be sealed prior to filling scoured areas behind it with hydraulic concrete. Sealing of the holes would be done by divers welding steel patches over the holes. Workers would drill through the concrete deck that is behind the wall and out of the water, then after the sheet-pile holes are sealed, pump hydraulic concrete into the voids with a tremie pipe.

The NMFS also considered whether or not the proposed action described above would cause any other activities that could affect listed resources. The proposed action described would arguably extend the useful life of a structure that affects listed species and their habitats by its physical properties and by the effects of its operation. However, the COE is currently engaged in formal consultation with the NMFS for a 20-year maintenance and operation program for that structure (WCRO-2020-01290). That consultation considers the effects that would be caused by extending the life of this structure. Therefore, this consultation focuses only on the effects that are likely to be caused by performing the urgent repairs described above.

## **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 COE determined that the proposed action is likely to adversely affect PS Chinook salmon and PS steelhead, is not likely to adversely affect designated critical habitat for PS Chinook salmon, and would have no effect designated critical habitat for PS steelhead because the action area has been excluded from that designation. Because the proposed action is likely to adversely affect listed species, the NMFS has proceeded with formal consultation. However, as described in Section 2.5 of this opinion, the NMFS has determined that the proposed action is likely to adversely affect designated critical habitat for PS Chinook salmon. Further, as described in Section 2.12, the NMFS has also concluded that the proposed action may affect, but is not likely to adversely affect PS steelhead (Table 1).

**Table 1.** ESA-listed species and critical habitats that may be affected by the proposed action.

<b>ESA-listed species and critical habitat likely to be adversely affected (LAA)</b>				
<b>Species</b>	<b>Status</b>	<b>Species</b>	<b>Critical Habitat</b>	<b>Listed / CH Designated</b>
Chinook salmon ( <i>Oncorhynchus tshawytscha</i> ) Puget Sound	Threatened	LAA	LAA	06/28/05 (70 FR 37160) / 09/02/05 (70 FR 52630)
<b>ESA-listed species and critical habitat not likely to be adversely affected (NLAA)</b>				
<b>Species</b>	<b>Status</b>	<b>Species</b>	<b>Critical Habitat</b>	<b>Listed / CH Designated</b>
steelhead ( <i>O. mykiss</i> ) Puget Sound	Threatened	NLAA	N/A	05/11/07 (72 FR 26722) / 02/24/16 (81 FR 9252)
North American Green Sturgeon ( <i>Acipenser medirostris</i> ) southern	Threatened	NLAA	N/A	04/07/06 (71 FR 17757) / 10/09/09 (74 FR 52300)
killer whales ( <i>Orcinus orca</i> ) southern resident	Endangered	NLAA	NLAA	11/18/05 (70 FR 57565) / 11/29/06 (71 FR 69054)

LAA = likely to adversely affect      NLAA = not likely to adversely affect

N/A = not applicable. The action area is outside designated critical habitat, or critical habitat has not been designated.

## 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).

Critical habitat designations prior to 2016 used the terms “primary constituent element” (PCE) or “essential feature” (EF) to identify important habitat qualities. However, the 2016 critical habitat regulations (50 CFR 424.12) replaced those terms 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, EFs, or PBFs. In this biological opinion, we use the term PBF to mean PCE or EF, 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 range-wide 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 Rangewide 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.

The summaries that follow describe the status of the ESA-listed species, and their designated critical habitats, that occur within the action area and are considered in this opinion. More

detailed information on the biology, habitat, and conservation status and trend of these listed resources can be found in the listing regulations and critical habitat designations published in the Federal Register and in the recovery plans and other sources at: <https://www.fisheries.noaa.gov/species-directory/threatened-endangered>, and are incorporated here by reference.

### **Listed Species**

Viable Salmonid Population (VSP) Criteria: For Pacific salmonids, we commonly use four VSP criteria (McElhany et al. 2000) to assess the viability of the populations that constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation in single genes to complex life history traits.

"Abundance" generally refers to the number of naturally-produced adults that return to their natal spawning grounds.

"Productivity" refers to the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is in decline.

For species with multiple populations, we assess the status of the entire species based on the biological status of the constituent populations, using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

The summaries that follow describe the status of the ESA-listed species, and their designated critical habitats, that occur within the geographic area of this proposed action and are considered in this opinion. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register.

Puget Sound (PS) Chinook Salmon: The PS Chinook salmon evolutionarily significant unit (ESU) was listed as threatened on June 28, 2005 (70 FR 37160). We adopted the recovery plan

for this ESU in January 2007. The recovery plan consists of two documents: the Puget Sound salmon recovery plan (SSPS 2007) and the final supplement to the Shared Strategy's Puget Sound salmon recovery plan (NMFS 2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
- Populations that do not meet all the Viable Salmon Population (VSP) parameters are sustained to provide ecological functions and preserve options for ESU recovery.

Spatial Structure and Diversity: The PS Sound Chinook salmon ESU includes all naturally spawning populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. The ESU also includes the progeny of numerous artificial propagation programs (NWFSC 2015). The PSTRT identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The PSTRT distributed the 22 populations among five major biogeographical regions, or major population groups (MPGs), that are based on similarities in hydrographic, biogeographic, and geologic characteristics (Table 2).

Hatchery-origin spawners are present in high fractions in most populations within the ESU, with the Whidbey Basin the only MPG with consistently high fractions of natural-origin spawners. Between 1990 and 2014, the fraction of natural-origin spawners has declined in many of the populations outside of the Skagit watershed (NWFSC 2015).

**Table 2.** Extant PS Chinook salmon populations in each biogeographic region (Ruckelshaus *et al.* 2002, NWFSC 2015).

Biogeographic Region	Population (Watershed)
Strait of Georgia	North Fork Nooksack River
	South Fork Nooksack River
Strait of Juan de Fuca	Elwha River
	Dungeness River
Hood Canal	Skokomish River
	Mid Hood Canal River
Whidbey Basin	Skykomish River
	Snoqualmie River
	North Fork Stillaguamish River
	South Fork Stillaguamish River
	Upper Skagit River
	Lower Skagit River
	Upper Sauk River
	Lower Sauk River
	Suiattle River
	Upper Cascade River
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

General Life History: Chinook salmon are anadromous fish that require well-oxygenated water that is typically less than 63° F (17° C), but some tolerance to higher temperatures is documented with acclimation. Adult Chinook salmon spawn in freshwater streams, depositing fertilized eggs in gravel “nests” called redds. The eggs incubate for three to five months before juveniles hatch and emerge from the gravel. Juveniles spend from three months to two years in freshwater before migrating to the ocean to feed and mature. Chinook salmon spend from one to six years in the ocean before returning to their natal freshwater streams where they spawn and then die.

Chinook salmon are divided into two races, stream-types and ocean-types, based on the major juvenile development strategies. Stream-type Chinook salmon tend to rear in freshwater for a year or more before entering marine waters. Conversely, ocean-type juveniles tend to leave their natal streams early during their first year of life, and rear in estuarine waters as they transition into their marine life stage. Both stream- and ocean-type Chinook salmon are present, but ocean-type Chinook salmon predominate in Puget Sound populations.

Chinook salmon are further grouped into “runs” that are based on the timing of adults that return to freshwater. Early- or spring-run chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and finally spawn in the late summer and early autumn. Late- or fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas, and spawn within a few days or weeks. Summer-run fish show intermediate characteristics of spring and fall runs, without the extensive delay in maturation exhibited by

spring-run Chinook salmon. In Puget Sound, spring-run Chinook salmon tend to enter their natal rivers as early as March, but do not spawn until mid-August through September. Returning summer- and fall-run fish tend to enter the rivers early-June through early-September, with spawning occurring between early August and late-October.

Yearling stream-type fish tend to leave their natal rivers late winter through spring, and move relatively directly to nearshore marine areas and pocket estuaries. Out-migrating ocean-type fry tend to migrate out of their natal streams beginning in early-March. Those fish rear in the tidal delta estuaries of their natal stream for about two weeks to two months before migrating to marine nearshore areas and pocket estuaries in late May to June. Out-migrating young of the year parr tend to move relatively directly into marine nearshore areas and pocket estuaries after leaving their natal streams between late spring and the end of summer.

Abundance and Productivity: Available data on total abundance since 1980 indicate that abundance trends have fluctuated between positive and negative for individual populations, but productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Available data now show that most populations have declined in abundance over the past 7 to 10 years. Further, escapement levels for all populations remain well below the PSTRT planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the PSTRT as consistent with recovery (NWFSC 2015). The current information on abundance, productivity, spatial structure and diversity suggest that the Whidbey Basin MPG is at relatively low risk of extinction. The other four MPGs are considered to be at high risk of extinction due to low abundance and productivity (NWFSC 2015). The most recent 5-year status review concluded that the ESU should remain listed as threatened (NMFS 2017).

