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-2021-00940

January 12, 2022

Patricia Crandell
Center Director
Abernathy Fish Technology Center, USFWS
1440 Abernathy Creek Road
Longview, Washington 98642

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Abernathy Fish Technology Center Water Intake Improvement, Washington, Hydrologic Unit Code: 17080003

Dear Ms. Walker:

Thank you for your letter of April 26, 2021, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the United States Department of Fish and Wildlife's (USFWS) Abernathy Fish Technology Center upgrades proposed in Wahkiakum County, Washington. 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 (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 Lower Columbia River (LCR) coho salmon. The NMFS also concludes that the proposed action is likely to adversely affect designated critical habitat for LCR coho, but is not likely to result in the destruction or adverse modification of that 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 terms and conditions that the USFWS must comply with to meet those RPMs. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species.

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 adversely affect designated EFH for Pacific Coast Salmon. Therefore, we have provided five Conservation Recommendations that can be taken by the USFWS to avoid, minimize, or otherwise offset potential adverse effects on EFH. Section 305(b) (4) (B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving this recommendation.

Please contact Scott E. Anderson (scott.anderson@noaa.gov, 360-753-5828) 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: Linda Mark

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

Abernathy Fish Technology Center Water Intake Improvements
Wahkiakum County, Washington

NMFS Consultation Number: WCRO-2021-00940

Action Agency: United States Fish and Wildlife Service

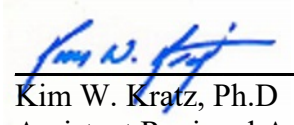
Affected Species and NMFS' Determinations:

ESA-Listed Species	ESA Status	Is Action Likely to Adversely Affect Species?	Is the Action likely to Jeopardize Species?	Is the action likely to adversely affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Lower Columbia River Chinook salmon	T	No	N/A	No	N/A
Columbia River chum salmon	T	No	N/A	No	N/A
Lower Columbia River coho salmon	T	Yes	No	Yes	No

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

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:



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

Date: January 12, 2022

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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 U.S.C. 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 and Washington Coastal Office in Lacey, Washington.

1.2 Consultation History

This opinion is based on the information provided in the April 7, 2021, biological evaluation (BE) and supporting documents. At that time, the U.S. Fish and Wildlife Service (USFWS) requested formal consultation. The project proponent requested a hold on consultation on May 25, 2021 to address design concerns. On June 23, 2021, the project proponent requested to initiate consultation. NMFS initiated formal consultation on June 23, 2021. A complete record of this consultation is on file at the Oregon Washington Coastal Office located in Lacey, Washington. The USFWS concluded that the proposed action is likely to adversely affect:

- Lower Columbia River (LCR) coho salmon (*Oncorhynchus kisutch)* and its designated critical habitat

The USFWS also concluded the proposed action is not likely to adversely affect:

- LCR Chinook salmon (*O. tshawytscha)* and its designated critical habitat
- Columbia River chum salmon (*O. keta*) and its designated critical habitat

NMFS concurred with the USFWS's determinations.

NMFS also reviewed the likely effects of the proposed action on EFH, and concluded that the action would adversely affect the EFH of Pacific Coast salmon.

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). Under MSA, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (50 CFR 600.910).]

The USFWS proposes to obtain a U.S. Army Corps of Engineers permit under Section 404 to bring the Abernathy Fish Technology Center (FTC) fish ladder and water intake infrastructure into compliance with NMFS and Washington Department of Fish and Wildlife (WDFW) fish passage and water intake screening criteria, as well as to address historic operational deficiencies. The project will replace the existing fish hatchery water intake structure and will upgrade the existing fish ladder associated with the FTC.

The water intake for the FTC incorporates a diversion weir and fish ladder as part of the structure. A screen for the supply pipeline is near the tailwater pool just downstream of the ladder entrance. The hatchery intake weir is located at a natural bedrock cascade location on Abernathy Creek, which creates an apron on the downstream side of the weir (Figure 1)

Figure 1. Downstream view of fish ladder and weir with pool behind weir. (Biological Assessment for Abernathy FTC Intake Upgrades, Prepared by Linda Mark, KPFF Project #1900372

The existing intake facility is aligned parallel to the streambank and is 24-feet long and 4.5-feet wide. Flow passes into the structure through a series of 4-foot wide openings protected by wooden trash racks constructed with 2-foot by 4-foot members and 1.5-inch vertical openings.

The intake structure has a 30-inch hatchery supply line that exits on the eastern end and then runs parallel to the ladder. The supply pipeline enters a reverse incline horizontal debris screen chamber downstream of the existing ladder entrance, where an 18-inch cleanout pipe discharges to the creek, along with a 30-inch overflow pipe.

The existing 12-pool fish ladder is positioned alongside the intake structure and has a total vertical drop (forebay to tailwater) of approximately 9feet. The existing ladder's pools are 8-feet long by 6-feet wide and the ladder approximately 90 feet in length. Over time, the pools have filled with bedload cobbles, causing the weirs to be damaged or buried.

According to the WDFW fish passage website, (Https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html), the fish ladder fishway and natural barrier is considered a partial passage barrier with approximately 12 miles of accessible habitat if the barrier is made to be fully passable. Currently, juvenile and adult passage is limited in the existing fishway during high flow, and passage is not possible during low flow conditions. The existing fishway does not meet current NMFS criteria for hydraulic drop, entrance depth, and general pool geometry.

The existing fish hatchery water intake is unscreened at the point of diversion. Screening of water is currently accomplished via a non-compliant inclined debris screen structure farther downstream from the intake. The existing debris screen configuration has a number of fundamental flaws that are detrimental to fish:

1. Fish are entrained in the supply pipe.
2. Fish are forced over the weir and down the face of the screens.
3. The overflow pipe exists in a location where Abernathy Creek is essentially dry during lower flows (summer and autumn months).

The proposed action will upgrade the existing partial-passage-barrier fishway to conform to NMFS passage criteria by reconfiguring the pool bulkheads to provide appropriate pool volume, hydraulic drop, and energy dissipation. The basic existing concrete ladder structure will remain in place and be utilized. The project will replace the existing non-compliant fish hatchery water intake with an intake that is fully compliant with NMFS screening requirements. In addition, the proposed action is also intended to:

- Provide improved access and safety for cleaning operations, particularly during high flow events. The current facility has access and safety issues during high flows.
- Improve the ability for the intake facility to adequately divert water to the hatchery during low (95% exceedance) stream flows. The current water intake is outside of the water during low flows.
- Modify the interior of the uppermost pool of the existing fish ladder to include design elements so that WDFW, who owns the fishway, will have the ability to install and safely operate an adult fish trap at some point in the future. A fish trap will not be installed as part of this project.

Construction is anticipated to start in summer 2022 and is anticipated to last approximately three months.

