National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Consultation on the Issuance of Three ESA Section 10(a)(1)(A) Scientific Research Permits Affecting Salmon and Steelhead in the West Coast Region Beginning in 2018

NMFS Consultation Number: WCR-2018-10088

Action Agencies: The National Marine Fisheries Service (NMFS)
U.S. Geological Survey (USGS)

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Upper Willamette River Chinook salmon *(O. tshawytscha)*	Threatened	Yes	No	No	No
Oregon Coast coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Lower Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Upper Willamette River steelhead *(O. mykiss)*	Threatened	Yes	No	No	No
Southern Resident (SR) killer whale (*Orcinus orca*)	Endangered	No	No	No	No

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

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

Issued By: Chris E Yates For _

Barry A. Thom
Regional Administrator

Date: July 10, 2018

cc: Administrative record number: 151422WCR2018PR00122

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List of Acronyms

CFR – Code of Federal Regulation
DPS – Distinct Population Segment
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
ISAB – Independent Scientific Advisory Board
LCR – Lower Columbia River
LCRFB – Lower Columbia River Fish Recovery Board
LHAC – Listed Hatchery Adipose Clipped
LHIA – Listed Hatchery Intact Adipose
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
OC – Oregon Coast
ODFW – Oregon Department of Fish and Wildlife
OSU – Oregon State University
SR – Southern Resident
USGS –United States Geological Survey
UWR – Upper Willamette River
VSP – Viable Salmonid Population

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402. It constitutes NMFS' review of three scientific research permit applications and is based on information provided in the applications for the proposed permits, published and unpublished scientific information on the biology and ecology of potentially affected species under NMFS' jurisdiction in the action areas, and other sources of information.

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 through NMFS' Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts]. A complete record of this consultation is on file with the Protected Resources Division in the Portland, Oregon office of NMFS's West Coast Region: 1201 NE Lloyd Blvd, Portland, Oregon 97232.

1.2 Consultation History

The West Coast Region's Protected Resources Division (PRD) received three applications for scientific research permits from state and federal entities. Because the permit requests are similar in nature and duration and are expected to affect the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c). The affected species are Lower Columbia River (LCR) steelhead, Upper Willamette River (UWR) Chinook salmon, UWR steelhead, and Oregon Coast (OC) coho salmon. The proposed actions also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales' prey base. We concluded that the proposed activities are not likely to adversely affect SR killer whales or their critical habitat and the full analysis is found in the "Not Likely to Adversely Affect" Determination section (2.11).

We divide our permit and consultation workload for ESA Section 10(a)(1)(A) scientific research permits into five geographic areas: (1) Puget Sound/Georgia Basin, (2) Lower Columbia-Upper Willamette/Oregon Coast, (3) Interior Columbia-Snake basins, (4) California Coast, and (5)

California Central Valley. This biological opinion covers Lower Columbia and Upper Willamette River salmon ESUs and steelhead DPSs, as well as SR killer whales. We issue permits after analysis is complete and we have signed the biological opinion.

The United States Geological Survey (USGS) applied to modify a current permit (1135-10M) on January 10, 2018. We reviewed the application and deemed it to be complete on February 5, 2018.

The Oregon State University (OSU) applied for a new permit (21837) on December 1, 2017. We completed an initial review of the application and asked OSU for additional information on December 28, 2017, to clarify the proposed sampling methods, minimization measures, and take levels. OSU edited their permit application and provided additional information via email on January 16, 2017. We asked staff at the NMFS' Oregon and Washington Coastal Office and the Oregon Department of Fish and Wildlife (ODFW) to review the application during February – March, 2018, and we provided the resultant comments to the OSU on April 9, 2018. We had multiple phone and email correspondences with the researchers from April 9 to April 26, 2018, when OSU resubmitted their application providing additional information. We reviewed the revised application and deemed it to be complete on April 27, 2018.

The ODFW applied for a new permit (22069) on February 13, 2018. We reviewed the application and requested additional information from ODFW on April 5 and April 25, 2018. We had multiple email and phone correspondences during this timeframe. ODFW provided additional information and resubmitted their application on April 26, 2018. We deemed the application to be complete on April 27, 2018.

When we requested additional information from applicants, typically it was to clarify the proposed sampling dates, locations, or methods. We asked some applicants to revise the numbers of fish in their requested take authorizations to better reflect mortality rates typically associated with specific sampling protocols, or to account for updated information on the distribution and abundance of ESA-listed species.

We provided information on the applications in a Federal Register notice on May 18, 2018 (83 FR 23257). We accepted public comments on the applications until June 18, 2018, and then commenced consultation. We do not present the full consultation histories for the actions here because they are lengthy and not directly relevant to the analysis. We maintain a complete record of this consultation at NMFS Protected Resources Division in Portland, Oregon.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02). When analyzing the effects of the action, we also consider the effects of other activities that are interrelated or interdependent with the proposed action. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). In this instance, we found no actions that are interrelated to or interdependent with the proposed research actions. In the absence of any such actions, the proposed action here is NMFS's proposal to issue permits to the various applicants.

"Take" is defined in section 3 of the ESA; it means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect [a listed species] or to attempt to engage in any such conduct.

This opinion constitutes formal consultation and an analysis of effects solely for the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion.[1] We issue permits after we sign the biological opinion.

NMFS' issuance of permits for scientific research activities proposed by the USGS, OSU, and ODFW constitutes the proposed federal action. As the action agency, NMFS is responsible for complying with section 7 of the ESA, which requires Federal agencies to ensure any actions they fund, permit, or carry out are not likely to jeopardize listed species' continued existence nor destroy or adversely modify their critical habitat. This consultation examines the effects of the proposed research on UWR Chinook salmon, LCR steelhead, UWR steelhead, OC coho salmon, and SR killer whales. This consultation also examines the effects of the permits NMFS proposes to issue, and thus it fulfills NMFS' section 7 consultation obligations.

Permit 1135-10M

The USGS requests to modify a permit that currently authorizes them to take juvenile LCR steelhead in the Wind River subbasin (Washington). The permit would expire on December 31, 2021. The purpose of the study is to provide information on growth, survival, habitat use, and life histories of LCR steelhead.

The USGS proposes to capture juvenile LCR steelhead using backpack electrofishing equipment, hold the fish in aerated buckets, anesthetize them with MS-222, measure length and weight, tag age-0 and age-1 fish with passive integrated transponders (PIT-tags), and release all fish at the site of collection after they recover from anesthesia. The permit modification would not change the methods or scope of the ongoing research, except to increase the take of juvenile LCR steelhead that are captured, handled, and then released without PIT-tagging from 2500 to 4500 fish annually. The USGS also requests to increase the unintentional mortalities authorized for fish that are released without PIT-tagging, from 75 to 135 fish annually. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities.

The USGS requests this increase in take because they captured unusually high numbers of age-0 LCR steelhead in 2017, exceeding their take authorization and requiring them to stop sampling authorized by permit 1135-9R. Their incident report filed in 2017 stated that they had increased sampling intensity at four sites. Their prior calculations to predict the expected additional take had not indicated that the extra sampling would result in a take exceedance. However, on one

[1] An ESU of Pacific salmon (Waples 1991) and a DPS of steelhead (71 FR 834) are considered to be "species" as the word is defined in section 3 of the ESA. In addition, it should be noted that we use the terms "artificially propagated" and "hatchery" are used interchangeably in the Opinion, as are the terms "naturally propagated" and "natural."

date they caught an unexpectedly high number of age-0 steelhead. They hypothesized that these age-0 fish might have emerged between sample rounds (however, they have not previously observed this), or that recent heavy rain and elevated streamflow might have moved fish from upstream areas into their sample sections. These age-0 fish were too small for them to PIT-tag, and they were quickly released in good condition. So they did not meet their tagging goals. Their request for additional take would allow them to meet their tagging goals in case they experience another year where they catch unexpectedly high numbers of age-0 fish that are too small to tag.

Permit 21837

Researchers at OSU request a permit to take juvenile and adult UWR Chinook salmon and UWR steelhead. The research permit would expire on December 31, 2022. The researchers propose to work in the upper Willamette River (Oregon) and its tributaries including the Middle Fork Willamette, Coast Fork Willamette, Calapooia, Long Tom, Marys, and Luckiamute Rivers. The purpose of the research is to describe how water temperature and the presence of coldwater refugia influence the behavior, growth, diet, body condition, seasonal movements, and habitat associations of coastal cutthroat trout.

The researchers propose to capture fish using boat and backpack electrofishing, stick and beach seining, and angling. The researchers would identify fish immediately after capture and hold them in cool, aerated buckets. The researchers propose to hold ESA-listed fish only long enough to avoid recapturing them. They would release the fish to the site of capture, with no further handling or measurements, as soon as they complete sampling at a site. The researchers propose the following measures to minimize take of adult UWR Chinook and UWR steelhead for each sampling date: (1) request current information from the ODFW on adult run timing and distribution, (2) conduct visual reconnaissance surveys before sampling each site, and (3) avoid sampling in areas where adult salmonids are likely to hold, such as pools, glides, and tributary junctions. If researchers observe adult salmon or steelhead, the researchers would immediately stop sampling and leave the site. The researchers would not seine a single site more than five times or electrofish a single site more than three times across the summer sampling season. The researchers do not propose to kill any fish but a small number of juveniles may die as an unintended result of research activities.

Permit 22069

The ODFW requests a permit to take OC coho in the Tillamook Bay (Oregon). The research permit would expire on December 31, 2022. ODFW proposes to conduct a radio telemetry study of OC fall-run Chinook salmon, which are not ESA-listed. Researchers may unintentionally take OC coho salmon while collecting Chinook salmon. The goal of the research study is to improve information on the distribution and abundance of Chinook spawners in the Tillamook basin.