Limiting Factors: Factors limiting recovery for PS Chinook salmon include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation 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

PS Chinook Salmon within the Action Area: The PS Chinook salmon that are likely to occur in the action area would be fall-run Chinook salmon from the Cedar River population and from the North Lake Washington / Sammamish River population (NWFSC 2015; WDFW 2020a). Both stream- and ocean-type Chinook salmon are present in these populations, with the majority being ocean-types.

The Cedar River population is relatively small, with a total annual abundance fluctuating at close to 1,000 fish (NWFSC 2015; WDFW 2020b). Between 1965 and 2019, the total abundance for PS Chinook salmon in the basin has fluctuated between about 133 and 2,451 individuals, with

the average trend being slightly negative. The 2015 status review reported that the 2010 through 2014 5-year geometric mean for natural-origin spawner abundance had shown a positive change since the 2010 status review, with natural-origin spawners accounting for about 82% of the population. WDFW data suggest that natural-origin spawners accounted for about 71% of a combined total return of 855 fish in 2019 (WDFW 2020b).

The North Lake Washington / Sammamish River population is also small, with a total abundance that has fluctuated between about 33 and 2,223 individuals from 1983 through 2019. Natural-origin spawners make up a small proportion of the total population, accounting for about 30% of the 365 total return in 2019, and the trend is rather flat to slightly negative (NWFSC 2015; WDFW 2020b).

Some returning adults and out-migrating juveniles from these populations, as well as individuals that spawn in some of the smaller streams around the lake, are likely to pass through the action area. Adult Chinook salmon pass through Chittenden Locks (aka Ballard Locks) between mid-June through September, with peak migration occurring in mid-August (City of Seattle 2008). Spawning occurs well upstream of the action area between early August and late October. Juvenile Chinook salmon are found in Lake Washington between January and July, primarily in the littoral zone (Tabor *et al.* 2006). Outmigration through the ship canal and through the locks occurs between late-May and early-July, with the peak occurring in June (City of Seattle 2008).

### **Critical Habitat**

This section describes the status of designated critical habitat that would be affected by the proposed action by examining the condition and trends of physical or biological features (PBFs) that are essential to the conservation of the listed species throughout the designated areas. The PBFs are essential because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The proposed project would affect critical habitat for PS Chinook salmon.

The NMFS designated critical habitat for PS Chinook salmon on September 2, 2005 (70 FR 52630). That critical habitat is located in 16 freshwater subbasins and watersheds between the Dungeness/Elwha Watershed and the Nooksack Subbasin, inclusively, as well as in nearshore marine waters of the Puget Sound that are south of the US-Canada border and east of the Elwha River, and out to a depth of 30 meters. Although offshore marine is an area type identified in the final rule, it was not designated as critical habitat for PS Chinook salmon.

The PBFs of salmonid critical habitat include: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders,

side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation; (5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation. The PBF for PS Chinook salmon CH are listed in Table 3.

**Table 3.** Physical or biological features (PBFs) of designated critical habitat for PS Chinook salmon, and corresponding life history events. Although offshore marine areas were identified in the final rule, none was designated as critical habitat.

Physical or Biological Features		Life History Event
Site Type	Site Attribute	
Freshwater spawning	Water quantity Water quality Substrate	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Water quantity and Floodplain connectivity Water quality and Forage Natural cover	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	(Free of obstruction and excessive predation) Water quantity and quality Natural cover	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine	(Free of obstruction and excessive predation) Water quality, quantity, and salinity Natural cover Forage	Adult sexual maturation and “reverse smoltification” Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine	(Free of obstruction and excessive predation) Water quality, quantity, and forage Natural cover	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing
Offshore marine	Water quality and forage	Adult growth and sexual maturation Adult spawning migration Subadult rearing

Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek. Critical habitat throughout the Puget Sound basin has been degraded by numerous activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood from the waterways,

intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity, and flow, temperature, sediment load and channel instability are common limiting factors of critical habitat throughout the basin.

Land use practices have likely accelerated the frequency of landslides delivering sediment to streams. Fine sediment from unpaved roads also contributes to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and LW recruitment (SSPS 2007).

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and LW. The loss of side-channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water which ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Thousands of acres of lowland wetlands across the region have been drained and converted to agricultural and urban uses, and forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993; Spence et al. 1996; SSPS 2007).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of suspended sediment, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (SSPS 2007).

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (SSPS 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho spawner mortality likely due to runoff containing contaminants emitted from motor vehicles (Feist et al. 2011).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected PS Chinook salmon populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat, changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and LW to

downstream areas (SSPS 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (SSPS 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of Puget Sound's tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand (SSPS 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (HCCC 2005; SSPS 2007).

Critical Habitat within the Action Area: The marine waters and substrates west (downstream) of the spillway and fish ladder have been designated as nearshore marine critical habitat for PS Chinook salmon, whereas the waters and substrates east (upstream) of those structures have been designated as freshwater critical habitat. The critical habitat within the action area primarily supports the migration of juvenile and adult PS Chinook (NOAA 2020; WDFW 2020a).

### **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 COE's repair site is located the LWSC Project, immediately west (downstream) of the Hiram M. Chittenden Locks in Seattle, Washington (Figure 1). Based on the best available information, the NMFS estimates that the action area for this consultation would be limited to the waters and substrates of the LWSC within 50 feet upstream, and 150 feet downstream of the repair site.

The described area overlaps with the geographic ranges of the ESA-listed species and the boundaries of designated critical habitats identified in Table 1. The action area also overlaps with areas that have been designated, under the MSA, as EFH for Pacific Coast salmon, Pacific Coast groundfish, and coastal pelagic species.

## **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).

Environmental conditions at the project site and the surrounding area: The COE’s repair site is located within the LWSC Project, immediately west (downstream) of the Hiram M. Chittenden Locks in Seattle, Washington (Figure 1). The geography and ecosystems in and adjacent to the action area have been dramatically altered by human activity since European settlers first arrived in the 1800s. Historically, a small stream flowed from Lake Union to Shilshole Bay, with no surface water connection between Lake Union and Lake Washington. The waters of Lake Washington flowed south to the Duwamish River via the now absent Black River. The LWSC Project was created by dredging and excavation that began in the 1880s to provide a navigable passage between Lake Washington and the marine waters of Shilshole Bay. The canal is 8.6 miles long, about 150 to 260 feet wide in the cuts, and widens at Portage Bay, Lake Union, and Salmon Bay. The average depth in the navigational channel is about 30 feet. Depths along the edges are typically between 10 and 20 feet.

The canal was completed in 1916. As part of this, the Hiram M. Chittenden Locks (aka Ballard Locks) were constructed near the west end of the canal to maintain navigable water levels in the canal and lakes. This permanently converted Salmon Bay from an estuary to freshwater. Flows through canal are highly controlled by the locks, and are typically very slow, and the canal supports high levels of commercial and recreational vessel traffic.

Little natural shoreline exists in the ship canal, which was constructed during a time when little was known about the environmental needs of the ESA-listed salmonids that now depend on it. In cross-section, the canal closely resembles an elongated box culvert along most of its length, and about 96% of the canal’s banks are armored (City of Seattle 2008). Instead of slopes that gently rise to the surface, as typically occurs along the banks of natural streams, the bank slope along most of the canal is vertical, with depths of tens of feet.

The vast majority of the shoreline from Lake Washington to Shilshole Bay is lined by shipyards, industrial properties, large marinas, and residential piers. Unbroken urban development extends

north and south immediately landward of both shorelines. With the exception of the southern shoreline of Portage Bay, and along the armored banks of the Fremont and Mountlake Cuts, very little riparian vegetation exists along the banks of the canal.

Water quality within the area is influenced by the inflow of freshwater from Lake Washington, by point and non-point discharges all along the waterway, and by a saltwater lens that intrudes through the Ballard Locks, underlays the outflowing freshwater, and occasionally extends into Lake Union. Industrial, commercial, and residential development has impacted water quality in the canal since before the canal was completed in 1916. Lumber and plywood mills, machine shops, metal foundries, fuel and oil facilities, concrete and asphalt companies, and power plants were quickly developed along the shoreline of the waterway, along with numerous shipyards, marinas, commercial docks, and houseboats. Virtually all of the early industrial, commercial, and residential facilities discharged untreated wastes directly to the waterway, some of which persisted into the 1940s and beyond. Tomlinson (1977) cites a 1943 Washington State Pollution Commission report that indicated that the Seattle Gas Plant (now Gasworks Park) discharged oily wastes so routinely that the water surface was covered and fish kills occurred in its vicinity. The report also identified raw sewage discharge into the waterway from most of the residences, commercial establishments, and all of the houseboats that lined the shoreline. Stormwater drainage has also contributed to pollutant loading. Most of the direct discharge of raw sewage was stopped and the gas plant ceased operation during the 1960s.