Construction Activities
The primary anticipated construction activities and equipment are outlined below:

Pre-Construction Activities
Underground utilities, e.g., electrical and pipelines, will be located and flagged to prevent damage during construction per state law. The clearing limits will be marked. Construction fencing and erosion control sediment fence will be used to mark boundaries and control sediment, respectively. The construction contractor will prepare and submit a Construction Stormwater Pollution Prevention Plan (SWPP) as outlined in 2014 Washington Department of Ecology Stormwater Management Manual for Western Washington (SWMMWW). The contractor will use the following best management practices (BMPs) as described in the current SWMMWW: preserve vegetation/mark clearing limits; establish construction access; control flow rates; install sediment controls; stabilize soils; protect slopes; protect drain inlets; stabilize channels and outlets; control pollutants; control dewatering; and maintain BMPs throughout construction.

Construction Staging
Construction staging and laydown areas will be coordinated between the contractor and the Abernathy FTC, with restrictions. No work shall be performed outside of the designated work areas without the approval of the Abernathy FTC. It is likely that construction worker vehicles will be parked along the edge of the gravel access road to the project site. Because staging areas are limited, with advance approval from the USFWS, contractor staging may occur at the Abernathy FTC main facility located approximately one-half mile south. Staging, storage, and refueling areas as well as any equipment repair or similar activity areas shall be located a minimum of 100 feet from Abernathy Creek.

Work Area Isolation and Dewatering
Prior to in-water construction activities, the contractor will isolate an approximately 3,000-square foot section of Abernathy Creek. Isolation methods include a cofferdam created from one-cubic-yard super sacks filled with clean rock material on one side and a precast ecology block wall (two blocks tall) on the other side with a 30-mil flexible membrane liner in place between the ecology blocks and the super sack for waterproofing. This cofferdam work isolation system is would extend between the upstream end of the proposed new intake structure and the concrete weir on the downstream end, to accommodate work in the dry.

Work area isolation will require fish salvage and exclusion. Fish capture and removal methods will be determined by a qualified biologist based on site conditions at the time of work area isolation. Fish may be excluded from entering the fish ladder via stop logs or other physical barriers in advance so that any fish present in the ladder could voluntarily leave the area prior to the fish ladder being dewatered. Fish may be initially herded, using nets, out of the work area due to the streambed and banks being relatively free of vegetation and composed primarily of cobbles, gravels, and bedrock. It is anticipated that most, if not all, fish can successfully be

herded out of the work area without the need for electrofishing. The NMFS electrofishing guidelines be followed if electrofishing is used to capture fish.

After all fish have been removed from inside the cofferdam, the work area will be dewatered and dried. Dewatering will be accomplished by one of three methods: by pumping, as needed, to an upland location which will allow the water to infiltrate; by piping the water to the hatchery water intake pipe, which will be offline during construction and currently conveys diverted water to a large settling pond at the main Abernathy FTC facility; or by piping the water overland directly to the main Abernathy FTC waste facility and into an approved settling pond.

While Abernathy Creek will be allowed to flow freely outside of the cofferdams during construction, fish passage will not be maintained in the immediate area of Abernathy Creek during construction because Abernathy Creek flows will be directed over the non-fish-passable top of the concrete weir and natural bedrock cascade barrier during construction. Fish passage within Abernathy Creek will be reinstated at the end of construction.

Demolition of Existing Infrastructure
The existing intake structure and associated trash racks, debris screens, vaults, pipes, gate valves, and 30-inch concrete supply line will be removed using a jack hammer, diesel-powered excavator, or hydraulic hoe ram to break up the concrete. Concrete and other debris will be removed with a diesel-powered excavator or other mechanized equipment depending on the size of the debris. Debris will be hauled away for disposal at an approved facility via haul truck or re-used on site and moved via haul truck.

Installation of New Intake
The new concrete intake structure will be constructed using plywood forms and poured concrete from a pumper truck or hand methods. After the concrete is sufficiently cured, the forms will be removed.

Bank Stabilization
The existing bank will be protected during construction. The new riprap bank sections will be integrated smoothly into the existing bank line at the interface. A 6-inch minimum layer of 4-inch minus crushed rock will be placed first as a pad for the riprap, likely using a haul truck and excavator or similar equipment. Riprap geotextile fabric will be placed on top of the crushed rock pad. Riprap will be individually placed on top of the geotextile fabric, likely using an excavator placing material brought to the site via haul truck. Rip rap will be removed and bank sections will be revegetated following construction.

Weir Modification
The project will remove 14.5-feet of the existing weir structure nearest to the fish ladder with a saw cutter, a gas operated abrasive wheel, a hand-held jackhammer, or other methods. Broken concrete pieces will be removed from the site using a diesel-powered excavator and haul truck.

The weir will be rebuilt with concrete and a new low flow sluice gate. Plywood forms will be put into place and concrete will be poured from a pumper truck. After the concrete is sufficiently

cured, the forms will be removed. The new sluice gate will likely be moved into place using a crane.

Depressed Sediment Ditch
Existing loose substrate (gravels, cobbles, etc.) will be removed from the area of the depressed sediment ditch below the Ordinary High Water Line (OHWL) using a small excavator. Subsequently, the underlying bedrock will be chipped out down to elevation 213.5 feet to create a low flow sediment sluice, using a small excavator.

Fishway Modification
Existing rock bedload in the ladder pools will be removed with an excavator. The existing ladder weir concrete dividing walls and timbers will be sawcut and removed, using an excavator, and the outside walls will be smoothed with a concrete grinder. New ladder weir stoplog guides will be installed. Forms will be placed inside the fish ladder for the concrete infill for the existing ladder opening, using a pumper truck. After the concrete is sufficiently cured, the forms will be removed. New guides and trash rack will be placed at the ladder exit, and the ladder exit will be cut down (sawcut) approximately 18 inches. A ladder exit slide gate will be installed for isolation of the ladder during fish handling, and a second guide will be installed so that a trap picket barrier can be accommodated. A 12-inch to 18-inch wall penetration will be sawcut and an isolation slide gate installed for release of fish during handling. A fabricated ladder will be mounted to the inside wall of the fishway and removeable grating will be installed for access down into the upper ladder pool during fish handling. All work will in the fish ladder will be done in the dry.

Utility Line Changes
New electrical power utility will be trenched in through the isolated area, below OHWL. A small trench for several electrical conduits will be dug and backfilled using a narrow excavator bucket or chain trencher. A new meter vault will be installed into the existing water supply line to the hatchery in the location where the existing debris screen structure is located. New, short 30-inch piping connections will be required to plumb the meter assembly into the existing water supply line.

Vegetation Removal
One tree larger than 6-inches diameter at breast height (dbh) may be removed as part of this project: a multi-stemmed red alder (28-inch dbh) on the stream side of the existing debris screen. Other vegetation impacts will be limited to trees less than 6-inches dbh and the shrub and herb layer within the project footprint due to ground disturbance for construction access and grading (15,400 square feet [sf] outside of graveled areas and above OHWL).