The ODFW proposes to capture fish from August through December in the lower portion of Tillamook Bay, below the mouths of the five primary Chinook spawning streams that flow into the bay. ODFW proposes to capture juvenile and adult OC coho using angling, seines, and tangle nets. The nets would have a nylon mesh size of 4.5 inches and range from 75 to 150 feet in length and 8 to 20 feet in depth, dependent upon water levels and sampling conditions. To minimize stress and injury of fish captured using tangle nets, the researchers propose to: (1) observe nets constantly during deployment, (2) remove fish immediately upon detection of capture (i.e., typically less than two minutes after entanglement), and (3) relocate tangle nets if a coho is captured or if any fish is recaptured on the same day. ODFW proposes to identify fish upon capture, and immediately release any coho salmon without further handling. The researchers do not propose to kill any fish but a small number may die as an unintended result of the activities.

Common Elements among the Proposed Permit Actions

In each of the permit applications, the applicant has requested take numbers that are slightly higher than they expect to occur. This is done to avoid exceeding take limits due to higher-than-expected encounter rates that could result from unexpected environmental conditions, higher-than-expected population abundance, or other reasons. Inflating take estimates also helps us to conduct a conservative analysis of the effects of the actions, because the actual levels of take typically are lower than analyzed.

Research permits prescribe conditions to be followed before, during, and after research is conducted. These conditions are intended to (a) ensure that research activities are coordinated among permit holders and between permit holders and NMFS, (b) minimize impacts on listed species, and (c) ensure that NMFS receives information about the effects the permitted activities have on the species concerned. All research permits NMFS' NWR issues have the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the terms and conditions in the permit.

2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.

3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

4. The permit holder must stop handling listed juvenile fish if the water temperature exceeds 70 ºF (21 ºC) at the capture site. Under these conditions, listed fish may only be visually identified and counted. In addition, electrofishing is not permitted if water temperature exceeds 64 ºF.

5. If the permit holder anesthetizes listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

6. The permit holder must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

7. If the permit holder unintentionally captures any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

8. The permit holder must exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when the only activity is determining fish presence.

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at: http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

10. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.

11. The permit holder must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

12. The permit holder is responsible for any biological samples collected from listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

13. The person(s) actually doing the research must carry a copy of this permit while conducting the authorized activities.

14. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

15. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

16. The permit holder may not transfer or assign this permit to any other person as defined in section 3(12) of the ESA. This permit ceases to be in effect if transferred or assigned to any other person without NMFS' authorization.

17. NMFS may amend the provisions of this permit after giving the permit holder reasonable notice of the amendment.

18. The permit holder must obtain all other Federal, state, and local permits/authorizations needed for the research activities.

19. On or before January 31st of every year, the permit holder must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on our permit website, and the forms can be found at https://apps.nmfs.noaa.gov/. Falsifying annual reports or permit records is a violation of this permit.

20. If the permit holder violates any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA section 10(d) findings are no longer valid.

"Permit holder" means the permit holder or any employee, contractor, or agent of the permit holder. NMFS may include conditions specific to the proposed research in the individual permits. NMFS uses annual reports for each permit to monitor the actual number of listed fish taken annually in the scientific research activities and will adjust permitted take levels if they are deemed to be excessive or if cumulative take levels rise to the point where they are detrimental to the listed species.

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION

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 at the conclusion of consultation, section 7(b)(3) of the ESA requires that NMFS provide an opinion stating how the proposed action 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 incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (81 FR 7214). The adverse modification analysis considers the impacts of the federal action on the conservation value of designated critical habitat.

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. New critical habitat regulations (81 FR 7414) published in 2016 replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting an analysis of ‘‘destruction or adverse modification.” In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

ESA Section 4(d) protective regulations prohibit the take of naturally spawned salmonids and of listed hatchery salmonids with an intact adipose fin, but do not prohibit take of listed hatchery salmonids that have their adipose fins removed prior to release into the wild (70 FR 37160 and 71 FR 834). As a result, researchers do not require a permit to take hatchery fish that have had their adipose fin removed. Nevertheless, this document evaluates impacts on both natural and hatchery fish to allow a full examination of the effects of the action on the species as a whole.

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

- *Identify the rangewide status of the species and critical habitat likely to be affected by the proposed action* (Section 2.2). We describe the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We use viability assessments and criteria in technical recovery team documents and recovery plans, which provide assessments for specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of PBFs, which were identified when the critical habitat was designated. We also discuss potential past and future effects of climate change on the status of the species and critical habitat.
- *Describe the environmental baseline in the action area* (Section 2.4). We describe the environmental baseline, which includes the past and present impacts of federal, state, or private actions and other human activities *in the action area*. The environmental baseline includes the anticipated impacts of proposed federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.
- *Analyze the effects of the proposed action on species and habitat using an "exposure-response-risk" approach* (Section 2.5). We consider how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, VSP characteristics. We also evaluate the proposed action's effects on critical habitat.
- *Describe any cumulative effect in the action area* (Section 2.6). We describe cumulative effects, which are defined as the effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.
- *Integrate and synthesize the above factors* (Section 2.7). We analyze how the effects of the action integrate with the environmental baseline and the cumulative effects. We assess whether the action could reasonably be expected to (1) reduce appreciably the likelihood of both survival and recovery of each listed species in the wild by reducing its numbers, reproduction, or distribution, or (2) reduce the value of designated or proposed critical habitat for the conservation of the listed species. In making these assessments, we fully consider the status of the species and critical habitat.
- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified* (Section 2.8). We describe our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat.
- *List reasonable and prudent alternatives, if warranted.* If necessary, we suggest a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

In this opinion we examine the status of each species that would be adversely affected by the proposed action. We evaluate 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 our description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. We also examine the condition of critical habitat throughout the designated area, evaluate the conservation value of the watersheds and coastal and marine environments that make up the designated area, and discuss the current function of the essential PBFs that help to form that conservation value.

The ESA defines species to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." NMFS adopted a policy for identifying salmon DPSs in 1991 (56 FR 58612). The policy states that a population or group of populations is considered an ESU if it is "substantially reproductively isolated from conspecific populations," and if it represents "an important component of the evolutionary legacy of the species." The policy equates an ESU with a DPS. Hence, the UWR Chinook and OC *coho* salmon listing units in this biological opinion constitute ESUs of the species *O. tshawytscha*, and *O. kisutch*, respectively. The LCR and UWR steelhead listing units in this biological opinion constitute DPSs of the species *O. mykiss*. The ESUs and DPSs of salmon and steelhead include natural-origin populations and hatchery populations, as described below.

2.2.1 Climate Change

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014, Mote et al. 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% 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. 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 1.0-3.7^{o}C 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 affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (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 affect 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 will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of listed species in the future.

2.2.2 Status of the Species

For Pacific salmon and steelhead, NMFS uses four parameters to assess the viability of populations: spatial structure, diversity, abundance, and productivity (McElhaney et al. 2000). These "viable salmonid population" (VSP) criteria encompass the "reproduction, numbers, or distribution" of a species, which are described in 50 CFR 402.02. Adequate population spatial structure, diversity, abundance, and productivity reflect that a population is well adapted to environmental conditions and other influences that affect individuals throughout the life cycle (e.g., biological interactions, harvest).

"Spatial structure" refers both to the spatial distributions of individuals in populations and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population. For example, for the spatial structure analysis of salmonids in the Willamette and Lower Columbia domains, the Oregon and Washington recovery plans evaluated (1) the proportion of stream miles currently accessible to the species relative to the historical miles accessible, and (2) quality of currently accessible habitat, and (3) loss of habitat considered to be a key production area (ODFW 2010; LCFRB 2010).

"Diversity" refers to the distribution of traits within and among populations. These traits range in scale from DNA sequence variation at single genes to complex life-history traits. Diversity in salmon populations is represented by differences within and among populations in morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology and molecular genetic characteristics (McElhaney et al. 2000). Some of these traits are genetically based while others vary as a result of combined environmental and genetic factors.

"Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds). In this opinion we also describe abundance for juvenile life stages and hatchery-produced fish. There are nuances to consider when interpreting estimates for juvenile abundance, including: (1) we generally report data for outmigrating smolts, however, research effects occur at other juvenile life stages (e.g., egg, fry, parr) and we typically do not have comparable data sets for these other life stages; (2) estimates of juvenile abundance often are derived from data on spawner abundance, sex ratios, and fecundity, and these data are associated with high levels of uncertainty; and (3) survival rates between life stages often are unknown and are subject to multiple natural and human-induced influences (e.g., predation, floods, harvest). For hatchery-origin fish, estimates of juvenile abundance may also be affected by the factors above; however, hatchery production generally is easier to quantify than natural production.

"Productivity" reflects survival across the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhaney et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which reflects the long-term population growth rate.

For species with multiple populations, NMFS assesses status using criteria for groups of populations. These groups of populations, called major population groups (MPGs) or strata, typically are populations within the same ecological zone and with similar life history traits. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and ensuring that some viable populations are close enough to allow functioning as metapopulations while other viable populations are dispersed enough to avoid concurrent extinctions from mass catastrophes (McElhaney et al. 2000). Recovery plans and guidance documents from technical recovery teams explain these criteria in detail.