The City of Seattle (1987) reported water quality problems in the canal that included saltwater intrusion, low dissolved oxygen, and elevated fecal coliform, as well as sediments that were contaminated with Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), cadmium, chromium, lead, mercury, nickel, and zinc, particularly in the area off the former Seattle Gas Plant. Today, the overall water quality in the ship canal has improved substantially. However, Lake Union and the ship canal are included on the Washington State Department of Ecology's (WDOE) list of impaired and threatened water bodies for total phosphorus, fecal coliform bacteria, lead, and the insecticide aldrin in the water column, and for sediment bioassay (City of Seattle 2010). The most likely sources of phosphorus and fecal coliform are point and nonpoint stormwater discharges. Other sources of fecal coliform include wastes from domestic pets and waterfowl, and sewage from boats (City of Seattle 2010).

Although total copper and total lead concentrations have exceeded state water quality criteria for acute toxicity in the past (Herrera 1998), the mean concentrations of dissolved metals have typically been below the state water quality criteria for acute and chronic toxicity (Herrera 2005), and the concentrations of total and dissolved metals in the water are considered relatively low (City of Seattle 2010). Mercury is the primary metal of concern in Lake Union bottom sediments, with concentrations ranging from 0.35 to 9.18 mg/kg near certain South Lake Union discharges (City of Seattle 2010). Elevated concentrations of other pollutants also have been found in canal sediments along the north shoreline of the canal (metals, PAHs, PCBs, phthalates, and other organic compounds) (Herrera 1998; RETEC 2002).

Since 1979, water temperatures in the ship canal have increased an average of 1° Celsius (C, 1.8° F) per decade, with temperatures that can reach 20 to 22° C during the summer and early fall, and the number of days that temperatures are in that range is increasing (City of Seattle 2010).

The preferred temperature limits for salmon are 13 to 18° C (55-64° F), and temperatures of 23 to 25° C (73-77° F) can be lethal. Saltwater intrusion through the locks creates a wedge of high-density saltwater that can extend into and past Lake Union during low flow periods. Freshwater typically floats over the saltwater with little mixing between the two water masses, and the saltwater wedge often becomes anoxic early in the summer as bacteria consume organics in the sediment. DO concentrations range from 9.5 to 12.6 mg/L during the winter and spring, but can decrease to as low as 1 mg/L during the summer months.

The artificial shorelines and widespread presence of overwater structures along the length of the canal and much of Lake Union provide habitat conditions that favor fish species that prey on juvenile salmonids, especially the non-native smallmouth bass. Other predators in the canal include the native northern pikeminnow and the non-native largemouth bass (Celedonia et al. 2008a and b; Tabor et al. 2004 and 2010). Tabor et al. (2004) estimated that about 3,400 smallmouth bass and 2,500 largemouth bass, large enough to consume salmon smolt (> 130 mm fork length), were in the ship canal. They also estimated that smallmouth bass consumed about 48,000 salmon smolts annually, while largemouth bass consumed about 4,200 smolts. Of those, over half were Chinook salmon smolts. Predation appeared to be highest in June, and near Portage Bay, when smolts made up approximately 50% of the diet for smallmouth bass, and about 45% for northern pikeminnow. Returning adult salmon and steelhead are often exposed to excessive predation by pinniped marine mammals (seals and sea lions) that feed on the fish that accumulate downstream of the fish ladder.

At the repair site, the infrastructure includes a 235-foot-long concrete gravity spillway dam, a large lock, a small lock, a saltwater drain, and a concrete fish ladder. Smolt slides are seasonally installed on the spillways to aid out-migration of juvenile salmonids, but they are typically removed by early September and would be removed before the proposed in-water repair work would begin. The spillway empties into a stilling basin with a concrete apron that extends 115 feet downstream of the dam. The apron has a floor elevation of about minus 14 feet relative to mean lower low water (-14 feet re. MLLW), and an 8-foot-deep cutoff wall located at its downstream end. A weir and orifice type fish ladder is located on the south side of the spillway to allow upstream migration of anadromous fish.

The repair area is located along the only migratory route to and from marine waters for juvenile and adult PS Chinook salmon and all other anadromous salmonids in the Lake Washington and Lake Sammamish watersheds. Therefore, those fish must pass through or close to the action area twice to reproduce; first as out-migrating juveniles, then again as returning adults. The past and ongoing anthropogenic impacts described above have established conditions that maintain low current velocities, as well as salinity and temperature gradients that hinder migration of both juvenile and adult salmonids, and expose PS Chinook salmon to high levels of predation.

Climate Change: Climate change has affected the environmental baseline of aquatic habitats across the region and within the action area. However, the effects of climate change have not been homogeneous across the region, nor are they likely to be in the future. During the last century, average air temperatures in the Pacific Northwest have increased by 1 to 1.4° F (0.6 to 0.8° C), and up to 2° F (1.1° C) 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° F (1.7 to 5.6° C), with the largest increases predicted to occur in the summer (Mote et al. 2014).

Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013 and 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° C increases in Columbia Basin streams and a peak temperature of 26° C 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. 2011; 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).

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 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.

## **2.5 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).

As described in Section 1.3, the COE proposes to perform 4 weeks of urgent in-water repair work in the southwest corner of the Hiram M. Chittenden Locks in the City of Seattle, Washington (Figure 1). The work would include the use barge-mounted and land-based equipment and divers between September 15, 2020 and October 15, 2020 to remove concrete debris, repair scoured concrete, replace lost fill, and repair holes in a steel sheet-pile wall.

As described in Section 2.2, PS Chinook salmon inhabit the action area. Also, the action area has been designated critical habitat for that species. The proposed in-water work window avoids the typical period of juvenile PS Chinook salmon out-migration, but overlaps with the end of the return run for adults. Therefore, the planned construction may cause direct effects on PS Chinook salmon and/or the PBFs of their critical habitat through exposure to construction-related noise and in-water activity, water quality impacts, and propeller wash.

### **2.5.1 Effects on Listed Species**

#### **Construction-related Noise and In-water Activity**

Exposure to construction-related noise and in-water activities would adversely affect PS Chinook salmon. Elevated in-water noise and in-water activities capable of causing detectable effects in exposed fish would be caused by in-water use of equipment such as concrete chippers and saws, tugboat operations, and divers working in close proximity to the fish ladder entrance.

The effects of fishes’ exposure to noise vary with the hearing characteristics of the exposed fish, the frequency, intensity, and duration of the exposure, and the context under which the exposure occurs. At low levels, effects may include the onset of behavioral disturbances such as acoustic masking (Codarin et al. 2009), startle responses and altered swimming (Neo et al. 2014), abandonment or avoidance of the area of acoustic effect (Mueller 1980; Picciulin et al. 2010; Sebastianutto et al. 2011; Xie et al. 2008) and increased vulnerability to predators (Simpson et al. 2016). At higher intensities and/or longer exposure durations, the effects may rise to include temporary hearing damage (a.k.a. temporary threshold shift or TTS, Scholik and Yan 2002) and increased stress (Graham and Cooke 2008). At even higher levels, exposure may lead to physical injury that can range from the onset of permanent hearing damage (a.k.a. permanent threshold shift or PTS) and mortality. The best available information about the auditory capabilities of the

fish considered in this Opinion suggest that their hearing capabilities are limited to frequencies below 1,500 Hz, with peak sensitivity between about 200 and 300 Hz (Hastings and Popper 2005; Picciulin et al. 2010; Scholik and Yan 2002; Xie et al. 2008).

The NMFS uses two metrics to estimate the onset of injury for fish exposed to high intensity impulsive sounds. The metrics are based on exposure to peak sound level and sound exposure level (SEL), respectively. Both are expressed in decibels (dB). The metrics are: 1) exposure to 206 dB<sub>peak</sub>; and 2) exposure to 187 dB SEL<sub>cum</sub> for fish 2 grams or larger, or 183 dB SEL<sub>cum</sub> for fish under 2 grams. Any received level (RL) below 150 dB<sub>SEL</sub> is considered “Effective Quiet”. The distance from a source where the RL drops to 150 dB<sub>SEL</sub> is considered the maximum distance from that source where fishes can be affected by the noise, regardless of accumulation of the sound energy (Stadler and Woodbury 2009). Therefore, when there is a difference between the ranges to the isopleths for effective quiet and SEL<sub>cum</sub>, the shorter range shall apply. The discussion in Stadler and Woodbury (2009) makes it clear that the thresholds likely overestimate the potential effects of exposure to impulsive sounds. Further, the assessment did not consider non-impulsive sound because it is believed to be less injurious to fish than impulsive sound. Therefore, any application of the criteria to non-impulsive sounds is also likely to overestimate the potential effects in fish. However, this assessment applies the criteria to both impulsive and non-impulsive sounds for continuity, and as a tool to gain a conservative idea of the sound energies that fish may be exposed to during the majority of this project.

Tugboat operations would likely be infrequent. However the operation of barge-mounted equipment such as generators, pump motors, and the crane would be in operation relatively continuously during the work days. The noise levels from that equipment would likely be similar to that of tugboat operations, and it would transfer into the water via the barge’s hull. The use of diver-operated concrete chippers or similar equipment to clean surfaces prior to patching the holes in concrete and in the sheet-pile wall would periodically create in-water noise across the workday.