Site Restoration
Topsoil will be stockpiled and replaced on graded surfaces to a thickness of 6-inches as part of the backfill operation. The topsoil areas to be restored are relatively minor and consist mainly of the perimeter impacted areas around the new intake structure and the restoration of the existing debris screen location. Topsoil will be raked smooth and hydroseeded with a hydroseeding truck, with drought tolerant seed mix on all new and disturbed soil areas. All construction debris will be removed from the work site and all temporary erosion and sediment control measures will be removed.

Impact Avoidance and Minimization Measures

- The proposed project has a net benefit to fish, as it will improve the existing fish ladder and bring it up to *Anadromous Salmonid Passage Facility Design* (NMFS 2011) and WDFW standards. The design also considers Pacific lamprey passage (Pacific Lamprey Technical Workgroup 2017).

- The project will screen the water intake at the point of diversion in order to reduce fish mortality. The fish ladder and water intake will be brought up to current NMFS (NMFS 2011) and WDFW design criteria.

- The existing fish ladder is being retrofitted in this original footprint in order to reduce additional OHW impacts.

- Construction impacts will be confined to the minimum area necessary to complete the project.

- All in-water work will be performed during the proposed extended in-water work (IWW) window of July 2 – September 15, which is the WDFW-approved July 16 to September 15 IWW window, plus a two-week extension on the front end to ensure that there is adequate time for the contractor to complete the IWW during a single construction season.

- The in-water work areas for Abernathy Creek will be isolated from the actively flowing channel through the use of isolation structures. Flows will be diverted around the work areas during construction.

- The contractor will be required to develop an IWW area isolation plan and will be required to submit it to USFWS for approval.

- Fish will be removed from the isolated work areas prior to any in-water construction activities. Washington State Department of Transportation (WSDOT) Fish Exclusion Protocols (2016) will be followed. Additionally, NMFS electrofishing guidelines (NMFS 2000) will be followed if electrofishing is used to capture fish.

- Sediment-laden water pumped from the isolated work areas will be: 1) discharged to upland areas and allowed to infiltrate and/or filter through vegetation; 2) piped to the hatchery water intake pipe, which will be offline during construction and currently conveys diverted water to a large settling pond at the main Abernathy FTC facility; or 3) piped overland directly to the main Abernathy FTC waste facility and into an approved settling pond.

- Containment will be required for any equipment staged on the project.

- All equipment used in or around Abernathy Creek will be required to be clean, in good repair, and inspected prior to use to ensure there are no leaks of petroleum products, hydraulic fluids, coolants, or other deleterious materials.

- The amount and duration of in-stream work with machinery will be limited to the minimum necessary to complete the work.

- Earthwork construction activities for the project are scheduled to occur from July 2 to September 15 to minimize the site's exposure to precipitation and its susceptibility to erosion.

- An Erosion and Sediment Control Plan (ESCP) will be implemented to minimize soil erosion and prevent its entry into surface waters, particularly Abernathy Creek. An ESCP is presented on Sheet C- 301 in Appendix C. Expected erosion and sediment control measures to be employed for this project include stabilized construction entrances, check dams, inlet protection, straw wattles, and silt fence. The contractor will be required to submit the SWPPP to USFWS for approval prior to construction.

- Sensitive areas, including Abernathy Creek and wetlands, will be flagged.

- All of the construction site and access roads shall be maintained, as necessary, to minimize the transmission of dust and prevent nuisance to adjacent properties.

- Construction materials, debris and waste shall be placed or stored where it cannot enter or be washed into waters of the U.S./State.

- The contractor shall take preventative measures to avoid any spills and leaks onto the site from petroleum products.

- At a minimum, staging, storage, and refueling areas as well as any equipment repair or similar activity areas shall be located a minimum of 100 feet from any active creek or channel.

- The contractor shall immediately clean up and report any such leaks or spills that occur on site.

- Construction stormwater BMPs will be installed at the perimeter of all water resources near the work area as a redundant prevention of construction stormwater runoff into wetlands and streams.

- The contractor will be required to coordinate with USFWS to establish specific construction staging locations to minimize environmental impacts including the potential for releases of potential pollutants to Abernathy Creek and area wetlands.

- The contractor will be required to prepare a Spill Prevention, Control, and Countermeasures (SPCC) Plan prior to beginning construction to ensure pollutants are

controlled and contained. The SPCC Plan will be required to be kept onsite at all times during construction.

We considered whether or not the proposed action would cause any other activities and determined that it would not cause other activities.

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 reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This 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 CFR402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

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

The designation of critical habitat for LCR coho salmon uses the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not

change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide 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 PBFs that are essential for the conservation of the species.

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

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase

per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (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; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

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 (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (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; Winder and Schindler 2004, Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright and Weitkamp 2013; Raymondi et al. 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 (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7ºC by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also impacts sensitive estuary habitats,

where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011, Reeder et al. 2013).

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 likely intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of Critical Habitat

A summary of the status of designated critical habitat for LCR coho salmon is provided in Table 1.

Table 1. Critical habitat designations and critical habitat status for species with critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River coho salmon	2/24/16 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.

2.2.2 Status of the Species

Table 2 provides a summary of listing and recovery plan information, status summaries, and limiting factors for LCR coho salmon. More information can be found in recovery plans and status reviews for these species. These documents are available on the NMFS West Coast Region website (http://www.westcoast.fisheries.noaa.gov/). Additional information (e.g., abundance estimates) that has become available since the latest status reviews and technical support documents also comprises the best scientific and commercial data available and has also been summarized..

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for fish species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River coho salmon	Threatened 6/28/05	NMFS 2013	NWFSC 2015	Of the 24 populations that make up this ESU, 21 populations are at very high risk, 1 population is at high risk, and 2 populations are at moderate risk. Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer term data sets it is not possible to parse out these effects. Populations with longer term data sets exhibit stable or slightly positive abundance trends. Some trap and haul programs appear to be operating at or near replacement, although other programs still are far from that threshold and require supplementation with additional hatchery-origin spawners. Initiation of or improvement in the downstream juvenile facilities at Cowlitz Falls, Merwin, and North Fork Dam are likely to further improve the status of the associated upstream populations. While these and other recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels and the majority of the populations remain at moderate or high risk. For the Lower Columbia River region land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. The recent data available at the population level indicate a mix of recent increases, decreases, and relatively static numbers of natural-origin spawners in 2014 to 2018 compared to the 2009 to 2013. The degree to which abundance has been driven by below average ocean survival or by environmental conditions and management actions in freshwater spawning and rearing habitat, appears to vary between populations. Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave.. Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019.	• Degraded estuarine and near-shore marine habitat • Fish passage barriers • Degraded freshwater habitat: Hatchery-related effects • Harvest-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants

Acronyms: DPS (Distinct Population Segment), ESU (Evolutionarily Significant Unit), ICTRT (Interior Columbia Technical Recovery Team), MPG (Multiple Population Grouping), NWFSC (Northwest Fisheries Science Center), TRT (Technical Recovery Team), and VSP (Viable Salmonid Population)

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area includes the 3,000 square foot in-water work area and an approximately 200-foot long section of Abernathy Creek beyond the zone of in-water work, starting from the upstream-most part of the in-water work area and extending approximately 200-feet downstream of the work area where turbidity is expected to extend. Specific information about the action area is found in the Environmental Baseline section in Part 2 of this document.