Information on the status and distribution of the species considered here can be found in the following documents:

- Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (NWFSC 2015)
- 2016 5-Year Review: Summary & Evaluation of Upper Willamette River Steelhead, Upper Willamette River Chinook (NMFS 2016)
- 2016 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho Salmon, Lower Columbia River Steelhead (NMFS 2016)
- 2016 5-Year Review: Summary & Evaluation of Oregon Coast Coho Salmon (NMFS 2016)

More information can be found in recovery plans and earlier status reviews for these species. These documents and other relevant information may be found at the NMFS West Coast Region website (http://www.westcoast.fisheries.noaa.gov). Table 1 summarizes listing and recovery plan information, status summaries, and limiting factors for the species addressed in this opinion.

Table 1. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River steelhead	Threatened 1/5/06	NMFS 2013	NWFSC 2015	This DPS comprises 23 historical populations, including 17 winter-run populations and six summer-run populations. Nine populations are at very high risk, 7 populations are at high risk, 6 populations are at moderate risk, and 1 population is at low risk. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead populations were similarly stable, but at low abundance levels. The decline in the Wind River summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer-runs; however, the most recent abundance estimates suggest that the decline was a single year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability.	• Degraded estuarine and nearshore marine habitat • Degraded freshwater habitat • Reduced access to spawning and rearing habitat • Avian and marine mammal predation • Hatchery-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
Upper Willamette River Chinook salmon	Threatened 6/28/05	NMFS 2011	NWFSC 2015	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the 2010 status review indicates that the fraction of hatchery origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural origin spawners improved in the North and South Santiam basins, but is still well below recovery goals. Abundance levels for five of the seven populations remain well below recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers rose between the 2010 and 2015 reviews, but still range only in the	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats • Altered food web due to reduced inputs of microdetritus • Predation by native and non-native species, including hatchery fish

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	• Competition related to introduced salmon and steelhead • Altered population traits due to fisheries and bycatch
Upper Willamette River steelhead	Threatened 1/5/06	NMFS 2011	NWFSC 2015	This DPS has four demographically independent populations. Three populations are at low risk and one population is at moderate risk. Abundance of natural origin winter steelhead in the UWR has fluctuated significantly for decades, with a range of 822 to 26,647 fish counted annually between 1971 and 2018. Declines in abundance noted in the 2010 status review continued through the period from 2010-2015. In 2016-2017, adult abundance was only 822, representing a dramatic decline and the lowest abundance recorded since comparable fish counts started in 1971. In 2017-2018, adult abundance was 1829. The most recent five-year average (2014-2018) is 3,657 adults. This is below the historically low counts of the 1990s, where the five-year average (1995-2000) ranged from 3981 to 4337 fish. Thus the DPS is demonstrating even lower abundance levels than those during the 2010 and 2015 status reviews, which were already of concern. The causes of these declines are not well understood, but there are numerous likely factors. Much of the accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery releases in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. In addition, pinniped predation near Willamette Falls is of increasing concern. And continued declines and potential negative impacts from climate change may cause increased risk in the near future.	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats due to impaired passage at dams • Altered food web due to changes in inputs of microdetritus • Predation by native and non-native species, including hatchery fish and pinnipeds • Competition related to introduced salmon and steelhead • Altered population traits due to interbreeding with hatchery origin fish
Oregon Coast coho salmon	Threatened 6/20/11	NMFS 2016b	NWFSC 2015	This ESU has 56 populations, including 21 independent and 35 dependent populations. The last status review indicated a	• Reduced amount and complexity of habitat

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				moderate risk of extinction. Significant improvements in hatchery and harvest practices have been made for this ESU. Most recently, spatial structure has improved in terms of spawner and juvenile distribution in watersheds; none of the geographic area or strata within the ESU appear to have considerably lower abundance or productivity. The ability of the ESU to survive another prolonged period of poor marine survival remains in question.	including connected floodplain habitat • Degraded water quality • Blocked/impaired fish passage • Inadequate long-term habitat protection • Changes in ocean conditions
Southern Resident killer whale	Endangered 11/18/05	NMFS 2008	Ford 2013	The SR killer whale killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. The estimated effective size of the population (based on the number of breeding individuals under ideal genetic conditions) is only approximately 30 whales, which is about 1/3 of the current population size. The small effective population size, the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration. As of July 1, 2013, there were 26 whales in J pod, 19 whales in K pod and 37 whales in L pod, for a total of 82 whales. Estimates for the historical abundance of SR killer whale killer whales range from 140 whales (based on public display removals to 400 whales.	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risk from oil spills

For each species that we consider in this opinion, we report average annual abundance by life stage and origin (Table 2). Typically we do so at the ESU/DPS scale but when proposed actions may have more localized effects, we also report abundance at the population scale. For life stage we estimate abundance of juveniles (smolts or parr, described below) and adults. For origin we estimate abundance of natural-origin fish, ESA-listed hatchery-origin fish with the adipose fin clipped ("listed hatchery adipose clipped," or LHAC), and ESA-listed hatchery-origin fish that with an intact adipose fin ("listed hatchery intact adipose," or LHIA). We use hatchery production estimates for abundance of LHAC and LHIA juveniles. We estimate the abundance of LHAC and LHIA adults using: (1) available data on the abundance of all hatchery adults (LHAC + LHIA); (2) the ratio of LHAC:LHIA for juveniles; and (3) an assumption that LHAC and LHIA juveniles survival to the adult life stage at equal rates.

Table 2. Average annual abundance estimates for the ESU/DPSs and individual populations that we consider in this opinion.

ESU/DPS or Population	Life Stage	Origin	Abundance
LCR steelhead DPS	Adult	Natural	12,920
	Adult	LHAC	21,882
	Adult	LHIA	415
	Adult	Total	35,217
	Juvenile	Natural	323,607
	Juvenile	LHAC	1,194,301
	Juvenile	LHIA	22,649
	Juvenile	Total	1,540,557
LCR steelhead, Wind River population	Adult	Natural	n/a
	Adult	LHAC	n/a
	Adult	LHIA	n/a
	Adult	Total	738
	Juvenile	Natural	25,432
	Juvenile	LHAC	0
	Juvenile	LHIA	0
	Juvenile	Total	25,432
UWR Chinook ESU	Adult	Natural	11,443
	Adult	LHAC	34,353
	Adult	LHIA	101
	Adult	Total	45,897
	Juvenile	Natural	1,275,681
	Juvenile	LHAC	5,543,371
	Juvenile	LHIA	16,278
	Juvenile	Total	6,835,329

Table 2, continued.

ESU/DPS or Population	Life Stage	Origin	Abundance
UWR steelhead DPS	Adult	Natural	4,280
	Adult	LHAC	0
	Adult	LHIA	0
	Adult	Total	4,280
	Juvenile	Natural	143,898
	Juvenile	LHAC	0
	Juvenile	LHIA	0
	Juvenile	Total	143,898
OC coho ESU	Adult	Natural	135,705
	Adult	LHAC	1,201
	Adult	LHIA	0
	Adult	Total	136,906
	Juvenile	Natural	10,119,970
	Juvenile	LHAC	60,000
	Juvenile	LHIA	0
	Juvenile	Total	10,179,970
OC coho, Tillamook Bay population	Adult	Natural	7,173
	Adult	LHAC	205
	Adult	LHIA	0
	Adult	Total	7,378
	Juvenile	Natural	499,100
	Juvenile	LHAC	0
	Juvenile	LHIA	0
	Juvenile	Total	499,100

Data quality varies; for some ESU/DPSs we have reliable annual estimates of abundance by origin and life stage, while for other ESP/DPSs data are less consistent (Table 3). For ESU/DPSs with sufficient data, we use the most recent five years of data to calculate average abundance. In cases where data are insufficient to calculate a recent five-year average, we use the best available data to estimate juvenile and adult abundance for the ESU/DPS and, if warranted, for individual populations. For example, for LCR steelhead the data on adult abundance varies dramatically between populations; for some populations we have only one year of data for adult abundance (Table 4). For OC coho salmon, we lack data on juvenile production, and so we derive abundance for natural-origin juveniles from prior-year spawner abundance (ODFW 2017), fecundity (Sandercock 1991), and egg-to-parr survival rates (Nickelson 1998).

Table 3. Data sources for average abundance by ESU/DPS and life stage.

ESU/DPS or Population	Life Stage	Temporal Range of Data Used	Notes	References
LCR steelhead DPS	Smolt	2013-2017	5-year average of annual estimates	Zabel 2014a, 2014b, 2015, 2017a, and 2017b
	Adult	2003-2015	Sum of best-available population-level spawner abundance estimates, see Table 4	Streamnet 2016; WDFW 2018; ODFW 2016a
LCR steelhead, Wind R population	Smolt	2013-2017	5-year average, derived from prior year spawner abundance, fecundity, and egg-to-smolt survival[2]	Spawner abudance: WDFW 2018; Fecundity and egg-to-parr survival: Quinn (2005)
	Adult	2010-2014	5-year average of "jumper" counts at Shipherd Falls	WDFW 2018
UWR Chinook ESU	Smolt	2013-2017	5-year average of annual estimates	Zabel 2014a, 2014b, 2015, 2017a, and 2017b
	Adult	2011-2015	5-year average of annual sums of escapement to the Clackamas River and Willamette Falls fish ladder	ODFW and WDFW 2012, 2013, 2014, 2015; ODFW 2017
UWR steelhead DPS	Smolt	2013-2017	5-year average of annual estimates	Zabel 2014a, 2014b, 2015, 2017a, and 2017b
	Adult	2013-2017	5-year average of winter steelhead counts (November 1 – May 31) at Willamette Falls fish ladder	ODFW 2017
OC coho ESU	Parr	2013-2017	5-year average, derived from prior year spawner abundance, fecundity, and egg-to-parr survival[3]	Spawner abudance: ODFW 2016; Fecundity: Sandercock (1991); Egg-to-parr survival: Nickelson (1998).
	Adult	2013-2017	ODFW summary of spawning ground surveys, Winchester Dam counts, lake standardized surveys, and management reports	https://odfw.forestry.oregonstate. edu/spawn/index.htm, accessed on June 22, 2018

[2]We estimated smolt abundance for the Wind River as the *# of spawners x % female x fecundity x egg-to-smolt survival rate*. We assumed half of the escapement was female, prespawn mortality was zero, and other parameters (4923 eggs/female x 0.014 smolts/egg) from Quinn (2005)

[3]We estimated parr abundance for OC coho as the *# of spawners x % female x fecundity x egg-to-parr survival rate*. We assumed half of the escapement was female and prespawn mortality was zero. Sandercock (1991) reported that average fecundity for several coho stocks ranged from 1,983-5,000 eggs per female; we applied a conservative estimate of 2,000 eggs per female. We applied an egg-to-parr survival for OC coho of 7%, reported by Nickelson (1998).