The estimated in-water source levels (SL, sound level at 1 meter from the source) used in this assessment are based on the best available information, as described in recent acoustic assessments for projects with similar sound sources (NMFS 2016 & 2018), and in other sources (Blackwell and Greene 2006; FHWA 2017; Richardson et al. 1995). The best available information supports the understanding that all of the SLs would be below the 206 dB<sub>peak</sub> threshold for the onset of instantaneous injury in fish (Table 4).

**Table 4.** Estimated in-water source levels for the loudest project-related sources with the estimated ranges to the source-specific effects thresholds for fish.

Source	Acoustic Signature	Source Level	Threshold Range
Jackhammer	< 1 kHz Impulsive	188 dB <sub>peak</sub>	206 @ N/A
Surrogate for concrete chipper		168 dB <sub>SEL</sub>	150 @ 16 m
Tugboat Propulsion	< 1 kHz Combination	185 dB <sub>peak</sub>	206 @ N/A
Also a surrogate for operation of barge-mounted equipment		170 dB <sub>SEL</sub>	150 @ 22 m
Concrete Saw	0.1 - 4 kHz Non-Impulsive	145 dB <sub>peak</sub>	206 @ N/A
		135 dB <sub>SEL</sub>	150 @ N/A

In the absence of location-specific transmission loss data, variations of the equation  $RL = SL - \# \log(R)$  are often used to estimate the received sound level at a given range from a source (RL = received level (dB); SL = source level (dB, 1 m from the source); # = spreading loss coefficient; and R = range in meters (m)). Acoustic measurements in shallow water environments support the use of a value close to 15 for projects like this one (CalTrans 2015). This value is considered the practical spreading loss coefficient.

Application of the practical spreading loss equation to the expected SLs suggests that noise levels above the 150 dB<sub>SEL</sub> threshold could extend to about 72 feet (22 m) around tugboats and barges, and about 52 feet (16 m) around in-water operation of concrete chippers or similar equipment (Table 4). Fish that are beyond the 150 dB<sub>SEL</sub> isopleth for any of these sources would likely be unaffected by the noise. However, fish within the 150 dB<sub>SEL</sub> isopleth are likely to experience a range of behavioral disturbance, such as acoustic masking, startle responses, altered swimming patterns, avoidance, and increased risk of predation.

As explained previously, the planned work window overlaps with the end of in-migration season for returning adult PS Chinook salmon. The proposed work would not create injurious sound levels. However, the project-related noise and diver activities would likely cause behavior disturbance, such as avoidance of the area around the entrance to the fish ladder that would temporarily delay access to upstream spawning habitat for some individuals that attempt to use the fish ladder to move upstream into the Lake Washington watershed. Exposure to the elevated noise levels would also increase salmon vulnerability to pinniped predators in the area, which would be exacerbated by the salmon's extended duration in predator habitat on the west side of the locks.

The numbers of adult PS Chinook salmon that may be impacted by this stressor is unquantifiable with any degree of certainty. However, it is expected to be extremely low based on the timing and short duration of the repair project. Based on numerous sources that are summarized in the COE's BA, over 90% of each year's return of Chinook salmon has typically passed the locks by mid-September. Additionally, returning adults are about evenly split between using the fish ladder and the large lock to migrate past the spillway dam. Further, the late season stragglers that would be exposed to the project would likely consist mostly of non-listed fish from the Issaquah Creek hatchery (Berge et al. 2006). Therefore, the numbers of adult PS Chinook salmon that may be exposed to construction-related noise would comprise such a small subset of their cohort that their loss would cause no detectable population-level effects.

#### Degraded Water Quality

Exposure to construction-related water quality impacts would cause minor effects in PS Chinook salmon. The planned work would temporarily affect water quality in the action area through increased turbidity that may also temporarily reduce dissolved oxygen concentrations. Curing concrete would temporarily affect pH, and construction-related spills and discharges may release toxic materials into the water.

Turbidity: Project-related tugboat propeller wash and the clearing of debris, rust, and encrusting organisms from areas to be repaired would briefly mobilize small amounts of bottom sediments

and other material that could cause turbidity plumes. However, based on the very small scale of the work that would be done, the plumes would be too short-lived, and the concentrations of total suspended sediments would be too low to cause anything more than temporary, non-injurious behavioral effects such as mild avoidance of the plume and mild gill flaring that would not affect the fitness or meaningfully affect normal behaviors in any PS Chinook salmon that may be exposed to the turbidity.

Dissolved Oxygen: The planned work is extremely unlikely to mobilize any anaerobic sediments or other substances that would cause any detectable decrease in dissolved oxygen levels.

Curing Concrete: The underwater installation of concrete would temporarily affect pH levels in the water around the concrete while it cures. However, with the exception of the concrete fill that would be installed behind the sheet-pile wall where no salmon could be exposed to the curing concrete, the repaired areas would continuously exposed to high volumes of flowing water that would quickly dilute any pH changes. Further, the amounts of concrete that would be installed in the individual repairs would relatively small. Therefore, altered pH would be brief, and undetectable within a few feet downstream of a repair, and too small to cause anything more than temporary, non-injurious behavioral effects such as mild avoidance of the area immediately downstream of a fresh concrete patch that would not affect the fitness or meaningfully affect normal behaviors in any PS Chinook salmon that may be exposed to the project area.

Toxic Materials: Toxic materials may enter the water through construction-related spills and discharges and/or by the mobilization of contaminated sediments. Fish can uptake contaminants directly through their gills, and through dietary exposure (Karrow et al. 1999; Lee and Dobbs 1972; McCain et al. 1990; Meador et al. 2006; Neff 1982; Varanasi et al. 1993). Many of the fuels, lubricants, and other fluids commonly used in motorized vehicles and construction equipment are petroleum-based hydrocarbons that contain Polycyclic Aromatic Hydrocarbons (PAHs), which are known to be injurious to fish. Other contaminants can include metals, pesticides, Polychlorinated Biphenyls (PCBs), phthalates, and other organic compounds.

Depending on the pollutant, its concentration, and/or the duration of exposure, exposed fish may experience effects that can range from avoidance of an affected area, to reduced growth, altered immune function, and mortality (Beitinger and Freeman 1983; Brette et al. 2014; Feist et al. 2011; Gobel et al. 2007; Incardona et al. 2004, 2005, and 2006; McIntyre et al. 2012; Meadore et al. 2006; Sandahl et al. 2007; Spromberg et al. 2015).

The project includes BMPs specifically intended to reduce the risk and intensity of discharges and spills during construction. In the unlikely event of a construction-related spill or discharge, the event would likely be very small, quickly contained and cleaned. Additionally, non-toxic and/or biodegradable lubricants and fluids are strongly encouraged by the State, and are commonly used by many of the local contractors. Based on the best available information, the in-water presence of spill and discharge-related contaminants would be very infrequent, very short-lived, and at concentrations too low to cause detectable effects should a listed fish be exposed to them. The COE estimates that project-related effects would extend no more than 150 feet downstream from the repair site. Based on the small scale of the planned project activities, and

the absence of information to the contrary, the NMFS considers the COE's estimate to be reasonable and protective of listed fish.

Based on the best available information, as described above, any fish that may be exposed to construction-related water quality impacts would experience no more than temporary low-level behavioral effects, which individually, or in combination would not affect the fitness or meaningfully affect the normal behaviors of the exposed individuals.

#### Construction-related Propeller Wash

Construction-related propeller wash would cause minor effects in PS Chinook salmon. Spinning boat propellers can kill fish and small aquatic organisms (Killgore et al. 2011; VIMS 2011). Spinning propellers also generate fast-moving turbulent water that is known as propeller wash. Exposure to propeller wash can displace and disorient small fish.

During in-water work with tugboats and other work boats, vessel operations would cause propeller wash within the action area. However, it is extremely unlikely that an adult Chinook salmon would be struck by a spinning propeller. Adult Chinook salmon that migrate through the action area are likely to avoid construction-related noise and activity. Further, they would be able to swim against most propeller wash they may be exposed to without any meaningful effect on their fitness or normal behaviors.

#### **2.5.2 Effects on Critical Habitat**

This assessment considers the intensity of expected effects in terms of the change they would cause in affected Primary Biological Features (PBFs) from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely last for weeks, and long-term effects are likely to last for months, years or decades.

Puget Sound Chinook Salmon Critical Habitat: The proposed action, including full application of the planned conservation measures and BMPs, is likely to adversely affect designated critical habitat for PS Chinook salmon as described below.