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).

Water Quality
Abernathy Creek is rated as Category 5 (on the 303(d) list; requires a water improvement project) for temperature (Ecology 2020). In 2009, two of nine sample values (22%) showed an excursion of the criteria (17.5 degrees Celsius) for this waterbody (Ecology 2020). While stream temperatures generally cool in the fall as water levels increase, high temperatures may remain a problem for early-returning salmon (LCFRB 2004). Abernathy Creek is rated as Category 1 (meets standards) for bacteria and Ammonia-N and is Category 2 (waters of concern) for pH (Ecology 2020).

Channel Condition and Dynamics
Abernathy Creek has a high percentage of fines in the tidally-influenced lowest reach and has scoured bedrock channels just upstream (Lower Columbia Fish Recovery Board [LCFRB] 2004). Fifty-five percent of surveyed reaches in Abernathy Creek are in the poor category for substrate fines. In the low gradient channels within the upper basin, high fines are of particular concern. Three sub-watersheds (Mill, Abernathy, and Germany) are rated as impaired, and three are rated as functional, with respect to landscape conditions that influence sediment supply.

The tidal reaches of Abernathy Creek have good floodplain connectivity, as described in LCFRB (2004). Above the tidally influenced area, in the lower to middle reaches of the creek, the channel is highly incised due to the effects of historic splash dam logging and agricultural practices, and roads confine the lower portions of the creek and tributaries.

Portions of the lower and middle reaches of Abernathy Creek, as well as tributary stream reaches, are within agricultural and rural residential areas. Associated bank stabilization has negatively impacted fish habitat in these areas (LCFRB 2004). While the human population in the watershed is low, it is anticipated to continue to increase in the future, primarily in the lower watershed, and may result in additional constraints on streambanks.

In the immediate project vicinity, the existing water intake and existing fish ladder limit floodplain access and natural streambank processes on the right bank. The left bank is natural and steep, with some exposed bedrock, and has a limited floodplain. It is generally covered with native vegetation.

Abernathy Creek's bed in the vicinity of the fish ladder upstream of the weir is dominated by bedrock, with some rounded cobbles (up to 10-inches in diameter) and smaller gravels. Some fines are present in the pool across from the fish ladder upstream of the weir. There is a partial break in the tree canopy at the fish ladder due to the private residence, fish ladder/intake infrastructure, and very steep left bank. Immediately downstream of the fish ladder and weir, the creek's bed is largely cobbles (up to 10-inches in diameter) and gravels with limited sand, and there is one willow-dominated cobble/gravel bar island. There are narrow floodplains on either bank. A large pool immediately downstream of the concrete weir and bedrock falls provides rearing habitat for coho. The tree canopy downstream of the weir is almost completely closed over the creek, lending ample shade and opportunities for large wood recruitment. Just upstream of the project, in the vicinity of the Wiest Road Bridge, the streambed is boulder and cobble bedded, and red alder *(Alnus rubra)* and bigleaf maple *(Acer macrophyllum)* line the creek on both sides and form a shade-producing canopy over the creek.

Flows from the Washington Department of Ecology Abernathy Creek near mouth gage (ID 25E060, located downstream near the mouth of the Abernathy Creek shortly before it enters the Columbia River) were examined for the July 2 to September 15 in-water work window between 2004 and 2019. Mean daily flows during the in-water work period averaged 14 cubic feet per second (cfs) and had a maximum of 226 cfs, with only four days exceeding 100 cfs at the gage (all four of these days were in 2004). Flows at the project site are anticipated to be lower on average because the project site is higher in the watershed. Regardless, it can be assumed that flows will generally be less than 100 cfs during the in-water work period.

Habitat Access

The fishway and natural barrier at the project site is the only fish passage barrier on Abernathy Creek listed on the Washington State Fish Passage Website (https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html).
WDFW considers the fishway to be a partial passage barrier (surveyed on June 29, 2016). Furthermore, it states that this reach of Abernathy Creek is significant and that it stands to have a linear gain of 19,473 meters (12 miles) of accessible habitat if the barrier is made to be fully passable. Currently, juvenile (and some adult) passage is limited in the existing fishway during high flow, and passage is not possible during low flow conditions. The existing fishway does not meet current NMFS criteria for hydraulic drop, entrance depth, and general pool geometry.

Surveys in 2016, 2017, and 2018 identified 432, 240, and 255 natural-origin coho spawners in the Abernathy watershed, respectively (WDFW, 2020b). Screw trap and summer parr surveys indicate thousands of juvenile coho are in the vicinity of the fish ladder year-round, primarily in the pool below the bedrock falls at the fish ladder.

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).

Construction-related effects of the action on habitat and species from this project are temporary. These temporary effects include: elevated suspended sediment and turbidity above background levels, temporary loss of stream habitat and forage from placement of isolation structures, and fish handling. Implementation of the proposed action will result in long-term beneficial effects of improved passage at the facility.

2.5.1 Effects on Critical Habitat

Critical habitat includes PBFs necessary to support various life stages of listed fish (i.e, rearing, migration), including good water quality, appropriate substrate, good riparian conditions, and sufficient prey.

The action area contains designated critical habitat for LCR coho salmon. No other species have critical habitat in the action area.

Summary of Temporary Effects on Critical Habitat

The PBFs of freshwater spawning and incubation sites, include water flow, quality and temperature conditions and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles. These features are essential to conservation because without them, the species cannot successfully spawn and produce offspring. The PBFs of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean.

Substrate, forage and water quality will each be temporarily diminished during construction. Substrate and forage in the 3,000 square foot cofferdam area will be disturbed and inaccessible for about 75 days. Water quality will be intermittently degraded during excavation and placement of the cofferdam.

Temporary loss of substrate: The cofferdam would temporarily degrade substrate and prohibit fish use in the 3,000-sf area for a period of 75 days.

Forage: Because forage for salmonids is mainly derived from invertebrates that live and emerge from the substrate, temporary loss of substrate is commensurate with loss of forage. Cofferdam areas will be inaccessible to coho salmon during the work, and the disturbance of materials within work area will affect substrate and benthic colonies that are forage base for juvenile salmonids. In total, forage will be temporarily lost in approximately 3,000 sf of the Abernathy Creek during construction below the OHWL. The period of time that fish will be excluded from the isolated work area is 75 days. Following construction, it is likely to take several weeks to a few months for the benthic prey to re-colonize the area. In the interim, both the abundance and diversity of prey will be diminished relative to the baseline condition of the habitat, described in more detail below.