Table 3, continued.

ESU/DPS or Population	Life Stage	Temporal Range of Data Used	Notes	References
OC coho, Tillamook Bay population	Parr	2013-2017	5-year average, derived from prior year spawner abundance, fecundity, and egg-to-parr survival	Spawner abudance: ODFW 2016; Fecundity: Sandercock (1991); Egg-to-parr survival: (Nickelson 1998).
	Adult	2013-2017	ODFW summary of spawning ground surveys, Winchester Dam counts, lake standardized surveys, and management reports	https://odfw.forestry.oregonstate. edu/spawn/index.htm, accessed on June 22, 2018

Table 4. Abundance estimates for adult LCR steelhead populations (Streamnet 2016; WDFW 2018; ODFW 2016). HOR = hatchery-origin spawners, NOR= natural-origin spawners.

Stratum (Run)	Population	Years	Total	HOR	NOR	Recovery Target(3)
Cascade (Winter)	Lower Cowlitz	2009	4,559	4559		
	Upper Cowlitz/Cispus	2010-2014	489	51	438	500
	Tilton	2010-2013	279	0	279	200
	South Fork Toutle	2010-2014	508	7	501	500
	North Fork Toutle	2010-2014	507	121	387	600
	Coweeman	2010-2014	462	166	296	600
	Kalama	2011-2015	930	455	475	600
	North Fork Lewis	2007-2011	2,355	2,126	129	400
	East Fork Lewis	2010-2014	364	0	364	500
	Washougal	2010-2014	362	195	167	350
	Clackamas	2014-2015	5,483	1,876	3,607	10,655
	Sandy	2013-2015	4,094	284	3,810	1,510
Cascade (Summer)	Kalama	2011-2015	626	499	127	500
	North Fork Lewis	2009	10,508	10,508		
	East Fork Lewis	2011-2015	928	168	760	500
	Washougal	2012-2015	723	621	102	500
Gorge (Winter)	Upper Gorge	2010-2014	36		36	322
	Hood	2003-2007	818	380	438	1,633
Gorge (Summer)	Wind	2010-2014	805	42	763	1,000
	Hood	2003-2007	480	239	241	1,988
Total			35,316	22,297	12,920	

2.2.3 Status of the Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

For most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each ESA-listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or is serving another important role.

A summary of the status of critical habitats, considered in this opinion, is provided in Table 5, below.

Table 5. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River 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 28 watersheds, medium for 11 watersheds, and low for two watersheds.
Upper Willamette River Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Upper Willamette River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses seven subbasins in Oregon containing 34 occupied watersheds, as well as the lower Willamette/Columbia River 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. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 25 watersheds, medium for 6 watersheds, and low for 3 watersheds.
Oregon Coast coho salmon	2/11/08 73 FR 7816	Critical habitat encompasses 13 subbasins in Oregon. The long-term decline in Oregon Coast coho salmon productivity reflects deteriorating conditions in freshwater habitat as well as extensive loss of access to habitats in estuaries and tidal freshwater. Many of the habitat changes resulting from land use practices over the last 150 years that contributed to the ESA-listing of Oregon Coast coho salmon continue to hinder recovery of the populations; changes in the watersheds due to land use practices have weakened natural watershed processes and functions, including loss of connectivity to historical floodplains, wetlands and side channels; reduced riparian area functions (stream temperature regulation, wood recruitment, sediment and nutrient retention); and altered flow and sediment regimes (NMFS 2016b). Several historical and ongoing land uses have reduced stream capacity and complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Beaver removal, combined with loss of large wood in streams, has also led to degraded stream habitat conditions for coho salmon (Stout et al. 2012)
Southern Resident killer whale	11/29/06 71 FR 69054	Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the SR killer whale and its habitat needs, NMFS identified three PCEs, or physical or biological features, essential for the conservation of SR killer whales: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including SR killer whale and its prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features In regards to passage, human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior. Reduced prey abundance, particularly Chinook salmon, is also a concern for critical habitat.

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). For the purposes of this opinion, the action area includes all river reaches accessible to UWR Chinook salmon and UWR steelhead in the UWR above Willamette Falls, the Tillamook Bay and all tributary reaches accessible to listed OC coho salmon, and all reaches in the Wind River drainage that are accessible to LCR steelhead. Additionally, the action area includes all marine waters off the West Coast of the continuous United States, including nearshore waters from the Mexican to Canadian borders, which are accessible to these species. For proposed permits 1135-10M and 22069 we account for their limited geographic scope when analyzing the proposed action's impacts on listed species and their critical habitat.

The action area thus encompasses a large and discontinuous areas. Salmon exist in large areas between the locations for the multiple proposed actions, but they would not be affected by the proposed activities. There is one geographically distinct area: the portion of the Puget Sound occupied by SR killer whales. As noted earlier, the proposed actions could affect Chinook salmon, which constitutes the killer whales' prey base. Therefore some effects of the proposed actions could be felt as much as hundreds of miles away from where the activities would take place. Those effects are described in the Not Likely to Adversely Affect section (2.11).

In all cases, the proposed research activities would take place in individually small sites. For example, researchers might electrofish a few hundred feet of river, deploy a net covering only a few hundred square feet of estuary, or operate a trap in a few tens of square feet of habitat. Many of the actions would take place in designated critical habitat.

Detailed habitat information (e.g., migration barriers, physical and biological habitat features, and special management considerations) for species considered in this opinion may be found in the federal Register notices designating critical habitat for UWR Chinook Salmon, LCR steelhead, UWR steelhead (70 FR 52630); and OC coho salmon (73 FR 7816).

2.4 Environmental Baseline

The "environmental baseline" includes past and present impacts of all federal, state, or private actions and other human activities in the action area, anticipated impacts of all proposed federal projects in the action area that have undergone formal or early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this opinion therefore includes the impacts of many activities on survival and recovery of the listed species. Because the action area for this opinion includes substantial parts of the range of the listed species in Oregon and Washington, effects from many past and present actions are reflected by species status (Section 2.2). For habitat, the environmental baseline reflects effects of these multiple actions on the PBFs that are essential to conservation of the species. For proposed actions where the action area can be defined at spatial scales smaller than the ESU/DPS, we consider the environmental baseline at these finer scales.

2.4.2 Summary for all Listed Species

Factors Limiting Recovery

The best scientific information available demonstrates that multiple factors have contributed to the decline of west coast salmonids (Table 6). NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species in this opinion identify factors that have caused decline and factors that prevent recovery. These include habitat degradation caused by human development and harvest and hatchery practices. Migratory fish in the Columbia River basin have been affected profoundly by dams that alter river flow and water quality, obstruct or delay passage of fish, and fundamentally change river ecology. In many larger subbasins of the Columbia River, dams block access of anadromous fish to large areas of productive habitat. Climate change (Section 2.2.2) also represents a potentially significant threat to all listed species. None of the references cited in Section 2.2 of this opinion identify scientific research as a factor associated with the decline or recovery potential of west coast salmonids.

Table 6. Major Factors Limiting Recovery (Adapted from NOAA, NMFS, 2005 Report to Congress: Pacific Coast Salmon Recovery Fund FY 2000-2004, 51p. July 2005.)

	Estuarine and Nearshore Marine	Floodplain Connectivity and Function	Channel Structure and Complexity	Stream Substrate	Stream Flow	Water Quality	Fish Passage	Harvest-related Adverse Effects	Predation/Competition/ Disease
LCR steelhead		●	●	●	●	●	●		●
UWR Chinook		●	●			●	●		
UWR steelhead		●	●		●		●		
OC coho		●	●	●	●	●			●

For detailed information on how various factors have degraded PCEs in the Idaho, Oregon, and Washington see Busby et al. (1996), Ford (2011), Good et al. (2005), Gustafson et al. (2010), Jacobs et al. (2002), LCFRB (2004), LCFRB (2010), McElhaney et al. (2004), NMFS (1991), NMFS (1997), NMFS (1998), NMFS (2004), NMFS (2008), NMFS (2011), Nickelson et al. (1992), ODFW (2005b), ODFW (2010), Stout et al. (2011), Weitkamp et al. (1995), Ford et al. 2010, and WDFW (2010).

Research Effects

Scientific research has the potential to affect survival and recovery of listed species by killing, harming, and harassing fish. Several dozen section 10(a)(1)(A) scientific research permits have already been authorized, permitting researchers to take listed salmonids in the Pacific Northwest.

These previously authorized Section 10 permits expire between 2018 and 2022. In addition, NMFS has authorized state scientific research programs for Oregon and Washington for 2018, under ESA section 4(d). The total levels of take previously authorized for research in 2018 under ESA Sections 10(a)(1)(A) and Section 4(d) represent the “baseline” take for the species considered in this opinion (Table 7).