1. Freshwater spawning sites – None in the action area.
2. Freshwater rearing sites – None in the action area.
3. Freshwater migration corridors – None in the action area.
4. Estuarine areas free of obstruction and excessive predation:
  - a. Obstruction and predation – The proposed action would cause short-term minor adverse effects on this attribute. Construction noise is likely to briefly delay migration through the fish ladder, and may increase salmonid vulnerability to predators.
  - b. Water quality – The proposed action would episodically cause very minor and ephemeral water quality impacts that would not measurably reduce the quality of this attribute. The

action would cause no changes in water temperature or dissolved oxygen, but construction would briefly cause very minor increases in suspended sediments, slightly alter pH, and it may introduce very low levels of contaminants. Detectable water quality impacts would be limited to the area within about 150 feet downstream of the repair site.

- c. Water quantity – The proposed action would cause no effect on this attribute.
- d. Salinity – The proposed action would cause no effect on this attribute.
- e. Natural Cover – The proposed action would cause no effect on this attribute.
- f. Forage – The proposed action would cause no effect on this attribute.

5. Nearshore marine areas free of obstruction and excessive predation:

- a. Obstruction and predation – Same as above.
- b. Water quality – Same as above.
- c. Water quantity – Same as above.
- d. Forage – Same as above.
- e. Natural Cover – Same as above.

6. Offshore marine areas – None in the action area.

## **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.

The current condition of ESA-listed species and designated critical habitat within the action area are described in the status of the species and critical habitat and the environmental baseline sections above. The contribution of non-federal activities to those conditions include past and ongoing shoreline development, vessel activities, and upland urbanization in and around the action area, as well as upstream forest management, agriculture, urbanization, road construction, water development, and restoration activities. Those actions were driven by a combination of economic conditions that characterized traditional natural resource-based industries, general resource demands associated with settlement of local and regional population centers, and the efforts of conservation groups dedicated to restoration and use of natural amenities, such as cultural inspiration and recreational experiences.

The NMFS is unaware of any specific future non-federal activities that are reasonably certain to affect the action area. However, the NMFS is reasonably certain that future non-federal actions such as the previously mentioned shoreline and upstream activities are all likely to continue and

increase in the future as the human population continues to grow across the region. Continued habitat loss and degradation of water quality from development and chronic low-level inputs of non-point source pollutants will likely continue into the future. Recreational and commercial use of the waters within the action area is also likely to increase as the human population grows.

The intensity of these influences depends on many social and economic factors, and therefore is difficult to predict. Further, the adoption of more environmentally acceptable practices and standards may gradually reduce some negative environmental impacts over time. Interest in restoration activities has increased as environmental awareness rises among the public. State, tribal, and local governments have developed plans and initiatives to benefit ESA-listed PS Chinook salmon within the watersheds that flow into the action area. However, the implementation of plans, initiatives, and specific restoration projects are often subject to political, legislative, and fiscal challenges that increase the uncertainty of their success.

## **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) appreciably reduce 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.

As described in more detail above at Section 2.4, climate change is likely to increasingly affect the abundance and distribution of the ESA-listed species considered in the Opinion. It is also likely to increasingly affect the PBFs of designated critical habitats. The exact effects of climate change are both uncertain, and unlikely to be spatially homogeneous. However, climate change is reasonably likely to cause reduced instream flows in some systems, and may impact water quality through elevated in-stream water temperatures and reduced dissolved oxygen, as well as by causing more frequent and more intense flooding events.

Climate change may also impact coastal waters through elevated surface water temperature, increased and variable acidity, increasing storm frequency and magnitude, and rising sea levels. The adaptive ability of listed-species is uncertain, but is likely reduced due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. The proposed action will cause direct and indirect effects on the ESA-listed species and critical habitats considered in the Opinion well into the foreseeable future. However, the action's effects on water quality, substrate, and the biological environment are expected to be of such a small scale that no detectable effects on ESA-listed species or critical habitat through synergistic interactions with the impacts of climate change are expected.

### **2.7.1 ESA-listed Species**

PS Chinook salmon are listed as threatened, based on declines from historic levels of abundance and productivity, loss of spatial structure and diversity, and an array of limiting factors as a baseline habitat condition. This species will be affected over time by cumulative effects, some positive – as recovery plan implementation and regulatory revisions increase habitat protections and restoration, and some negative – as climate change and unregulated or difficult to regulate sources of environmental degradation persist or increase. Overall, to the degree that habitat trends are negative, as described below, effects on viability parameters of each species are also likely to be negative. In this context we consider the effects of the proposed action's effect on individuals of the listed species at the population scale.

#### **PS Chinook salmon**

The long-term abundance trend of the PS Chinook salmon ESU is slightly negative. Reduced or eliminated accessibility to historically important habitat, combined with degraded conditions in available habitat due to land use activities appear to be the greatest threats to the recovery of PS Chinook salmon. Commercial and recreational fisheries also continue to impact this species.

The PS Chinook salmon that occur in the action area would be fall-run Chinook salmon from the Cedar River and/or the North Lake Washington/Sammamish River populations. Abundance in both populations is relatively low, with a total annual abundances fluctuating between less than 100 and about 2,500 individuals since 1965, and slightly negative average abundance trends.

The repair site is located within the LWSC, immediately downstream of the Hiram M. Chittenden Locks in Seattle, Washington. The environmental baseline within the action area has been degraded by the effects of intense streambank and shoreline development. The baseline has also been degraded by nearby and upstream industry, urbanization, agriculture, forestry, water diversion, and road building and maintenance.

Construction-related impacts are likely to cause a range of effects that both individually and collectively would cause altered behaviors and possible mortality in low numbers of returning adults. However, the number of individuals that are likely to be impacted by action-related stressors would be extremely low.

Based on the best available information, the scale of the direct and indirect effects of the proposed action, when considered in combination with the degraded baseline, cumulative effects, and the impacts of climate change, would be too small to cause detectable effects on any of the characteristics of a viable salmon population (abundance, productivity, distribution, or genetic diversity) for the affected PS Chinook salmon population. Therefore, the proposed action would not appreciably reduce the likelihood of survival and recovery of this listed species.

## **2.7.2 Critical Habitat**

### **Chinook salmon critical habitat**

Past and ongoing land and water use practices have degraded salmonid critical habitat throughout the Puget Sound basin. Hydropower and water management activities have reduced or eliminated access to significant portions of historic spawning habitat. Timber harvests, agriculture, industry, urbanization, and shoreline development have adversely altered floodplain and stream morphology in many watersheds, diminished the availability and quality of estuarine and nearshore marine habitats, and reduced water quality across the region.

Global climate change is expected to increase in-stream water temperatures and alter stream flows, possibly exacerbating impacts on baseline conditions in freshwater habitats across the region. Rising sea levels are expected to increase coastal erosion and alter the composition of nearshore habitats, which could further reduce the availability and quality of estuarine habitats. Increased ocean acidification may also reduce the quality of estuarine habitats.

In the future, non-federal land and water use practices and climate change are likely to increase. The intensity of those influences on salmonid critical habitat is uncertain, as is the degree to which those impacts may be tempered by adoption of more environmentally acceptable land use practices, by the implementation of non-federal plans that are intended to benefit salmonids, and by efforts to address the effects of climate change.

The PBFs for PS Chinook salmon critical habitat in the action area are limited to estuarine and marine areas free of obstruction and excessive predation. The site attributes of those PBFs that would be affected by the action are limited to obstruction and predation and water quality. As described above, the proposed action would cause short-term minor adverse effects on the site attributes of those PBFs within about 150 feet of the repair site.

Based on the best available information, the scale of the proposed action's effects, when considered in combination with the degraded baseline, cumulative effects, and the impacts of climate change, would be too small to cause any detectable long-term negative changes in the quality or functionality of any of the site attributes of critical habitat PBFs in the action area. Therefore, the critical habitat will maintain its current level of functionality, and retain its current ability for PBFs to become functionally established, to serve the intended conservation role for PS Chinook salmon.

## **2.8 Conclusion**

After reviewing and analyzing the current status of the listed species and critical habitat, 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 the NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon or destroy or adversely modify its designated 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 incidental take statement (ITS).

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

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

Harm of adult Puget Sound Chinook salmon from:

- Exposure to construction-related noise and in-water activities.

The distribution and abundance of the fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can the NMFS precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action.

Therefore, the NMFS cannot predict with meaningful accuracy the number of PS Chinook salmon that are reasonably certain to be injured or killed by exposure to the stressor identified above. Additionally, the NMFS knows of no device or practicable technique that would yield reliable counts of individuals that may experience these impacts. In such circumstances, the NMFS uses the causal link established between the activity and the likely extent and duration of changes in habitat conditions to describe the extent of take as a numerical level of habitat disturbance. The most appropriate surrogates for take are action-related parameters that are directly related to the magnitude of the expected take.

For this action, the type, timing, and duration of in-water work are the best available surrogates for the extent of take of PS Chinook salmon from exposure to construction-related noise and in-water activities, despite the low density and random distribution of these fish in the action area. The type of work is appropriate because performing more intense construction methods would

likely increase the size of the action area, which in turn would increase the number of exposed individuals. It would also likely increase the intensity of effect caused by exposure to the work. The planned work window was selected to reduce the potential for salmonid presence at the repair site. Starting work earlier and/or working longer would increase the number of fish likely to be exposed to project-related stressors.