Water Quality: As outlined in WAC 173-201A-200, for waters with flows less than 10 cfs at the time of construction, the point of compliance is 100-feet downstream of the activity causing the turbidity exceedance. For flows between 10 and 100 cfs, the point of compliance is 200-feet downstream, and for flows greater than 100 cfs, the point of the compliance is 300 feet downstream.

As discussed in the baseline section above, mean daily flows during the in-water work period averaged 14 cfs and had a maximum of 226 cfs from 2004 to 2019, with only four days exceeding 100 cfs at the gage (all four of these days were in 2004). Flows at the project site are anticipated to be lower on average because the project site is higher in the watershed than the gage at the mouth. It is expected that flows will generally be less than 100 cfs during the in-water work period. It is therefore estimated that water quality impacts from construction-related sediment and turbidity will be commensurate with state water quality standards discussed above for flows between 10 and 100 cfs, and limited to the section of Abernathy Creek extending approximately 200 feet downstream from the construction area.

Prior to excavation, turbidity curtains will be deployed around the cofferdam area. Fish passage will be impeded for 75 days while the cofferdam is in place. Turbidity curtains will be deployed both up and downstream of the work area prior to excavation. The most significant increased turbidity within the aquatic portion of the action area is anticipated to be limited to the time when the cofferdam is constructed and when the cofferdam is removed following construction. Turbid plumes of less intensity could also occur during excavation, particularly if it rains during construction and turbid water leaves the cofferdam area. The zone of turbidity effects extends to a state water quality standard compliance point at 200 feet downstream, creating temporary adverse effects on the water quality PBF.

Site Restoration: In areas where construction equipment will access the creek channel, existing topsoil and vegetation will be removed. Existing vegetation includes primarily grass and weeds. No large trees or overhanging vegetation will be removed. Following construction, topsoil will replaced, raked smooth and hydroseeded. All disturbed soil areas will be hydroseeded with a drought-tolerant seed mix. All construction debris will be removed from the work site and all temporary erosion and sediment control measures will be removed slowly to minimize suspended sediment.

Beneficial effects: Fish passage is currently limited at the fish ladder. Following construction, fish passage will be improved, providing full access for adult and juvenile passage. Approximately 12 miles of habitat will have improved access. This will have a beneficial effect to coho freshwater migration corridor PBF of critical habitat.

Relevance of Effects on Primary Biological Features to Critical Habitat Conservation Value: As described above, the proposed action has temporary negative effects on water quality, forage, and substrate. We interpret this to create slightly negative effects on forage, along with temporary effects described above on water quality from elevated suspended sediment. The proposed action will also result in improvements to passage. When these temporary changes are added to the baseline condition, the function of PBFs are modified at a level that we do not anticipate to be appreciable within the watershed. Since these effects are difficult to distinguish beyond the site scale, we expect that they will not appreciably diminish the conservation role of the watershed in which the site is located. The beneficial effect of improved migration will result in an additional 12 miles of accessible habitat in the Abernathy Creek watershed.

2.5.2 Effects on Listed Species

Individuals of the listed species will have exposure to both long- and short-term effects in their habitat, described above, as well as experiencing "direct effects" – consequences of the proposed action that are focused on or can be immediately discerned among exposed individual fishes. Some direct effects occur concurrently with minimization measures that are standard best management practice.

Exposure and Response to Worksite Isolation and Fish Handling: As discussed above, to minimize the risk of harm or mortality, an attempt will first be made to herd fish out of the isolation area with nets. If fish are unable to be herded or captured with a seine or net, electrofishing equipment will be used. While effective at capturing fish, electrofishing has a higher likelihood of causing harm to fish. Reported rates of injury to juvenile salmonids captured by electrofishing range from 5.1 percent to 15 percent (McMichael et al. 1998; Ainslie et al. 1998). Only a few studies have examined the long-term effects of electrofishing on salmonid survival and growth (Ainslie et al. 1998; Dalbey et al. 1996). Use of electrofishing for fish salvage will comply with NMFS' electrofishing guidelines (NMFS 2000), which are expected to adequately minimize the levels of stress, mortality, and behavioral effects related to electrofishing.

A qualified fishery biologist will conduct and supervise fish removal and handling activities to minimize effects to fish, in accordance with the 2012 *WSDOT Fish Exclusion Protocols and Standards* (WSDOT 2012), or its equivalent. Excluded fish will be moved to another part of Abernathy Creek outside of the work area and released. Although listed salmonids occur in the area, only juvenile coho salmon are expected to be present in the isolated work areas when the work would occur. The work isolation area will be dewatered after initial fish removal efforts are completed. Pump intakes will be screened according to the guidance provided in *Anadromous Salmonid Passage Facility Design* (NMFS 2011a) to prevent impacts to aquatic organisms that may have been missed during fish removal activities. A qualified fishery biologist will monitor

the area being dewatered for any stranded fish. Any fish found during dewatering using dip nets or other similar means and released outside the work area.

Isolating the worksites is intended to reduce the number of individual fish exposed to the effects of in-water work including equipment operating in the channel. Installing cofferdams and removing fish from the isolated worksites are designed to reduce stranding, capture, and handling. While these activities minimize the number of fish exposed to in-water work, the activities themselves can adversely affect fish. All capture methods are stressful to some degree (Wydoski 1980 in Synder 2003). Therefore, the effects of capture and relocation are discussed below.

Typically fish recover fairly rapidly from the stress and fatigue of capture and relocation, unless injured. Stress and fatigue are physiological responses that disrupt physicochemical balance, osmoregulatory functions, and normal behavior, but usually require only a short time for recovery (Snyder 2003). To minimize stress, injury and death an experienced fishery biologist will directly supervise all fish capture and handling operations, and all staff working with the seining, netting, and trapping operations will have the necessary knowledge, skills, and abilities to ensure the safe capture and relocation of salmonids. Fish remaining within the isolated area when construction commences will likely die or be injured as a result of direct contact from heavy equipment or from extremely high turbidity expected within the isolated pockets of water within the cofferdam.

Even though the goal of the fish exclusion is to reduce overall stress and mortality, capturing and handling fish can cause short-term stress, disrupt normal behavior, and may result in injury or mortality (Frisch and Anderson 2000). Fish handling may also cause reduced predator avoidance (Olla et al. 1995). Injury and handling stress from nets and seines are expected to be lower than the stress from electroshocking but may still result in adverse effects. Worksite isolation, capture, handling, transport and release of at-risk fish species will strand some juvenile fish, disrupt normal behavior, and cause short-term stress, fatigue, and some injury and mortality. Capturing and handling fish causes them short-term stress, including increased plasma levels of cortisol and glucose (Frisch and Anderson 2000; Hemre and Krogdahl 1996). Even short-term, low intensity handling may cause reduced predatory avoidance for up to 24 hours (Olla et al. 1995).