In practice, take levels from research activities typically are far lower than authorizations allow. We work with research permit applicants to establish best estimates for take, and then suggest that they inflate these estimates slightly in their requested take levels to allow for higher-than-expected encounter rates or unexpected mortalities. Our research tracking system reveals that researchers report, on average, 28% of the total take and 15% of the mortalities that are authorized in their permits.

Table 7. Baseline effects for scientific research studies in 2018 for the species considered in this opinion. See text for explanation of data sources. LHAC = Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.

			4(d) Baseline (2018)		Sec 10(a)(1)(A) Baseline		Total Baseline	
ESU/DPS	Life Stage	Origin	Take	Mortality	Take	Mortality	Authorized Take	Authorized Mortality
LCR steelhead	Adult	Natural	2,343	24	1,082	11	3,425	35
	Adult	LHAC	0	0	89	2	89	2
	Adult	LHIA	0	0	0	0	0	0
	Adult	Total	2,343	24	1,171	13	3,514	37
	Juvenile	Natural	58,557	832	8,562	294	67,119	1,126
	Juvenile	LHAC	55,616	867	1,466	69	57,082	936
	Juvenile	LHIA	0	0	0	0	0	0
	Juvenile	Total	114,173	1,699	10,028	363	124,201	2,062
UWR Chinook	Adult	Natural	226	7	36	0	262	7
	Adult	LHAC	210	10	36	0	246	10
	Adult	LHIA	0	0	0	0	0	0
	Adult	Total	436	17	72	0	508	17
	Juvenile	Natural	47,875	773	3,976	189	51,851	962
	Juvenile	LHAC	7,931	112	2,886	174	10,817	286
	Juvenile	LHIA	22	1	25	7	47	8
	Juvenile	Total	55,828	886	6,887	370	62,715	1,256
UWR steelhead	Adult	Natural	261	4	23	0	284	4
	Adult	LHAC	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	LHIA	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	Total	261	4	23	0	284	4
	Juvenile	Natural	7,679	156	2,072	69	9,751	225
	Juvenile	LHAC	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	LHIA	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	Total	7,679	156	2,072	69	9,751	225

Table 7, continued.

ESU/DPS	Life Stage	Origin	4(d) Baseline (2018)		Sec 10(a)(1)(A) Baseline		Total Baseline	
			Take	Mortality	Take	Mortality	Authorized Take	Authorized Mortality
OC coho	Adult	Natural	5,953	59	45	0	5,998	59
	Adult	LHAC	6	0	13	0	19	0
	Adult	LHIA	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	Total	5,959	59	58	0	6,017	59
	Juvenile	Natural	564,097	12,404	2,795	207	566,892	12,611
	Juvenile	LHAC	99	3	260	20	359	23
	Juvenile	LHIA	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	Total	564,196	12,407	3,055	227	567,251	12,634

2.5 Effects of the Action on the Species and Their Designated Critical Habitat

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.5.1 Effects on Critical Habitat

We describe the effects of the proposed research activities in detail in the following section. In general, the permitted activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, and (3) tagging fish. These techniques are minimally intrusive in terms of their effect on habitat because they would involve little, if any, disturbance to streambeds or adjacent riparian zones. None of the activities will measurably affect any habitat PBF listed earlier. Moreover, the proposed activities are all of short duration. Therefore, we conclude that the proposed activities are not likely to have an adverse impact on any designated critical habitat.

2.5.2 Effects on the Species

As discussed above, the proposed research activities as permitted will have no measurable effects on the habitat of listed salmon and steelhead. The actions are not likely to affect measurably any of the listed species by reducing their habitat's ability to contribute to their survival and recovery.

Permit applicants for the three research projects proposed, taken together, request to capture fish using seining, tangle netting, angling, and boat and backpack electrofishing. In some cases, researchers would release fish quickly after capture, while other fish would be anesthetized and measured. A smaller subset of fish would be tagged.

We discuss below the effects of the sampling activities that are proposed collectively in the three permit applications. The proposed activities are evaluated inclusive of the permit conditions found in Section 1.3 above. Herein, we address the general effects that these types of sampling activities may have on the species. The effects of the proposed studies are described more specifically in Section 2.5.3 below.

Observation

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys or from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior.

Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Capturing/Handling

The primary effect of the proposed research will be on the listed species in the form of capturing and handling fish. Harassment caused by capturing (e.g., netting and trapping), handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, populations, and species (Sharpe et al. 1998). Handling of fish may cause stress, injury, or death, which typically are due to overdoses of anesthetic, differences in water temperatures between the river and holding buckets, depleted dissolved oxygen in holding buckets, holding fish out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding buckets can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps, nets, and buckets. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). The permit conditions identified in Section 1.3 contain measures that mitigate factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover fairly rapidly from handling.

Tangle Netting

Tangle nets are similar to gillnets, having a top net with floats and a bottom net with weights, but tangle nets have smaller mesh sizes than gill nets. Tangle nets are designed to capture fish by the snout or jaw, rather than the gills. Researchers must select the mesh size carefully depending on their target species, since a tangle net may act as a gill net for fish that are smaller than the target size.

Tangle nets can efficiently capture live salmonids in large rivers and estuaries (Ashbrook et al. 2005, Vander Haegen et al. 2004). However, fish may be injured or die if they become physiologically exhausted in the net or if they sustain injuries such as abrasion or fin damage. Entanglement in nets can damage the protective slime layer, making fish more susceptible to infections. These injuries can result in immediate or delayed mortality. Vander Haegen et al. (2005) reported that spring Chinook salmon had improved survival when captured in tangle nets

(92% survival) versus gill nets (50% survival), relative to a control group. Vander Haegen et al. (2005) emphasized that, to minimize both immediate and delayed mortality, researchers must employ best practices including using short nets with short soak times, and removing fish from the net carefully and promptly after capture. As with other types of capture, fish stress increases rapidly if the water temperature exceeds 18 ºC or dissolved oxygen is below saturation.

Angling

Fish caught with hook and line and released alive may still die due to injuries and stress they experience during capture and handling. Angling-related mortality rates vary depending on the type of hook (barbed vs barbless), the type of bait (natural vs artificial), water temperature, anatomical hooking location, species, and the care with which fish are handled and released (level of air exposure and length of time for hook removal).

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality with barbless hooks and artificial bait is low. Nelson et al (2005) reported an average mortality of 3.6% for adult steelhead that were captured using barbless hooks and radio tagged in the Chilliwack River, BC. The authors also note that there was likely some tag loss and the actual mortality might be lower. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait, and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catching and releasing adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 º C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Nelson et al (2005) or Hooton (1987) because of warmer water and that fact that summer fish have an extended freshwater residence that makes them more likely to be caught. As a result, NMFS expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of bait reduces juvenile steelhead mortality more than any other angling regulatory change. Artificial lures or flies tend to superficially hook fish, allowing expedited hook removal with minimal opportunity for damage to vital organs or tissue (Muoneke and Childress, 1994). Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Muoneke and Childress 1994; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984), mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found a notable difference in the mortality of fish associated with using barbed versus barbless hooks (Huhn and Arlinghuas 2011; Bartholomew and Bohnsack 2005; Taylor and White 1992; Mongillo 1984; Wydoski 1977). Researchers have generally concluded that barbless hooks result in less tissue damage, they are easier to remove, and because they are easier to remove the handling time is shorter. In summary, catch-and-release mortality of steelhead is generally lowest when researchers are restricted to use of artificial flies and lures. As a result, all steelhead sampling via angling must be carried out using barbless artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay et al. 2004). In hooking mortality studies, hooking location, gear type, and unhook time is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004)) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). Numerous studies have reported that deep hooking is more likely to result from using bait (e.g. eggs, prawns, or ghost shrimp) than lures (Lindsay et al 2004). One theory is that bait tends to be passively fished and the fish is more likely to swallow bait than a lure. Passive angling techniques (e.g. drift fishing) are often associated with higher hooking mortality rates for salmon while active angling techniques (e.g. trolling) are often associated with lower hooking mortality rates (Rogers et al 1999).

Catch and release fishing does not seem to have an effect on migration. Lindsay et al. (2004) noted that "hooked fish were recaptured at various sites at about the same frequency as control fish". Bendock and Alex (1993) found that most of their tagged fish later turned up on the spawning grounds. Cowen et al (2007) found little evidence of an adverse effect on spawning success for Chinook.

Not all of the fish that are hooked are subsequently landed. We were unable to find any studies that measured the effect of hooking and losing a fish. However, it is reasonable to assume that nonlanded morality would be negligible, as fish lost off the hook are unlikely to be deeply hooked and would have little or no wound and bleeding (Cowen et al 2007).

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA section 10 permit or 4(d) authorization may "operate to the disadvantage of the species," we allow no more than a three percent mortality rate for any listed species collected via angling, and all such activities must employ barbless artificial lures and flies.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them, which makes them easy to capture. It can cause a suite of effects ranging from disturbing the fish to killing them. The percentage of fish that are unintentionally killed by electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996; Dwyer and White 1997). Research indicates that using continuous direct current (DC) or low-frequency (30 Hz) pulsed DC waveforms produce lower spinal injury rates, particularly for salmonids (Fredenberg 1992, Snyder 1995, McMichael 1993, Sharber et al. 1994, Snyder 1995).

Most studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). Electrofishing can have severe effects on adult salmonids. Adult salmonids can be injured or killed due to spinal injuries that can result from forced muscle contractions. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Spinal injury rates are substantially lower for juvenile fish than for adults. Smaller fish are subjected to a lower voltage gradient than larger fish (Sharber and Carothers 1988) and may, therefore, be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997). McMichael et al. (1998) reported a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin.