In summary, the extent of PS Chinook salmon take for this action is defined as:

- Four weeks of in-water concrete and sheet-pile wall repairs completed between September 15 and October 15, as described in the proposed action section of this biological opinion.

Exceedance of any of these exposure limits would constitute an exceedance of authorized take that would trigger the need to reinitiate consultation.

Although these take surrogates could be construed as partially coextensive with the proposed action, they still function as effective reinitiation triggers because the Corps has authority to conduct compliance inspections and to take actions to address non-compliance (33 CFR 326.4).

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

In the opinion, the 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 to the species or destruction or adverse modification of critical habitat.

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

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

The COE shall require the applicant to:

1. Ensure the implementation of monitoring and reporting to confirm that the take exemption for the proposed action is not exceeded.

### **2.9.4 Terms and Conditions**

The terms and conditions described below are non-discretionary, and the COE or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The COE 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. To implement RPM Number 1, Implement monitoring and reporting to confirm that the take exemption for the proposed action is not exceeded, the COE shall develop and implement a plan to collect and report details about the take of listed fish. That plan shall:
  - a. Require the contractor to maintain and submit logs to verify the dates and description(s) of repair work;
  - b. Require the contractor to establish procedures for the submission of the logs and other materials to the COE; and
  - c. Require the COE to submit an electronic post-construction report to NMFS within six months of project completion. Send the report to: [projectreports.wcr@noaa.gov](mailto:projectreports.wcr@noaa.gov). Be sure to include Attn: WCRO-2020-01408 in the subject line.

## **2.10 Conservation Recommendations**

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. The COE should require the use of non-toxic and/or biodegradable lubricants and fluids for all project related heavy equipment.

## **2.11 Reinitiation of Consultation**

This concludes formal consultation for the U.S Army Corps of Engineers' spillway apron and fish ladder erosion emergency repairs at the Lake Washington Ship Canal Project in Seattle, King County, Washington.

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.

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

This assessment was prepared pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402 and agency guidance for preparation of letters of concurrence.

As described in Section 1.2 and below, the NMFS has concluded that the proposed action would be not likely to adversely affect PS steelhead, southern Green Sturgeon, and southern resident (SR) killer whales and their designated critical habitat. Detailed information about the biology,

habitat, and conservation status and trends of PS steelhead can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: <https://www.fisheries.noaa.gov/species-directory/threatened-endangered>, and are incorporated here by reference, and are incorporated here by reference.

The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. The effects analysis in this section relies heavily on the descriptions of the proposed action and project site conditions discussed in Sections 1.3 and 2.4, and on the effects analyses presented in Section 2.5.

### **2.12.1 Effects on Listed Species**

PS steelhead are very rare in the Lake Washington watershed. Fewer than 10 adults from the North Lake Washington and Lake Sammamish population returned to the watershed between 1994 and 1999 when the last WDFW survey was done. Similarly, 50 adults from the Cedar River population have returned to the watershed since 2000, with 10 or less returning since 2007 (WDFW 2020c). Given the timing, short duration, and very small spatial scale of the in-water work that would be done for this project, combined with very low numbers of PS steelhead that may be in the watershed, it is extremely unlikely that any individuals from either population would be exposed to any of the stressors identified in Section 2.5. Therefore, the action is not likely to adversely affect PS steelhead.

Similarly, southern green sturgeon are rare in Puget Sound, and there are no records of this species entering the Lake Washington watershed, including the lower reaches of ship canal. Given the short duration and very small spatial scale of the in-water work that would be done for this project, combined with the very low expectation that southern green sturgeon utilize the action area, it is extremely unlikely that any individuals from this species would be exposed to any of the stressors identified in Section 2.5. Therefore, the action is not likely to adversely affect southern green sturgeon.

There are no records of SR killer whales within the action area. Therefore it is extremely unlikely that any individuals of this species would be exposed to construction-related stressors. Additionally, the proposed action would affect far too few PS Chinook salmon to cause any detectable indirect effects on SR killer whales through the trophic web. Therefore, the action is not likely to adversely affect SR killer whales.

### **2.12.2 Effects on Critical Habitat**

This assessment considers the intensity of expected effects in terms of the change they would cause in affected PBFs from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are

likely to last for hours or days, short-term effects would likely to last for weeks, and long-term effects are likely to last for months, years or decades.

SR killer whale Critical Habitat: Designated critical habitat for SR killer whales includes marine waters of the Puget Sound that are at least 20 feet deep. The expected effects on SR killer whale critical habitat from completion of the proposed action, including full application of the conservation measures and BMP, would be limited to the impacts on the PBF as described below.

1. Water quality to support growth and development  
For up to 4 weeks, the proposed repair work would episodically cause very minor and ephemeral water quality impacts that would not measurably reduce the quality of this attribute.
2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth  
The proposed action would cause no detectable effects on prey availability and quality.
3. Passage conditions to allow for migration, resting, and foraging  
The proposed repairs would cause no detectable effects on passage conditions.

Therefore, the proposed action is not likely to adversely affect SR killer whale critical habitat.

For the reasons expressed immediately above, the NMFS concurs with the COE's determination that the proposed action is not likely to adversely affect ESA-listed PS steelhead, southern green sturgeon, and SR killer whales and their designated critical habitat.

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

Section 305(b) of the MSA directs Federal agencies to consult with the NMFS on all actions or proposed actions that may adversely affect essential fish habitat (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 the 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 COE and the descriptions of EFH for Pacific Coast Salmon (Pacific Fishery Management Council [PFMC] 2014), Pacific

Coast Groundfish (PFMC 2005), and Coastal Pelagic Species (PFMC 1998) contained 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 project site is located immediately downstream of the Hiram M. Chittenden Locks in Seattle, Washington (Figure 1). The waters and substrates of the action area are designated as marine EFH for various life-history stages of Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species.

Marine EFH for Pacific Coast Salmon is identified and described in Appendix A to the Pacific Coast salmon fishery management plan (PFMC 2014). The major components of marine EFH are: Estuarine rearing; Ocean rearing; and juvenile and adult migration. The important features of this EFH are: (1) Water quality (e.g., DO, nutrients, temperature, etc.); (2) Water quantity, depth, and velocity; (3) Riparian-stream-marine energy exchanges; (4) Channel gradient and stability; (5) Prey availability; (6) Cover and habitat complexity (e.g., LWD, pools, aquatic and terrestrial vegetation, etc.); (7) Space; (8) Habitat connectivity from headwaters to the ocean (e.g., dispersal corridors); (9) Groundwater-stream interactions; (10) Connectivity with terrestrial ecosystems; and (11) Substrate composition. Pacific Coast Salmon HAPC include: Complex channels and floodplain habitats; Thermal refugia; Spawning habitat; Estuaries; and Marine and estuarine submerged aquatic vegetation. The action area provides no other known HAPC habitat features.

Pacific Coast Groundfish EFH is identified as: All marine waters and substrate from mean higher high water (MHHW) or the upriver extent of saltwater intrusion out to depths less than or equal to 11,484 feet (3,500 m); Certain specifically identified seamounts in depths greater than 11,484 feet; and Areas designated as HAPCs not already identified by the above criteria (PFMC 2005). Pacific Coast Groundfish HAPC includes: Estuaries; Canopy Kelp; Seagrass; Rocky Reefs; and Areas of interest. For Coastal Pelagic Species, EFH is identified as all marine and estuarine waters from the shoreline to the offshore limits of the exclusive economic zone (EEZ) and above the thermocline where sea surface temperatures range between 10°C to 26°C (PFMC 1998).

Succinct identification of specific habitat features that are necessary to support the full life cycles of Groundfish and Pelagic Species are absent from their respective EFH descriptions. This is likely due to the large number of species, and the wide range of habitats that are considered in the associated fishery management plans (FMPs). However, the important features identified for Salmon EFH effectively address the habitat features that are necessary to support the full life cycle for all three species groups that may be affected by the proposed action. Therefore, the important features of Salmon EFH are used below to assess the impacts on EFH for all three species groups.

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

The ESA portion of this document (Sections 1 and 2) describes the proposed action and its adverse effects on ESA-listed species and critical habitat, and is relevant to the effects on EFH.

Based on the analysis of effects presented in Section 2.5 the proposed action will cause short- and long-term minor adverse effects, and long-term minor beneficial effects on EFH for Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species as summarized below.