Regardless of best practices used, salvage and relocation efforts could harm some listed juvenile salmonids that may be rearing in the vicinity of the project. In summary, the capture, transport, and release of ESA-listed fish, if needed, would cause short-term stress and possibly kill some juveniles from netting and electrofishing injury, as well as from an increased chance of predation. Effects of stocking captured fish into a new upstream habitat may lead to competitive interactions with fish residing at the site and in some cases can lead to predation on the disoriented fish being released. Further, fish salvage efforts may not recover every fish in the isolation area prior to construction below OHWL. Any fish remaining in the isolated work area are expected to be killed from extreme levels of suspended sediment, crushing by machinery, or entrainment during excavation.

Exposure and Response to Elevated Suspended Sediments: Elevated suspended sediment and turbidity above background levels can cause stress by impairing the ability to locate predators,

find prey, defend territories, or by interfering with gill functions (Newcombe and Jensen 1996). Increased stress can compromise the effectiveness of the immune system, thereby affecting mortality rates (USFWS, 1998). Increased stress can also affect blood physiology, thereby decreasing immunological competence, growth, and reproductive success.

A temporary increase in suspended sediments will occur during the placement cofferdams and removal of the cofferdam. Turbid plumes could also occur during excavation, particularly if rain occurs during in-water work. Turbidity is expected to occur within 200 feet of the excavation area in the project site. To lessen the impacts of sediment from upland erosion, appropriate sediment and erosion control BMPs will be put into place before construction begins and will be maintained in working order throughout the construction period. Juvenile salmonids present in the action area are reasonably likely to display behavioral and sublethal effects from the suspended sediment and associated turbidity, such as reduced feeding activity, and avoidance; forcing them to forage in other areas. Increased stress can compromise the effectiveness of the immune system, thereby affecting mortality rates (USFWS, 1998). Laboratory studies have consistently found that the 96-hour median lethal concentration (LC50) for juvenile salmonids is above 1,097 mg/L for 1 to 3 hour exposure (Newcombe and Jensen 1996). However, effects of suspended sediment and turbidity on juvenile ESA-listed fish outside the isolated work area will be minimized by the limited, temporary and localized area of disturbance to aquatic substrates, as well as BMP's implemented to reduce suspended sediment from the proposed project.

There is a small chance of an accidental contaminant release from construction equipment or activities; however, any release likely would be small and quickly contained due to the implementation of a pollution prevention and control plan, and is therefore not likely to have an adverse effect on ESA-listed species.

Exposure and Response to Temporary Loss of Forage: Work area isolation activities for the project are expected to occur over an estimated 75-day period. Work will begin on July 2. July 2 is two weeks prior to the in-water work window for Abernathy Creek, which is July 15 to September 15. A two-week extension will allow for work to occur in one season, which will avoid potential effects on fish and habitat that would occur from work over a 2 work windows, including effects from stream isolation and suspended sediment.

Temporary loss of forage at the project location is not expected to have lethal effects on listed fish. This is because fish will be able to access forage above and below the work area. This will create a small negative effect on an exposed individual's fitness, but should not result in long-term negative effects on individual fish.

The project will also result in improved fish passage for coho salmon. This improvement is likely to aid in productivity and spatial variability, benefiting the long-term survival of coho salmon.

Summary of Construction Effects on Listed Species.
While fish salvage activities are efficient at removing most fish in the isolated work area, some fish may still be present in isolated pools and interstitial spaces between rocks and other debris during project construction. At a minimum, fish present in the isolation area will incur stress due to interaction with construction equipment, noise, increased energetic costs, and reduced water

quality and foraging ability. However, we expect all fish in the excavation area to be killed by entrainment during excavation, crushed by the excavation equipment, or lethal levels of turbidity in the interstitial spaces and isolated pools that may remain after isolation.

A few other fish outside the isolation structure may die due to pulses of suspended sediment during initial cofferdam construction and cofferdam removal once in-water work is completed.

We evaluate project effects at the population scale by determining if effects to individual fish will negatively influence viability salmonid population (VSP) characteristics of exposed populations. Because listed fish are not likely to be present in large numbers due to timing of construction, and because minimization measures described in the BA will be implemented, the death or injury of juvenile LCR coho from the effects of the action will be limited to the areas described above for electroshocking, fish handling, and turbidity. These effects will be indiscernible against present abundance and therefore unlikely to influence the rate of juvenile to adult survival for returning adults.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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

Other effects that are likely to occur in the action area that are outside of any federal nexus are related to other uses of the Abernathy Creek, which are likely to intensify with increases in human population growth. These include increased water quality diminishment as the landscape in uplands continues to be transformed by intensifying uses (commercial, industrial, and residential). These effects, while certain to occur, are difficult to quantify in any degree.

2.7 Integration and Synthesis

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

diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

Species
Lower Columbia River coho salmon have lower abundance, productivity, spatial structure and diversity than was common in recent history. They also have less habitat and degraded quality of habitat available to them. These conditions contribute to their status, and also to the quality of their designated critical habitat. Even areas of critical habitat that have high conservation value are likely to be impaired in one or more of their PBFs, in particular, water quality. Impaired baseline conditions in the action area are representative of systemic habitat degradation, and are factors that inhibit the increases in productivity necessary for robust recovery of the species. We add the effects of the proposed action to this context.

The action will add short-term sublethal and lethal effects to LCR coho and their habitat. The most acute effects will occur during stream isolation (fish handling) and turbidity. Timing of the construction is intended to reduce exposure of vulnerable life stages, and we therefore conclude that fish injured or killed will be at levels low enough that the small reduction in abundance will not be discernible among returns of this cohort i.e., productivity is unlikely to be appreciably affected. Therefore, even assuming that the proposed action would impact population viability parameters, at most this would consist of a small contribution to maintaining those parameters in their current state. Because the abundance and productivities of this population is below recovery targets, maintaining the existing parameters presumably delays reaching recovery targets. The contribution of the proposed action to that delay, if any, is extremely small for the reasons described above – the primarily sublethal nature of the effects and small percentage of individuals within the affected population likely to be exposed to the effects of the proposed action, further, the beneficial effect of improved passage will boost productivity in the long term. Because the effects of the proposed action are not expected to measurably affect population trends among the salmonids exposed to the action that contribute to the viability of the of this species, and beneficial effects of improved fish passage will contribute to improved survival and productivity, the overall effects of the action will not jeopardize the existence of LCR coho salmon, or appreciably reduce the likelihood of both the survival and recovery of ESU in the wild.