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. Studies on the long-term effects of electrofishing indicate that even with spinal injuries, salmonids can survive long-term, however, severely injured fish may have stunted growth (Dalbey et al. 1996, Ainslie et al. 1998).

Permit conditions would require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.
- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.
- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.
- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

The preceding discussion focused on the effects backpack electrofishing and the ways those effects would be mitigated. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger and deeper areas. The environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. As a result, boat electrofishing can have a greater impact on fish. Researchers conducting boat electrofishing must follow NMFS' electrofishing guidelines.

Tagging/Marking

Techniques such as Passive Integrated Transponder (PIT) tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al., 1987; Jenkins and Smith, 1990; Prentice et al., 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling chinook salmon was not adversely affected by gastrically- or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall chinook salmon in 1992 (Rondorf and Miller, 1994) were similar to growth rates for salmon that were not tagged (Conner et al., 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen, 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al., 1968; Bordner et al., 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish’s stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

2.5.3 Species-Specific Effects of Each Permit

In the "Status of the Species" section, we reported the average annual abundance for adult and juvenile listed salmonids (Table 2). For most of the listed salmonids, we estimate abundance for outmigrating smolts and adult returning fish. For OC coho we estimate juvenile abundance using data on parr abundance. For hatchery propagated juvenile salmonids, we use hatchery production estimates. We do not have separate estimates for adult abundance of LHAC and LHIA fish, and so we apply the LHIA:LHAC proportions for juveniles to the abundance estimate for all hatchery-origin adults to estimate the adult proportions.

We evaluate the effects of proposed scientific research at the spatial scale or scales that are most relevant to the proposed action, i.e., at population- to ESU-scales. For permit 21837, effects could occur broadly across the entire ESU/DPSs, and so we analyzed effects of that permit at the ESU/DPS scale only. For permits 1135-10M and 22069, effects would be localized to individual populations and so we analyzed effects at both the population and ESU/DPS scales. We evaluate proposed levels of total take and potential mortalities for each project. We then quantify how each permit's potential take would affect abundance of the ESU/DPS by life stage and origin.

2.5.3.1 Permit 1135-10M

The USGS currently holds permit 1135-9R, which will expire on December 31, 2021. The permit authorizes the USGS to take listed species by backpack electrofishing in Trout Creek and the Wind River upstream of Carson National Fish Hatchery (Washington). The USGS proposes to modify their permit to increase the allowable take of juvenile LCR steelhead (Table 8). The additional juvenile fish that the USGS proposes to capture would be released without tagging or further sampling. The USGS does not propose to change sampling locations, methods, or any other aspect of their research relative to what is currently authorized. The researchers do not propose to intentionally kill any fish, but a small number may die as an unintended result of the research activities.

Table 8. New take proposed for Permit 1135-10M. Mortalities are also counted in the Proposed Take column. Take activities include Capture (C), Handle (H), Mark-Tag-Sample Tissue (M-T-S), and Release (R).

ESU/DPS	Life Stage	Origin	Take Activity	Previously authorized take under 1135-9R	Proposed Additional Take	Previously authorized mortalities under 1135-9R	Proposed Additional Mortalities
LCR steelhead	Juvenile	Natural	C/H/R	2500	2000	75	60
LCR steelhead	Juvenile	Natural	C/M-T-S/R	3500	0	105	0

Given the methods proposed by the USGS, we expect at least 97% of juvenile LCR steelhead that are captured during research activities to survive with no long-term consequences.

We previously analyzed effects for this permit in consultation WCR-2017-6650 at both the population and DPS scales because the LCR steelhead captured would come from only one population. To determine the effects of the proposed new take, we compare the numbers of additional fish that may be killed to the abundance of naturally produced juveniles that we expect at the population and DPS scales. In Section 2.7 (Integration and Synthesis) we describe the combined effects of the project's proposed new and previously authorized take.

Average abundance of natural-origin LCR steelhead smolts (2013-2017) was 323,607 for the entire DPS, inclusive of 25,432 for the Wind River population and (Table 2). The proposed research would kill up to 60 juveniles, which we estimated to be 0.2% of the Wind River population and 0.02% of the DPS annually (Table 9). Therefore, the proposed research would have a small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

Table 9. Percent of the Wind River population and the DPS taken or killed by activities conducted under permit 1135-10M.

ESU/DPS	Life Stage	Origin	Take	Percent of Population Taken	Percent of DPS Taken	Mortality	Percent of Population Killed	Percent of DPS Killed
LCR steelhead	Juvenile	Natural	2000	7.9%	0.6%	60	0.2%	0.02%

The USGS has requested what they expect would be the maximum possible amount of take. Likely, they will catch far fewer fish. During 2009-2016, the USGS killed between 0 and 31% of the levels authorized for this project. Only in 2017 did the USGS exceed their take limits due to unexpectedly high capture rates of age-0 fish (see Section 1.3). This project would benefit LCR steelhead by providing information on growth, survival, habitat use, and life histories of LCR steelhead in the Wind River subbasin. This new information would, in turn, help state, tribal, and Federal efforts to restore LCR steelhead.

2.5.3.2 Permit 21837

Researchers at the Oregon State University applied for a permit to take juvenile and adult UWR Chinook salmon and UWR steelhead in the upper mainstem and multiple tributaries of the Willamette Rivers (Table 10). The researchers would capture fish using boat and backpack electrofishing, stick and beach seining, and angling. The researchers do not propose to intentionally kill any fish, but a small number may die as an unintended result of the research activities.

Table 10. Take proposed for Permit 21837. Mortalities are also counted in the Proposed Take column. LHAC = listed hatchery adipose clipped, C/H/R = capture/handle/release.

ESU/DPS	Life Stage	Origin	Take Activity	Proposed Take	Proposed Mortalities
UWR Chinook	Adult	Natural	C/H/R	4	0
	Adult	LHAC	C/H/R	9	0
	Juvenile	Natural	C/H/R	1120	32
	Juvenile	LHAC	C/H/R	128	2
UWR steelhead	Adult	Natural	C/H/R	4	0
	Juvenile	Natural	C/H/R	155	4

We expect at least 99% of the fish that are captured using seines and traps to survive, and we expect at least 97% of fish that are captured by boat electrofishing to survive. For each combination of ESU/DPS, life stage, and origin, less than 0.11% of the fish would be taken. No adults would be killed. For natural-origin juveniles, less than 0.003% of the UWR steelhead DPS and the UWR Chinook salmon ESU would be killed (Table 11).

Table 11. Percent of the ESU/DPS taken or killed by activities conducted under permit 21837.

ESU/DPS	Life Stage	Origin	Take	Percent of ESU/DPS Taken	Mortality	Percent of ESU/DPS Killed
UWR Chinook	Adult	Natural	4	0.03%	0	0%
	Adult	LHAC	9	0.03%	0	0%
	Juvenile	Natural	1120	0.09%	32	0.003%
	Juvenile	LHAC	128	0.002%	2	0.00004%
UWR steelhead	Adult	Natural	4	0.09%	0	0%
	Juvenile	Natural	155	0.11%	4	0.003%

Research associated with permit 21837 would benefit UWR Chinook salmon and UWR steelhead by providing information on how a salmonid with similar ecological requirements, coastal cutthroat trout, adapts to increasing water temperatures. This new information would help fisheries managers prioritize conservation and management efforts in the context of climate change.

2.5.3.3 Permit 22069

ODFW applied for a permit to take OC coho in Tillamook Bay (Oregon) using angling, seines, and tangle nets (Table 12). The researchers do not intend to collect OC coho, but some may be captured while they collect unlisted OC Chinook salmon for a study on Chinook spawner distribution and abundance. The researchers do not propose to intentionally kill any fish, but a small number may die as an unintended result of the research activities.

Table 12. Take proposed for Permit 22069. Mortalities are also counted in the Proposed Take column. , C/H/R = capture/handle/release.

ESU/DPS	Life Stage	Origin	Take Activity	Proposed Take	Proposed Mortalities
OC coho	Adult	Natural	C/H/R	500	5
	Juvenile	Natural	C/H/R	200	2

Overall, the researchers have requested a 1% mortality rate associated with their combined sampling methods. We expect at least 99% of the fish that are captured using angling and seines to survive. The researchers have experience collecting Chinook salmon with tangle nets in similar settings and they propose to employ strict mitigation measures, including monitoring tangle nets continuously and immediately removing fish that are entangled. In their permit application, the researchers stated that “In 15 years of mark-recapture surveys using similar methods across 6 watersheds and more than 50,000 marked and/or tagged fish, our project has had less than 1% capture mortality.” Therefore, we expect at least 97% of the fish that are captured using tangle nets to survive.

Average abundance of natural-origin parr (2013-2017) was 499,100 for the Tillamook Bay population and 10,119,970 for the OC coho ESU (Table 2). The proposed research would kill up to 5 adults, which we estimated to be 0.07% of the Tillamook Bay population and 0.004% of the DPS annually. The proposed research would kill up to 2 juveniles, which we estimated to be 0.0004% of the Tillamook Bay population and 0.00002% of the DPS annually (Table 13). Therefore, the proposed research would have a small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

Table 13. Percent of the Tillamook Bay population and the ESU taken or killed by activities conducted under permit 22069.