1. Water quality: – For up to 4 weeks, the proposed repair work would episodically cause very minor and ephemeral water quality impacts that would not measurably reduce the quality of this attribute.
2. Water quantity, depth, and velocity: – The proposed action may episodically cause brief flow reductions through the fish ladder and over the near spillway that would not measurably reduce the quality of this attribute. No changes in water quantity or depth are expected.
3. Riparian-stream-marine energy exchanges: – No changes expected.
4. Channel gradient and stability: – No changes expected.
5. Prey availability: – No changes expected.
6. Cover and habitat complexity: – No changes expected.
7. Water quantity: – No changes expected.
8. Space: – No changes expected.
9. Habitat connectivity from headwaters to the ocean: – No changes expected.
10. Groundwater-stream interactions: – No changes expected.
11. Connectivity with terrestrial ecosystems: – No changes expected.
12. Substrate composition: – No changes expected.

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

For the reasons expressed immediately above, the NMFS concurs with the COE's determination that the proposed action would not adversely affect EFH for the various life-history stages of Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species. Therefore, additional conservation recommendations pursuant to MSA (§305(b)(4)(A)) are not necessary.

### **3.4 Statutory Response Requirement**

As stated immediately above, the NMFS concurs with the COE's determination that the proposed action would not adversely affect EFH for the various life-history stages of Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species. Therefore no EFH conservation recommendations have been made, and no response from the COE is required by section 305(b)(4)(B) of the MSA.

### 3.5 Supplemental Consultation

The COE 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 is the COE. Other users could include WDFW, the government and citizens of King County and the City of Seattle, and Native American tribes. Individual copies of this Opinion were provided to the COE and the Muckleshoot Indian Tribe. 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, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

## 5. REFERENCES

- Abatzoglou, J.T., Rupp, D.E. and Mote, P.W. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. *Journal of Climate* 27(5): 2125-2142.
- Beitinger, T.L. and L. Freeman. 1983. Behavioral avoidance and selection responses of fishes to chemicals. In: Gunther F.A., Gunther J.D. (eds) *Residue Reviews*. Residue Reviews, vol 90. Springer, New York, NY.
- Blackwell, S.B. and C.R. Greene Jr. 2006. Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels. *J. Acoust. Soc. Am.* 119(1): 182-196.
- Brette, F., B. Machado, C. Cros, J.P. Incardona, N.L. Scholz, and B.A. Block. 2014. Crude Oil Impairs Cardiac Excitation-Contraction Coupling in Fish. *Science* Vol 343. February 14, 2014. 10.1126/science.1242747. 5 pp.
- CalTrans. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Including Appendix 1 - Compendium of Pile Driving Sound Data. Division of Environmental Analysis California Department of Transportation, 1120 N Street Sacramento, CA 95814. November 2015. 532 pp.
- Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, D.W. Lantz, T.M. Lee, Z. Li, J.-M. Pratt, B.E. Price, and L. Seyda. 2008a. 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, WA. October 2008. 139 pp.
- Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and J. Grettenberger. 2008b. 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, WA. December 2008. 129 pp.
- City of Seattle. 1987. Lake Union/Ship Canal/Shilshole Bay Water Quality Management Program Data Summary Report Addendum. City of Seattle Office for Long Range Planning, Rm 200, Municipal Bld. Seattle, Washington 98104. May 1987. 60 pp.
- City of Seattle. 2008. Synthesis of Salmon Research and Monitoring – Investigations Conducted in the Western Lake Washington Basin. Seattle Public Utilities and US Army Corps of Engineers, Seattle Division. December 31, 2008. 143 pp.
- City of Seattle. 2010. Shoreline Characterization Report. Seattle Public Utilities and US Army Corps of Engineers, Seattle Division. January 2010. 221 pp.
- Codarin, A., L.E. Wysocki, F. Ladich, and M. Picciulin. 2009. Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy). *Marine Pollution Bulletin* 58 (2009) 1880–1887.
- Corps of Engineers, U.S. Army (COE). 2020a. Letter with an enclosed biological assessment to request formal ESA and EFH consultation for proposed spillway apron and fish ladder erosion emergency repairs at the Lake Washington Ship Canal Project (LWSC) in Seattle, King County, Washington. May 29, 2020. 2019. 2 pp.
- COE. 2020b. Lake Washington Ship Canal Spillway Apron and Fish Ladder Erosion Repairs, King County, Washington – Biological Assessment. May 2020. 69 pp. Sent as an enclosure with COE 2020a.

- Crozier, L.G., Hendry, A.P., Lawson, P.W., Quinn, T.P., Mantua, N.J., Battin, J., Shaw, R.G. and Huey, R.B., 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. *Evolutionary Applications* 1(2): 252-270.
- Crozier, L. G., M. D. Scheuerell, and E. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. *The American Naturalist* 178 (6): 755-773.
- 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.
- Federal Highway Administration (FHWA). 2017. On-line Construction Noise Handbook – Section 9.0 Construction Equipment Noise Levels and Ranges. Updated: August 24, 2017. Accessed June 12, 2020 at: [https://www.fhwa.dot.gov/environment/noise/construction\\_noise/handbook/handbook09.cfm](https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm)
- Feist, B.E., E.R. Buhle, P. Arnold, J.W. Davis, and N.L. Scholz. 2011. Landscape ecotoxicology of coho salmon spawner mortality in urban streams. *Plos One* 6(8):e23424.
- Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: An ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. 1993-793-071. U.S. Gov. Printing Office.
- Gobel, P., C. Dierkes, & W.C. Coldewey. 2007. Storm water runoff concentration matrix for urban areas. *Journal of Contaminant Hydrology*, 91, 26–42.
- 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.
- Graham, A.L., and S.J. 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*. 18:1315-1324.
- Hastings, M.C., and A. N. Popper. 2005. Effects of sound on fish. Final Report # CA05-0537 – Project P476 Noise Thresholds for Endangered Fish. For: California Department of Transportation, Sacramento, CA. January 28, 2005, August 23, 2005 (Revised Appendix B). 85 pp.
- Herrera. 1998. Lake Union Area Source Control, Stormwater Characterization and Treatment Options. Herrera Environmental Consultants, Seattle, Washington.
- Hicks, B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat change. *American Fisheries Society Special Publication* 19:483-519.
- Hood Canal Coordinating Council (HCCC). 2005. Hood Canal & Eastern Strait of Juan de Fuca summer chum salmon recovery plan. Version November 15, 2005. 339 pp.

- Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: A review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries. Technical Report No. 119. Olympia, Washington.
- Incardona, J.P., T.K. Collier, and N.L. Scholz. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. *Toxicology and Applied Pharmacology* 196:191-205.
- Incardona, J.P., M.G. Carls, H. Teraoka, C.A. Sloan, T.K. Collier, and N.L. Scholz. 2005. Aryl hydrocarbon receptor-independent toxicity of weathered crude oil during fish development. *Environmental Health Perspectives* 113:1755-1762.
- Incardona, J.P., H.L. Day, T.K. Collier, and N.L. Scholz. 2006. Developmental toxicity of 4-ring polycyclic aromatic hydrocarbons in zebrafish is differentially dependent on AH receptor isoforms and hepatic cytochrome P450 1A metabolism. *Toxicology and Applied Pharmacology* 217:308-321.
- Independent Scientific Advisory Board (ISAB, editor). 2007. Climate change impacts on Columbia River Basin fish and wildlife. In: *Climate Change Report*, ISAB 2007-2. Independent Scientific Advisory Board, Northwest Power and Conservation Council. Portland, Oregon.
- 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.
- Karrow, N., H.J. Boermans, D.G. Dixon, A. Hontella, K.R. Soloman, J.J. White, and N.C. Bols. 1999. Characterizing the immunotoxicity of creosote to rainbow trout (*Oncorhynchus mykiss*): a microcosm study. *Aquatic Toxicology*. 45 (1999) 223–239.
- Killgore, K.J, L.E. Miranda, C.E. Murphy, D.M. Wolff, J.J. Hoover, T.M. Keevin, S.T. Maynard, and M.A. Cornish. 2011. Fish Entrainment Rates through Towboat Propellers in the Upper Mississippi and Illinois Rivers. *Transactions of the American Fisheries Society*, 140:3, 570-581, DOI: 10.1080/00028487.2011.581977.
- Kondolf, G.M. 1997. Hungry water: Effects of dams and gravel mining on river channels. *Environmental Management* 21(4):533-551.
- 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
- Lee, R. and G. Dobbs. 1972. Uptake, Metabolism and Discharge of Polycyclic Aromatic Hydrocarbons by Marine Fish. *Marine Biology*. 17, 201-208.
- 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 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.