Critical Habitat
Critical habitat is designated only for LCR coho salmon in the action area. Construction effects on PBFs of critical habitat from the project are temporary and when we add them to the baseline, because they shortly revert to baseline levels, the conservation values of the habitat for rearing and migration are not considered diminished. Long-term beneficial effects include improved fish passage, adding approximately 12 miles of fully accessible habitat. This benefit will improve productivity, spatial structure, and the migration PBF in the Abernathy watershed. This PBF is a necessary element of habitat for rearing and migrating fish. Rearing and migration features as a baseline matter have been impaired by degraded water quality, bank armoring, channelization, and loss of riparian cover. Considering future population growth and climate change, there will continue to be private and state actions that will produce cumulative effects associated with development (e.g., associated impervious surfaces). The effects of human population growth will place additional pressures on PBFs of critical habitat, but the precise effect of these pressures

cannot be accurately predicted. Within the action area, the overall conservation value of the critical habitat is expected to remain unchanged from its currently constrained condition when the consequences of the proposed action are added to the baseline condition. As such, we do not expect this condition to permanently diminish the conservation value of any PBFs of critical habitat.

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 NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence LCR coho salmon, or destroy or adversely modify designated critical habitat for this species.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

Take in the form of harm is often impossible to quantify as a number of individuals, because the presence of the individuals (exposure to the harmful conditions) is highly variable over time, and is influenced by factors that cannot be easily predicted. Additionally the duration of exposure is highly variable based on species behavior patterns, and the wide variability in numbers exposed and duration of exposure create a range of responses, many of which cannot be observed without research and rigorous monitoring. In these circumstances, we describe an "extent" of take which is a measure of the harming condition spatially, temporally, or both. The extent of take is causally related to the amount of harm that will result, and each extent of take provided below is an observable metric for monitoring, compliance, and re-initiation purposes.

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

1. Harm associated with temporary loss of forage, and fish isolation including fish handling and electroshocking: The extent of take for fish isolation effects is the size of the

cofferdam, listed below in section 2.9.4. This surrogate is causally linked to incidental take because take from foreclosed habitat access increases as the size of the cofferdam increases.

2. Harm to coho salmon associated with suspended sediment related to placement of the cofferdam, during excavation, and removal of the cofferdam. If turbidity occurs in any Abernathy Creek beyond the authorized 200 ft mixing zone, the anticipated take would be exceeded. This surrogate is casually linked to incidental take by suspended sediment because the potential for harm increases as turbidity increases.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). The USFWS shall minimize incidental take by:

1. Ensuring completion of a monitoring and reporting program to confirm that the take exemption for the proposed action is not exceeded, and that the terms and conditions in this incidental take statement are effective in minimizing incidental take.

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the USFWS must comply (or must ensure that any applicant complies) with the following terms and conditions. The USFWS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1) The following terms and conditions implement reasonable and prudent measure:
   a) Require Specific Maximum Dimensions of Temporary Fish Isolation Structures.
      i) Temporary fish isolation structures (i.e., cofferdam) in Abernathy Creek shall not exceed 3,000 sf in total.
      ii) Confirm that as-built temporary cofferdams do not exceed these dimensions.

2) The following terms and conditions implement reasonable and prudent measure 2 (monitoring):
   a) Reporting: USFWS and the applicant shall monitor and report on the following items, at a minimum:

i) Turbidity monitoring. Report the results from the turbidity monitoring, including monitoring location and time. Report any exceedance of the 200-foot turbidity plume.
ii) Fish Isolation Structures. Report the as-built areas of temporary fish isolation structures (i.e., cofferdams), which shall not exceed 3,000 sf in Abernathy Creek.
v) Submit reports to NMFS addressing turbidity monitoring and fish isolation structures, no later than January 31, until project construction is substantially completed.
vi) Submit monitoring reports to NMFS through the following e-mail addresses: projectreports.wcr@noaa.gov with a cc to Scott.Anderson@noaa.gov.

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).

To further reduce the effects of land use on critical habitat, USFWS should encourage the landowners to look for additional opportunities to revegetate degraded riparian areas to encourage the recruitment of large woody debris in the Abernathy Creek watershed.

2.11 Reinitiation of Consultation

This concludes formal consultation for Abernathy Fish Technology Center Intake improvements.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by NMFS 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

The USFWS concluded the proposed action was NLAA for LCR Chinook salmon and Columbia River chum salmon and their designated critical habitats. NMFS concurs with these determinations for the reasons described below.

Lower Columbia River Chinook Salmon

There is a documented presence of fall Chinook salmon in Abernathy Creek (StreamNet 2020, SalmonScape 2020). SalmonScape (2020) mapping shows documented presence and rearing just above the mouth of Abernathy Creek, and documented spawning from a little below the Cameron Creek confluence up to the Abernathy FTC weir and fish ladder. LCFRB (2004) indicates that spawning occurs from the mouth up to the Abernathy FTC. Above the Abernathy FTC weir and fish ladder, SalmonScape (2020) shows presumed presence in Abernathy Creek upstream to the confluence with Ordway Creek and continuing up Ordway Creek for approximately 0.7 miles. Juvenile rearing occurs downstream of, and near, the spawning area (LCFRB 2004). Juvenile LCR Chinook are present from December to June, and are not expected to be present during the in-water work for the project. As such, effects on juvenile Chinook salmon are discountable.

Because the end of the in-water work window could coincide with early-returning adult Chinook salmon, they could be present in the pool below the cofferdam area prior to project completion. Sediment controls and the cofferdam would limit suspended sediment in the pool. Further, adult salmon are not as susceptible to suspended sediment as juveniles, and have the fitness and swimming ability to avoid potential turbid pulses. Best management practices for suspended sediment will limit the deposition of sediment in spawning areas. Further, because of the timing of in-water work, spawning would not occur until after the project is completed. As such, we do not expect suspended sediment to affect spawning success of LCR Chinook salmon.

Designated critical habitat for LCR chinook salmon is approximately 3 miles downstream of the project area. Suspended sediment is expected to decrease to background levels prior to reaching critical habitat of chinook salmon. As such, the proposed project will have insignificant effects on LCR chinook and their critical habitat, therefore is not likely to adversely affect LCR chinook salmon or their designated critical habitat.

Columbia River chum salmon

Critical habitat for this species has been designated and includes Abernathy Creek up to the main Abernathy FTC facility, approximately 1,800 feet downstream of the project. Fall chum are documented as being present in Abernathy Creek from the mouth up to the main Abernathy FTC facility (Salmon Scape 2020). Spawning occurs in the lower 0.4 miles of Abernathy Creek (LCFRB 2004).

The in-water work elements of the proposed project will be completed between July 2 and September 15, before adult chum return to spawn and after fry are expected to have out-migrated. Based on run timing, it is not expected that adult or fry chum salmon are likely to be present in the project action area during the proposed summer construction period. As such, the project will have discountable effects on Columbia River chum salmon.