ESU/DPS	Life Stage	Origin	Take	Percent of Population Taken	Percent of DPS Taken	Mortality	Percent of Population Killed	Percent of DPS Killed
OC coho	Adult	Natural	500	7.0%	0.4%	5	0.07%	0.004%
	Juvenile	Natural	200	0.04	0.002%	2	0.0004%	0.00002%

The goal of the research study is to improve information on the distribution and abundance of Chinook spawners in the Tillamook basin. The OC Chinook salmon ESU is subject to management under the Pacific Salmon Treaty, which calls for use of abundance-based management. Information on the distribution of spawning OC Chinook in the Tillamook basin is essential for developing an efficient and cost effective program to monitor Chinook spawner abundance. In addition, this research would benefit ESA-listed salmonids by demonstrating and improving methods for capturing and tagging fish in a large bay setting, and tracking spawner movement into multiple geographic strata.

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). We do not consider future federal actions that are unrelated to the proposed action 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 versus cumulative effects. Therefore, we describe all relevant future climate-related environmental conditions in the action area in the environmental baseline (Section 2.4).

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could affect listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities and the many private landholdings, make any analysis of cumulative effects difficult and speculative. However, projects affecting salmon, steelhead, and other listed fish species generally require federal funding or authorization to be completed, and so we can reasonably state that the vast majority of such actions in the region will undergo section 7 consultation.

In developing this biological opinion we considered efforts at the local, tribal, state, and national levels to conserve listed salmonids. These include the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010), the ESA Recovery Planning for Salmon and Steelhead in the Willamette and Lower Columbia River Basins (NMFS 2005b), the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010), the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW 2011), the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (WDFW 2010), and the Status Review Updates for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (Ford et al. 2011, NWFSC 2015). The result of that review was that salmon take—particularly associated with research, monitoring, and habitat restoration—is likely to continue to increase in the region for the foreseeable future. However, as noted above, all actions falling in those categories would also have to undergo consultation before they are allowed to proceed.

Non-federal activities are likely to continue to affect listed species and habitat within the action area. These cumulative effects in the action area are difficult to analyze because of this opinion's large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. The primary cumulative effects will arise from those water quality and quantity impacts that occur as upland human population growth and development shift the pattern of water use and land use, creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, base flows, and peak flows. But the specifics of these effects, too, are impossible to predict at this time. Although state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before we can consider them "reasonably foreseeable" in an analysis of cumulative effects.

One final point to consider regarding cumulative effects is the length of time over which the proposed action would occur. These permits would be approved for up to five years. Considering the life history for all potentially affected species, the proposed actions could affect the listed species for up to four years after an action ceases, with effects diminishing gradually over that time. We are unaware of any major non-federal activity that could affect listed salmonids and is certain to occur in the action area during that time frame.

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 due to implementing the proposed action. In this section, we assess this risk by integrating information on the status of the species and critical habitat (Section 2.2), the environmental baseline (Section 2.4), the potential effects of the proposed action (Section 2.5), and cumulative effects (Section 2.6). We formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) diminish appreciably the value of designated or proposed critical habitat for the conservation of the species. We integrate the take proposed for the permits considered here with that for research permits previously authorized under ESA Sections 10(a)(1)(A) or 4(d) to determine total take. We then compare this total take for research permits to the estimated annual abundance of each species (Table 14). As discussed in Section 2.5.2, effects of the proposed research on listed species are likely to be lower than the levels calculated in this analysis, because actual take described in annual reports typically is far less than the levels analyzed and authorized for research permits.

Table 14. Take and mortalities for proposed permits analyzed in this opinion ('Proposed') and proposed permits plus already authorized permits ('Proposed Plus Baseline') relative to abundance (LHAC[a] = Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose).

				Proposed				Proposed Plus Baseline			
ESU/DPS	Life Stage	Origin	Abundance	Proposed Take	Proposed % Taken	Proposed Mortality	Proposed % Killed	Total Take	Total % Take	Total Mortality	Total % Mortality
LCR steelhead	Adult	Natural	12,920	0	0%	0	0%	3,425	26.51%	35	0.27%
	Adult	LHAC	21,882	0	0%	0	0%	89	0.41%	2	0.009%
	Adult	LHIA	415	0	0%	0	0%	0	0.00%	0	0%
	Adult	Total	35,217	0	0%	0	0%	3,514	9.98%	37	0.11%
	Juvenile	Natural	323,607	2,000	0.62%	60	0.02%	69,119	21.36%	1,186	0.37%
	Juvenile	LHAC	1,194,301	0	0%	0	0%	57,082	4.78%	936	0.08%
	Juvenile	LHIA	22,649	0	0%	0	0%	0	0.00%	0	0%
	Juvenile	Total	1,540,557	2,000	0.13%	0	0%	126,201	8.19%	2,122	0.14%
UWR Chinook	Adult	Natural	11,443	4	0.03%	0	0%	266	2.32%	7	0.06%
	Adult	LHAC	34,353	9	0.03%	0	0%	255	0.74%	10	0.03%
	Adult	LHIA	101	0	0%	0	0%	0	0.00%	0	0%
	Adult	Total	45,897	13	0.03%	0	0%	521	1.14%	17	0.04%
	Juvenile	Natural	1,275,681	1,120	0.09%	32	0.003%	52,971	4.15%	994	0.08%
	Juvenile	LHAC	5,543,371	128	0.20%	2	<0.0001%	10,945	0.20%	288	0.01%
	Juvenile	LHIA	16,278	0	0%	0	0%	47	0.29%	8	0.05%
	Juvenile	Total	6,835,329	1,248	0.02%	34	0.0005%	63,963	0.94%	1,290	0.02%
UWR steelhead	Adult	Natural	4,280	4	0.09%	0	0%	288	6.73%	4	0.09%
	Adult	LHAC	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	LHIA	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	Total	4,280	4	0.09%	0	0%	288	6.73%	4	0.09%
	Juvenile	Natural	143,898	155	0.11%	4	0.003%	9,906	6.88%	229	0.16%
	Juvenile	LHAC	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	LHIA	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	Total	143,898	155	0.11%	4	0.003%	9,906	6.88%	229	0.16%

Table 14, continued.

ESU/DPS	Life Stage	Origin	Abundance	Proposed				Proposed Plus Baseline			
				Proposed Take	Proposed % Taken	Proposed Mortality	Proposed % Killed	Total Take	Total % Take	Total Mortality	Total % Mortality
OC coho	Adult	Natural	135,705	500	0.37%	5	0.004%	6,498	4.79%	64	0.05%
	Adult	LHAC	1,201	0	0%	0	0%	19	1.58%	0	0%
	Adult	LHIA	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Adult	Total	136,906	500	0.37%	5	0.004%	6,517	4.76%	64	0.05%
	Juvenile	Natural	10,119,970	200	0.00%	2	<0.0001%	567,092	5.60%	12,613	0.12%
	Juvenile	LHAC	60,000	0	0%	0	0%	359	0.60%	23	0.04%
	Juvenile	LHIA	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Juvenile	Total	10,179,970	200	0.00%	2	<0.0001%	567,451	5.57%	12,636	0.12%

[a]We estimate the abundance of LHAC adults using data on (1) abundance of all hatchery adults (LHAC + LHIA) and (2) the ratio of LHAC:LHIA for juveniles, assuming equal survival of LHAC and LHIA juveniles to the adult life stage.

Salmonids

The proposed research activities would cause very low rates of take and mortality for salmon and steelhead (Table 36). The effects of the proposed research are best seen in the context of potential mortality. Among the three proposed permits, researchers did not request to intentionally kill any adult salmonids. The vast majority of adult and juvenile fish that researchers capture and release would recover quickly with no long-term physiological, behavioral, nor reproductive effects.

The proposed research projects may kill, in sum, as much as 0.02% of the fish from any component of any listed salmonid species; that component is juvenile natural-origin LCR steelhead, with 60 mortalities requested for permit 21135-10M. Researchers request to kill up to 0.004% (5 fish) of natural-origin OC coho adults. Researchers request to kill up to 0.003% of natural-origin UWR Chinook juveniles (32 fish) and 0.003% of natural-origin UWR steelhead juveniles (4 fish) for permit 21837. For other affected ESU/DPSs, the proposed mortality rates are less than 0.0001% of estimated abundance for each component. For UWR Chinook and UWR steelhead, these very small effects would be spread across much of the range of the ESU/DPS. For OC coho and LCR steelhead, these very small effects would be localized to an individual population within each ESU/DPS (see Section 2.5.2).

When considering effects of the proposed research added to previous ESA Sections 10(a)(1)(A) and 4(d) research authorizations (i.e., the baseline), total effects of research on the listed species remain small. The projected mortality for juvenile and adult life stages from all research activities represent only fractions of a percent of the species' total abundance. The proposed plus baseline mortalities would always be less than 0.16% of the total (natural- and hatchery-origin) abundance of juveniles for any ESU/DPS – typically far less. Considering both hatchery- and natural-origin fish together, the highest mortality rates for juvenile salmonids occur for UWR steelhead (0.16%) and LCR steelhead (0.14%). The highest mortality rates for adults occurs for LCR steelhead (0.11%); however, the permits considered in this opinion do not contribute to this mortality, i.e., the mortalities were previously authorized in other permits.

The potential mortality would be no more than 0.37% of the abundance for naturally produced adults or juveniles. The low abundance of natural-origin fish relative to hatchery-origin fish for some ESU/DPSs means that mortality rates associated with research are consistently higher for the natural-origin component. This is particularly true for the natural-origin component of LCR steelhead adults (0.27%) and juveniles (0.37%), relative to the hatchery-origin components.

Only one of the proposed projects requests to kill natural-origin adults (22069). In that project the researchers need to capture unlisted adult Chinook salmon. Because OC Chinook and OC coho salmon overlap in their spawning migration timing, they may also unintentionally capture adult OC coho. The researchers have outlined mitigation measures they would take to ensure that any OC coho that are captured in seines and tangle nets would be promptly removed, in an attempt to avoid fish exhaustion or injury.