- McCain, B., D.C. Malins, M.M. Krahn, D.W. Brown, W.D. Gronlund, L.K. Moore, and S-L. Chan. 1990. Uptake of Aromatic and Chlorinated Hydrocarbons by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in an Urban Estuary. *Arch. Environ. Contam. Toxicol.* 19, 10-16 (1990).
- McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42. June 2000. 156 pp.
- McIntyre, J.K., D.H. Baldwin, D.A. Beauchamp, and N.L. Scholz. 2012. Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators. *Ecological Applications*, 22(5), 2012, pp. 1460–1471.
- 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.
- Meadore, 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: 2364-2376.
- Meyer, J.L., M.J. Sale, P.J. Mulholland, and N.L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. *JAWRA Journal of the American Water Resources Association* 35(6): 1373-1386.
- Mote, P.W., J.T. Abatzoglou, and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. 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.
- Mote, P.W., A. K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R.R. Raymond, and W.S. Reeder. 2014. Ch. 21: Northwest. In *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, 487-513.
- Mueller, G. 1980. Effects of Recreational River Traffic on Nest Defense by Longear Sunfish. *Transactions of the American Fisheries Society*. 109:248-251.
- NMFS. 2006. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. Prepared by NMFS Northwest Region. November 17, 2006. 47 pp.
- NMFS. 2016. Memorandum to the Record Re: WCR-2016-4769 Smith Pier Extension, 8341 Juanita Dr. NE, Kirkland, Washington - Acoustic Assessment for Planned Pile Driving June 9, 2016. 7 pp.
- NMFS. 2017. 2016 5-Year Review: Summary and Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Puget Sound Steelhead. NMFS West Coast Region, Portland, Oregon. April 6, 2017. 98 pp.
- NMFS. 2018. Memorandum to the Record Re: WCR-2017-7601 WA Parks Pier Replacement, Cornet Bay, Whidbey Island, Washington – Acoustic Assessment for Planned Pile Extraction and Driving, and for Recreational Boat Use at the Pier. March 26, 2018. 15 pp.
- National Oceanic and Atmospheric Administration (NOAA). 2020. Environmental Response Management Application – Pacific Northwest. On-line mapping application. Accessed on March 3, 2020 at:  
<https://erma.noaa.gov/northwest/erma.html#/layers=1+44000&x=122.20290&y=47.68411&z=12&view=881&panel=layer>

- Neff, J.M. 1982. Accumulation and release of polycyclic aromatic hydrocarbons from water, food, and sediment by marine animals. Pages 282-320 in N.L. Richards and B.L. Jackson (eds.). Symposium: carcinogenic polynuclear aromatic hydrocarbons in the marine environment. U.S. Environ. Protection Agency Rep. 600/9-82-013.
- Neo, Y.Y., J. Seitz, R.A. Kastelein, H.V. Winter, C. Cate, H. Slabbekoorn. 2014. Temporal structure of sound affects behavioural recovery from noise impact in European seabass. *Biological Conservation* 178 (2014) 65-73.
- Northwest Fisheries Science Center (NWFSC). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 356 pp.
- Pacific Fishery Management Council (PFMC). 1998. Description and identification of essential fish habitat for the Coastal Pelagic Species Fishery Management Plan. Appendix D to Amendment 8 to the Coastal Pelagic Species Fishery Management Plan. PFMC, Portland, Oregon. December 1998. 41 pp.
- PFMC. 2005. Amendment 18 (bycatch mitigation program), Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery – Appendix B Part 3 – Essential Fish Habitat text Descriptions. PFMC, Portland, Oregon. November 2005. 361 pp.
- PFMC. 2014. Appendix A to the Pacific Coast salmon fishery management plan, as modified by amendment 18 to the Pacific Coast salmon plan: identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. PFMC, Portland, OR. September 2014. 196 p. + appendices.
- Picciulin, M., L. Sebastianutto, A. Codarin, A. Farina, and E.A. Ferrero. 2010. In situ behavioural responses to boat noise exposure of *Gobius cruentatus* (Gmelin, 1789; fam. Gobiidae) and *Chromis chromis* (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area. *Journal of Experimental Marine Biology and Ecology* 386 (2010) 125–132.
- 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.
- RETEC. 2002. North Lake Union Phase 2 Sediment Investigation Work Plan. Prepared for Puget Sound Energy by The RETEC Group, Inc., Seattle, Washington.
- Richardson, W. J., C. R. Greene, C. I. Malme Jr., and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, 525 B Street, Ste. 1900, San Diego, California 92101-4495.
- Ruckelshaus, M., K. Currens, W. Graeber, R. Fuerstenberg, K. Rawson, N. Sands, and J. Scott. 2002. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit. Puget Sound Technical Recovery Team. National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle.
- Sandahl, J.F., D. Baldwin, J.J. Jenkins, and N.L. Scholz. 2007. A Sensory System at the Interface between Urban Stormwater Runoff and Salmon Survival. *Environmental Science and Technology*. 2007, 41, 2998-3004.
- Scholik, A.R., and H.Y. Yan. 2002. Effects of boat engine noise on the auditory sensitivity of the fathead minnow, *Pimephales promelas*. *Environmental Biology of Fishes*. 63:203-209.

- Sebastianutto, L., M. Picciulin, M. Costantini, and E.A. Ferrero. 2011. How boat noise affects an ecologically crucial behavior: the case of territoriality in *Gobius cruentatus* (Gobiidae). *Environmental Biology of Fishes*. 92:207-215.
- Shared Strategy for Puget Sound (SSPS). 2007. Puget Sound Salmon Recovery Plan – Volume 1. Shared Strategy for Puget Sound, 1411 4<sup>th</sup> Ave., Ste. 1015, Seattle, WA 98101. Adopted by NMFS January 19, 2007. 503 pp.
- Simpson, S.D., A.N. Radford, S.L. Nedelec, M.C.O. Ferrari, D.P. Chivers, M.I. McCormick, and M.G. Meekan. 2016. Anthropogenic noise increases fish mortality by predation. *Nature Communications* 7:10544 DOI: 10.1038/ncomms10544 [www.nature.com/naturecommunications](http://www.nature.com/naturecommunications) February 5, 2016. 7 pp.
- Spence, B.C., G.A. Lomnický, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc. Corvallis, Oregon. National Marine Fisheries Service, Portland, Oregon.
- Spromberg, J.A, D.H. Baldwin, S.E. Damm, J.K. McIntyre, M. Huff, C.A. Sloan, B.F. Anulacion, J.W. Davis, and N.L. Scholz. 2015. Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts. *Journal of Applied Ecology*. DOI: 10.1111/1365-2264.12534.
- Stadler, J.H., and D.P. Woodbury. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. 8 pp.
- Tabor, R.A., M.T. Celedonia, F. Mijia, R.M. Piaskowski, D.L. Low, and B. Footen. 2004. Predation of Juvenile Chinook Salmon by Predatory Fishes in Three Areas of the Lake Washington Basin. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Fisheries Division, 510 Desmond Drive SE, Suite 102, Lacey, WA 98503; Muckleshoot Indian Tribe, 39015 172<sup>nd</sup> Ave. SE, Auburn, WA; and NOAA Northwest Fisheries Science Center, 2725 Mountlake Blvd. E. Seattle, WA. February 2004. 86 pp.
- Tabor, R.A., H.A. Gearns, C.M. McCoy III, and S. Camacho. 2006. Nearshore Habitat Use by Juvenile Chinook Salmon in Lentic Systems, 2003 and 2004 Report. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Fisheries Division, 510 Desmond Drive SE, Suite 102, Lacey, Washington 98503. March 2006. 108 pp.
- Tabor, R.A., S.T. Sanders, M.T. Celedonia, D.W. Lantz, S. Damm, T.M. Lee, Z. Li, and B.E. Price. 2010. Spring/Summer Habitat Use and Seasonal Movement Patterns of Predatory Fishes in the Lake Washington Ship Canal. Final Report, 2006-2009 to Seattle Public Utilities. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Fisheries Division, 510 Desmond Drive SE, Suite 102, Lacey, Washington 98503. September 2010. 88 pp.
- 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.
- Tomlinson, R.D., R.J. Morrice, E.C.S. Duffield, and R.I. Matsuda. 1977. A baseline study of the water quality, sediments, and biota of Lake Union, METRO, Mar. 1977.
- Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S.L. Chan, T.K. Collier, B.B. McCain, and J.E. Stein. 1993. Contaminant Exposure and Associated Biological Effects in Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) from Urban and Nonurban Estuaries of Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-8. NMFS NFSC Seattle, WA. April 1993. 69 pp.

- Virginia Institute of Marine Science (VIMS). 2011. Propeller turbulence may affect marine food webs, study finds. ScienceDaily. April 20, 2011. Accessed September 12, 2019 at: <https://www.sciencedaily.com/releases/2011/04/110419111429.htm>
- 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.
- Washington State Department of Fish and Wildlife (WDFW). 2020a. SalmonScape. Accessed on March 2, 2020 at: <http://apps.wdfw.wa.gov/salmonscape/map.html>.
- WDFW. 2020b. WDFW Conservation Website – Species – Salmon in Washington – Chinook. Accessed on March 2, 2020 at: <https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook>
- Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. *Ecology* 85: 2100–2106.
- Xie, Y.B., C.G.J. Michielsens, A.P. Gray, F.J. Martens, and J.L. Boffey. 2008. Observations of avoidance reactions of migrating salmon to a mobile survey vessel in a riverine environment. *Canadian Journal of Fisheries and Aquatic Sciences*. 65:2178-2190.