Because the project will employ BMPs for suspended sediment, and because s the nearest designated critical habitat for chum is 1,800 feet downstream of the project, we expect effects on Columbia River chum salmon critical habitat to be insignificant. As such, the proposed project is not likely to adversely affect Columbia River chum salmon or their critical habitat in Abernathy Creek.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

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

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area are described in the Introduction of this document. The action area is designated as EFH for various life-history stages of Chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*).

3.2 Adverse Effects on Essential Fish Habitat

1. Stream isolation and 75 day temporary removal of benthic habitat (substrate) Abernathy Creek (3,000 sf) of channel substrate.
2. Temporary suspended sediment plumes in Abernathy Creek that will occur during cofferdam installation and removal, and during excavation.

These effects are described more fully in Section 2 of this document.

3.3 Essential Fish Habitat Conservation Recommendations

Fully implementing the EFH conservation recommendations described in this section would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, approximately 4 acres of designated EFH for Pacific Coast salmon:

1. Take care when removing cofferdams to minimize bed disturbance and suspended sediments.
2. Return flow to the coffered area at a slow, measured pace to minimize bed disturbance and downstream release of suspended sediments.
3. Excavate the minimum necessary to complete work below the OWHL.
4. Revegetate disturbed areas with appropriate native riparian vegetation.
5. Use erosion minimization measures and BMPs

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

The USFWS 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(l)).

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 user of this opinion is the USFWS. Other interested users could include the Cowlitz Tribe, the Lower Columbia Fish Recovery Board, or other interest groups such as American Rivers or American Audubon. Individual copies of this opinion were provided to the USFWS. 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.

B.J. Ainslie, J.R. Post and J. Paul. 1998 effects of pulsed and continuous dc electrofishing on juvenile rainbow trout, North American Journal of Fisheries Management, 18, pages 905– 918.

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.

EPA (U.S. Environmental Protection Agency). 2014. 2013-2014 National River and Streams Assessment Fish Tissue Study. HTTPS:// WWW.EPA.GOV/Fish-Tech/2013-2014 National Rivers and Streams Assessment Fish Tissue Study. Access 11/2/2020

Dalbey, S. R., T. E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury on long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management 16:560-569

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.

Feely, R.A., T. Klinger, J.A. Newton, and M. Chadsey (editors). 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Frisch, A.J. and T.A. Anderson. 2000. The response of coral trout (*Plectropomus leopardus*) to capture, handling and transport and shallow water stress. Fish Physiology and Biochemistry 23(1): 23-24.

Glick, P. Clough J., and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Seattle, WA.

Goode, J.R., Buffington, J.M., Tonina, D., Isaak, D.J., Thurow, R.F., Wenger, S., Nagel, D., Luce, C., Tetzlaff, D. and Soulsby, C., 2013. Potential effects of climate change on streambed scour and risks to salmonid s rvival in snow-dominated mountain basins. Hydrological Processes 27(5): 750-765.

Hemre, G.I. and A. Krogdahl. 1996. Effect of handling and fish size on secondary changes in carbohydrate metabolism in Atlantic salmon, Salmo salar L. Aquaculture Nutrition 2(4): 249-252.

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.

IPCC 2014 Summary for policymakers In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change ed C B Field et al (Cambridge)(Cambridge University Press)(Cambridge, United Kingdom and New York, NY, USA) pp 1–32

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.

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.

Luo, Y. Guo, W. H.H. Ngo, Long Duc, N. Hai, F.I. Zhang, J. Liang S. and Wang, X.C. Sci. Total Environ., 473 (2014), pp. 619-641

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. In The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, edited by M. M. Elsner, J. Littell, L. Whitely Binder, 217-253. The Climate Impacts Group, University of Washington, Seattle, Washington.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change 102(1): 187-223.

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.

McMichael, G. A. 1998. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229–233.

Mote, P.W., Dalton, M., Snover, A.K. 2013. Climate Change in the Northwest: Implications for our Landscapes, Waters, and Communities. Washington, D.C.: Island Press. 271 pp.

Mote, P.W, A. K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R.R. Raymondi, 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.

Mote, P.W., D.E. Rupp, S. Li, D.J. Sharp, F. Otto, P.F. Uhe, M. Xiao, D.P. Lettenmaier, H. Cullen, and M. R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States, Geophysical Research Letters, 43, doi:10.1002/2016GLO69665

Northwest Fisheries Science Center. 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

Newcombe C. P. and J. O. T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management. 16: 693-727.

Olla, B.L. Davis, M.W. Schreck, C.C. 1995. Stress-induced impairment of predator evasion and non-predator mortality in Pacific salmon. Journal of Aquatic Research, Volume 26 Issue 6. June 1995.

PFMC (Pacific Fishery Management Council). 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. Pacific Fishery Management Council, Portland, Oregon. December.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

PFMC. 2007. U.S. West Coast highly migratory species: Life history accounts and essential fish habitat descriptions. Appendix F to the Fishery Management Plan for the U.S. West Coast Fisheries for Highly Migratory Species. Pacific Fishery Management Council, Portland, Oregon. January.

PFMC. 2005. Amendment 18 (bycatch mitigation program), Amendment 19 (essential fish habitat) to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery. Pacific Fishery Management Council, Portland, Oregon. November.

PFMC. 2008. Management of krill as an essential component of the California Current ecosystem. Amendment 12 to the Coastal Pelagic Species Fishery Management Plan. Environmental assessment, regulatory impact review & regulatory flexibility analysis. Pacific Fishery Management Council, Portland, Oregon. February.]

Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation. In Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press,
Washington, DC.

Reeder W.S., P.R. Ruggiero, S.L. Shafer, A.K. Snover, L.L Houston, P. Glick, J.A. Newton, and S.M Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. In Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edi ed by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58.
Island Press, Washington, DC

Scheuerell, M.D., and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography 14:448-457.

Snyder, D.E. (2003) Electrofishing and its harmful effects on fish. Information and Technology Report USGS/BRD/ITR– 2003-0002, U.S. Geological Survey Biological Resources Division. U.S. Government Printing Office, Denver, CO, 149 pp

Stadler, John. 2019. National Marine Fisheries Service. Personal Communication. May 18, 2019.

Sunda, W. G., and W. J. Cai. 2012. Eutrophication induced CO2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO2.
Environmental Science & Technology, 46(19): 10651-10659

Tague, C. L., Choate, J. S., & Grant, G. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments.
Hydrology and Earth System Sciences 17(1): 341-354

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation
Cooperative Region. National Wildlife Federation.

Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho

salmon: habitat and life-cycle interactions. Northwest Science 87(3): 219-242.

Winder, M., and Schindler, D.E. (2004). Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology *85*, 2100-2106.

Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology 20(1):190-200