Although mortality rates remain low, we note that listed salmonids in the Lower Columbia Recovery domain are subject to high rates of research-related take. Take rates range from 10 to 36% of the estimated abundance for natural-origin juvenile LCR Chinook, natural- and hatchery-origin adult LCR coho, natural-origin juvenile LCR coho, and natural-origin adult and juvenile LCR steelhead (Table 14, WCR-2017-8556). Most of this take occurs through capturing, handling, and then releasing fish.

Our analysis of effects is likely to be conservative. As discussed previously, permit applications tend to overestimate actual take so that researchers are not likely to exceed their take authorization. In addition, we use conservative estimates of juvenile abundance. While we describe potential effects on all juvenile life stages (smolts, suyearlings, parr, and fry) as effects on “juveniles,” we estimate abundance of juveniles using data for smolts (LCR and UWR steelhead, UWR Chinook) or parr (OC coho; Table 2). Sub-yearlings, parr, and fry are life stages that represent multiple spawning years and have many more individuals than survive to the smolt life stage – perhaps as much as an order of magnitude more. Even if the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species’ entire range, they would be restricted to reductions in the species’ total abundance and productivity. Effects on spatial structure and diversity would be unmeasurably small and not assignable to any individual population. In addition, the small reductions in abundance and productivity would be offset to some degree by the information to be gained – information that in most cases would be used to protect salmon and steelhead and promote their recovery.

Critical Habitat

As noted earlier, we do not expect the individual actions to have any appreciable effect on any listed species’ critical habitat. This remains true for all the proposed permit actions taken together. The short duration, minimal intrusion, and overall lack of measureable effect of the actions on critical habitat signify that the proposed permit actions would have no discernible impact on critical habitat.

Summary

No listed species currently has all of its biological requirements met, as we discussed in Section 2.2. For these species to recover, there must be substantial improvement in habitat and other factors affecting survival. While the proposed research activities would have some negative effect on abundance and productivity for the species considered here, these effects are so small as to be negligible. Research activities have never been identified as a threat to listed fish in the Pacific Northwest. We therefore conclude that the proposed research activities, individually and collectively, do not threaten the listed species.

While specific future cumulative effects are uncertain, cumulative effects will likely continue to be negative. The effects of climate change are also likely to continue to be negative. However, the very small effects from the proposed research activities on abundance and productivity, and even smaller effects on spatial structure and diversity, will not exacerbate any negative cumulative effects on the listed species.

The proposed research activities may benefit these species by providing information on status, trends, and ecological requirements. These data inform NMFS' 5-year status reviews for listed species and species recovery efforts. For example, juvenile fish trapping studies inform population inventories, tagging efforts increase our knowledge of fish migration timing and survival, and fish passage studies enhance our understanding of behavior and survival as fish migrate past dams and through reservoirs. The resulting information improves our understanding of these species' life histories, biological requirements, genetics, migration timing, responses to human activities, and freshwater and marine survival. By issuing research authorizations, NMFS facilitates science-based management of fisheries resources. Furthermore, the effects of the research on listed species, to some degree, would be offset by the information to be gained—information that in most cases would be directly used to protect listed species or promote their recovery.

Additionally, the proposed research would contribute data to an information base that is, to some extent, legally mandated. Though no law mandates the specific work being done in the proposed research actions, Section 4(c)(2) of the ESA requires that we examine the status of each listed species every five years determine whether each listed species should be: (a) removed from the list, (b) have its status changed from threatened to endangered, or (c) have its status changed from endangered to threatened. Thus it is legally incumbent upon us to monitor the status of every species considered here and the research program, as a whole, is one of the primary means we have of doing that.

We expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. Because these reductions are so slight, the actions—even in combination—would have no appreciable effect on the species' diversity or structure. Habitat effects from the proposed actions would be negligible. Moreover, we expect the actions to provide lasting benefits for the listed fish and to contribute information that is needed to fulfill our mandate under the ESA.

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, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of LCR steelhead, UWR Chinook, UWR steelhead, or OC coho or destroy or adversely modify designated critical habitat for these 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 incidental take statement.

There is no incidental take for the actions considered in this opinion. The take associated with these scientific research permits is direct rather than incidental take, because in every case their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot be considered "incidental" under the definition given above. Nonetheless, one of the purposes of an incidental take statement is to lay out the amount or extent of take beyond which individuals carrying out an action cannot go without being in possible violation of section 9 of the ESA. That purpose is fulfilled here by the amounts of direct take laid out in the effects section above (2.5). Those amounts – displayed in the various permits' effects analyses – constitute hard limits on both the amount and extent of take the permit holders would be allowed in a given year. This concept is also reflected in the reinitiation clause just below.

2.10 Reinitiation of Consultation

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

As noted above, in the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. However, if any of the direct take amounts specified in this opinion's effects analysis section (2.5) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

2.11 "Not Likely to Adversely Affect" Determination

NMFS's determination that an action "is not likely to adversely affect" listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial (U.S. FWS and NMFS 1998). Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects on the species or their critical habitat.

SR Killer Whale Determination

The SR killer whale DPS composed of J, K, and L pods was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). The final rule listing SR killer whales as endangered identified several potential factors that may have caused their decline or may be limiting recovery. These factors include quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. The final recovery plan includes more information on these potential threats to SR killer whales (NMFS 2008).

NMFS published the final rule designating critical habitat for SR killer whales on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The physical or biological features (PBFs) of SR killer whale critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

SR killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands, and then move south into Puget Sound in early autumn. Pods make frequent trips to the outer coast during this season. In the winter and early spring, SR killer whales move into the coastal waters along the outer coast from Southeast Alaska south to central California (NMFS 2008a, Hilborn et al. 2012).

SR killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their preferred prey (review in NMFS 2008). Ongoing and past diet studies of SR killer whales conduct sampling primarily during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Hanson and Emmons 2010, Hanson et al. 2010; ongoing research by NWFSC). Therefore, our knowledge of diet preferences is specific to inland waters. Less is known about diet preferences of SR killer whales off the Pacific Coast. There are direct observations of two SR killer whale predation events in coastal waters, and in both the prey species was identified as Columbia River Chinook (Hanson et al. 2010). Chemical analyses also support the importance of salmon in the year-round diet of SR killer whales (Krahn et al. 2002; Krahn et al. 2007). SR killer whales' preference for Chinook salmon in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that SR killer whales likely prefer Chinook salmon when available in coastal waters.

The proposed actions may affect SR killer whales indirectly by reducing availability of their preferred prey, Chinook salmon. As described in the effects analysis for salmonids, approximately 34 juvenile Chinook may be killed during the course of the research; the juveniles would come from the UWR Chinook salmon ESU. As the previous effects analysis illustrated, these losses—even in total—are expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution.

The ten-year average smolt-to-adult ratio from coded wire tag returns is no more than 0.5% for hatchery Chinook in the Columbia Basin (http://www.cbr.washington.edu/cwtSAR/). Average smolt-to-adult survival of naturally produced Chinook in the Columbia Basin is 1% (Schaller et al. 2007). If one percent of the 34 juvenile Chinook salmon that may be killed by the proposed research activities were otherwise to survive to adulthood, this would translate to the effective loss of less than one half of one adult Chinook salmon. Given that the SR killer whale population must catch a minimum of 1,400 salmon daily to sustain their needs (Center for Whale Research 2018), this means that the research contemplated in this opinion could kill, in its entirety, less than 0.0003% of *one day's* worth of the fish that the SR killer whales need to survive.

In addition, the estimated Chinook mortality is likely to be smaller than stated. First, the mortality rate estimates for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer salmonids will be killed by the research than stated. In fact, over the last nine years, researchers have only killed about 15% of the juvenile Chinook salmon they were permitted to kill. Given the total quantity of prey available to SR killer whales throughout their range, this exceedingly small reduction in prey means the research would have an insignificant effect on the whales' survival and recovery.

Similarly, the future loss of Chinook salmon from UWR could affect the prey PBF of designated critical habitat for killer whales. As described above, however, and considering the conservative estimate of less than one Chinook salmon adult equivalents that could be taken by the proposed actions, and the total amount of prey available in critical habitat, the reduction would be so small that it would not affect the conservation value of the critical habitat in any meaningful or measurable way.

Given these circumstances, and the fact that we anticipate no direct interaction between any of the researchers and the SR killer whales, NMFS finds that potential adverse effects of the proposed research on SR killer whales are insignificant and determines that the proposed action may affect, but is not likely to adversely affect, SR killer whales or their critical habitat.

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

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

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

3.1 Essential Fish Habitat Affected by the Project

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. The EFH identified within the action areas are identified in the Pacific coast salmon fishery management plan (PFMC 2014). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC), and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

3.2 Adverse Effects on Essential Fish Habitat

As the Biological Opinion above describes, the proposed research actions are not likely, singly or in combination, to adversely affect the habitat upon which Pacific salmon, groundfish, and coastal pelagic species, depend. All the actions are of limited duration, minimally intrusive, and are entirely discountable in terms of their effects, short-or long-term, on any habitat parameter important to the fish.

3.3 Essential Fish Habitat Conservation Recommendations

No adverse effects upon EFH are expected; therefore, no EFH conservation recommendations are necessary.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Given that there are no conservation recommendations, there is no statutory response requirement.

3.5 Supplemental Consultation

The Action Agency 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 users of this opinion are the applicants and funding/action agencies listed on the first page. The agencies, applicants, and the American public will benefit from the consultation.

Individual copies of this opinion were made available to the applicants and it will be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). 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 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 reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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